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ABSTRACT

This conference paper describes the cooperative learning structure; presents the elements of cooperative learning; discusses how to plan, implement, and evaluate using the cooperative learning structure; introduces assistive technology services for students with disabilities; and examines how devices and services can be used to facilitate active involvement of students with disabilities in cooperative learning activities. It specifically addresses: (1) definitions of cooperative learning with empirical support for the definitions; (2) cooperative learning's essential elements of positive interdependence, accountability, collaboration, and group processing; (3) planning in the areas of curriculum, instruction and materials, student roles, environment, student groupings, and management; (4) the role of the Technology-Related Assistance for Individuals with Disabilities Act Amendments of 1994 in providing financial assistance for assistive technology; (5) development of the Texas Assistive Technology Partnership as a project of the University Affiliated Program at the University of Texas at Austin; (6) principles associated with matching assistive technology to instructional setting demands; and (7) devices, systems, or techniques which assist individuals with disabilities in classrooms, homes, and workplaces, such as keyboard enhancement mechanisms, speech recognition, voice output, and software for students with learning disabilities. (Contains 28 references.) (JDD)

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Using Assistive Technology to Facilitate Cooperative Learning

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Cooperative learning has become a popular instructional structure used by teachers to promote academic and social skills with students who have disabilities. Although cooperative learning primarily has been researched and implemented with regular education students, an increasing body of research is demonstrating its value for students with varying disabilities. Teachers have found the cooperative learning structure to be beneficial to students with disabilities in gaining much needed practice and reinforcement in various skills and concepts. In particular, the cooperative learning structure is most beneficial when students with disabilities practice and apply their academic, language, behavioral, and social skills. At a time when many schools are attempting to successfully involve students with disabilities into scholastic activities alongside their nondisabled peers, cooperative learning holds promise to facilitate such endeavors.

For students with disabilities, assistive technology is providing access to programs that have heretofore been inaccessible. Once thought of devices used solely by students with sensory or motor impairments, assistive technology devices are increasingly being used by students with disabilities in their classrooms. Recent rulings have supported the use of assistive technology devices by mandating their purchase if the devices are needed for attainment of the goals and objectives stated in the Individualized Education Program (IEP). Thus, there is increasing interest in assistive technology across disabilities and across ages.

The purpose of this paper is to (a) describe the cooperative learning structure; (b) present the elements of cooperative learning; (c) discuss how to plan, implement, and evaluate using the cooperative learning structure, (d) provide an introduction to assistive technology services for students with disabilities, and (e) present how devices and services can be used to facilitate the active involvement of students with disabilities in cooperative learning activities.

Introduction to Cooperative Learning

This section provides a brief explanation of several instructional structures, defines cooperative learning while providing empirical support for the definitional components, and presents cooperative learning's essential elements. Those seeking additional information about cooperative learning will find helpful the accompanying reference list and appendixes that contain teaching resource ideas.

Instructional Structures

Johnson and Johnson (1986, 1987) have identified three instructional structures that are most often employed in classrooms: individualistic, competitive, and cooperative. Each structure is defined by the behaviors of students and teachers, and by the instructional objectives.

According to Andersen, Nelson, Fox, and Gruber (1988), the individualistic structure is used when students work by themselves on activities designed to meet IEP goals and objectives. Teachers instruct students individually as necessary. The benefits of this structure are that (a) students work independently as teachers circulate and provide instruction as needed, and (b) activities are tailored to each student's needs. A typical modification of this structure is for teachers to have some students work independently (commonly referred to as "seat work") while small group instruction takes place with other students. The downside of the individualistic structure is that students have little opportunity to interact with their peers to develop important oral language and social skills.

The competitive structure challenges learners by pitting them against one another either individually or in groups. Thus, some students are winners while others are losers within a given activity. Although competition is viewed by some as healthy and a part of everyday

life, we feel that students with learning problems have already sustained a number of "losses" in academic activities and further struggles (and losses) should be minimized. Thus, we agree with Andersen et al. (1988) who recommend that when competitive structures are used (e.g., in game situations to drill particular skills), several winners should be recognized. In keeping with this philosophy, we feel that games (which are commonly-used vehicles in the competitive structure) can be used with students to encourage collective goal attainment (e.g., when they need to arrive at a group point total in order to win a game).

In the cooperative structure, students work collectively to achieve a common goal. Situations are contrived that enable students to rely on one another to accomplish a goal. The teacher's role in cooperative learning is multidimensional. On the one hand, the teacher is a facilitator who monitors student groups for evidence of academic and collaborative goal achievements. At the same time, teachers are instructors who first teach students (through modeling, imitation, and practice) specific interdependence, accountability, collaborative, and group processing skills. This instruction is a prerequisite to cooperative learning groupings and is planned for and taught accordingly. As we shall see, a major benefit of the cooperative structure is that students are expected to interact and to discuss activities; thus, oral language and social skills are reinforced.

Cooperative Learning Defined

Currently, there are several definitions of Cooperative Learning (e.g., the most oft-cited is offered by Johnson & Johnson, 1986). We have developed our own definition of Cooperative Learning and present it here, followed by the rationale for each component.

Webster's New World Dictionary (Guralnik, 1984) defines cooperative as "owned collectively by members who share its benefits" (p. 139). The same source defines learning as "(getting) knowledge of or skill in (an art, trade, etc.) by study, experience, etc" (p. 344). Thus, we choose to define Cooperative Learning as *sharing the benefits of working collectively to gain knowledge or skill through study and experience*. As we analyze this definition, we identify how Cooperative Learning can be of benefit to all students, including those with disabilities.

Sharing the benefits...

Each student engaged in Cooperative Learning benefits from working as a team, not only by developing academic, communication, and social skills but by receiving credit for the work of the group as a whole. Johnson and Johnson (1986) identify three structures of learning that take place in classrooms: (a) competitive (i.e., learning that focuses on identifying those who know the studied material and those who don't), (b) individualistic (i.e., learning that takes place without peer interactions), and cooperative (i.e., collective learning that takes place in pairs or small groups). The first two structures provide contingencies based on individual performance (although competition can occur using teams). Students who do well receive credit for their performance; those with inferior products also receive their due. This is the traditional fare in education. In a sense, such structures, whether intended or not, separate the *haves* from the *have nots* (in this case, with regard to knowledge or performance). The third structure focuses on group performance and provides contingencies based on a collective effort. Cosden, Pearl, and Bryan (1985) refer to such a group contingency as forming "cooperative goal structures." Although one could provide separate contingencies to each group member based on the individual's contribution -- Johnson, Johnson, Warring, & Maruyama (1986) call this a mixture of cooperation and competition -- such a procedure introduces competitiveness and

promotes individual efforts rather than group interaction. Thus, we adhere to an underlying tenet of Cooperative Learning, which is that all group members should share equally the benefits accorded to their collective efforts.

...of working collectively...

Students within Cooperative Learning activities serve as team members. In "the real world," team members need not have the same general beliefs, nor do they even need to like each other very much. In sports, we see this acted out on a daily basis. Teammates can have different philosophies, interests, strengths and weaknesses, and so forth; but such heterogeneity need not deleteriously affect performance as a team. In fact, members of successful teams forget (or at least set aside) their differences as soon as they step onto "the playing field," and the team benefits from the diversity of its members. As we will point out later, there are many issues associated with team selection and group interaction that teachers consider during preparation. For now, though, consider that a primary concern with Cooperative Learning is team members working toward a single purpose, in this case, the completion of an assignment.

...to gain knowledge or skill...

One of the principle appeals of Cooperative Learning is its multiplicity of benefits. As is evident in our model, we advocate Cooperative Learning as a vehicle for positive, concurrent outcomes for each student in academics, communication, and social skills. Thus, acquiring academic knowledge is but one aim of Cooperative Learning. Cooperative Learning affords an excellent opportunity to develop interpersonal skills (e.g., turn taking, collaborating) (Putnam & Markovchick, 1989; Stevens, 1989; Yager, 1985). Additionally, we encourage teachers to employ Cooperative Learning to increase overall communicative competence, particularly those associated with language content and form (Bloom & Lahey, 1978). Because a number of students with disabilities have spoken language deficiencies (Wiig & Semel, 1984), the improvement of students' communication skills is a goal found on many of their IEPs. Cooperative Learning affords an ideal opportunity for students to practice newly acquired language skills.

Whether an activity is intended to focus on academics, communication, or social skills, it is imperative that specific goals and objectives be targeted for improvement. Engaging in Cooperative Learning for its own sake rather than for knowledge or skill attainment can result in what has been called a "feel good" outcome (see Fuchs & Fuchs [1992] for an analogous situation in consultation activities), that is, feeling good about students working together yet failing to pay close attention to whether knowledge is being acquired by each student within the group. Simply "working together well," without measurable knowledge or skill attainment in the targeted content area(s), is insufficient. Particularly if a student with a disability is a group member, one must ensure that knowledge or skill is acquired in accordance with the IEP goals and objectives. To help assure that knowledge is being acquired, it is our belief that Cooperative Learning activities for students with disabilities should take place only after direct instruction has occurred that targets specific skills. In this way, Cooperative Learning activities allow students to practice their newly acquired skills in a social and communicative context.

...by such means as study and experience.

In a grammatic sense, our perspective of Cooperative Learning views *learning* as a verb and *cooperative* as an adverb. Although this may seem trite at first glance, our perspective

is that Cooperative Learning fosters active involvement in a course of study; and experience, by its very nature, is an active concept. Thus, we view Cooperative Learning as each student being actively engaged in the learning process by studying together (i.e., collectively exploring the nature of the content) and using their experiences (i.e., prior knowledge) to arrive at a common goal. As we will see later, any of a variety of roles can be assigned to each group member, but it is critical that each student be actively involved in some way. This, perhaps, is the essence of Cooperative Learning, that is, each participant is an active, rather than a passive, learner. Each member *experiences* learning, and all members contribute to the effort by calling upon their experiences and strengths. One of the many challenges the teacher faces in Cooperative Learning is to facilitate the emergence of those contributions. Finally, students gain experience (though practice) with communication and interpersonal relations by using language correctly and engaging in group social interactions.

To summarize, Cooperative Learning is an instructional approach that involves active participation by a heterogeneous group of students toward common goals. There are two dimensions of our Cooperative Learning model: Content and Phases. The intent is for students to work together as a team to complete their academic work, to communicate effectively, and to interact appropriately.

Elements of Cooperative Learning

Johnson and Johnson (1986) identify four elements employed in cooperative learning: (a) positive interdependence, (b) accountability, (c) collaboration, and (d) group processing. Each of these elements is explained in this section and is accompanied by suggestions for implementation during cooperative learning activities. Teachers should personalize each element to the specific goals being emphasized in their classroom.

Positive Interdependence

Positive interdependence means that the success of the group depends on the success of each group member; therefore, group members work together to promote individual and group success. Several techniques are used to foster positive interdependence, including (a) instructing and modeling, (b) grading, (c) providing rewards, (d) selecting materials and resources, (e) coordinating activity structures, and (f) assigning roles. Descriptions and examples of these techniques are provided in this section.

Instruction and modeling

Prior to implementing cooperative learning, students are shown that a major goal of this instructional structure is working together for the benefit of the group. Students gain an understanding that the success of the group depends on the actions of each member and that they will be expected to form a team and collectively complete group activities.

1. Teachers can discuss examples and nonexamples of teaming skills. For example, members of a team encourage and help each other for the benefit of the group. Team members take pride in what their group accomplishes, so each member should work hard to ensure group success. Nonexamples might include working on an activity in isolation and being uninterested in how the other members of the team are doing.

2. Teachers can model examples and nonexamples of positive interdependence while students make notes of what the teacher does under each condition. Modeling and note

taking could be followed by group discussion of examples and nonexamples of team behavior.

3. Students can display team behaviors in contrived situations; for example, give each group member a dictionary and a worksheet to complete -- then provide one worksheet and dictionary with assigned roles (e.g., recorder, leader, materials coordinator) for completing the assignment. This activity could be followed by students discussing the differences of how they worked when given an individual and a cooperative activity.

Grading

Once students understand the concept of positive interdependence (and the other cooperative learning elements), they can begin working in groups. Several techniques (Johnson & Johnson, 1986) can be used to promote interdependence.

1. Teachers can provide a group grade that reflects the efforts of all group members.
2. One paper could be produced by the group and assigned a grade which each member earns.
3. A grade could be given for interdependent behaviors. This grade is determined as the teacher monitors team behaviors while students are engaged in cooperative activities.

Rewards

Rewards can be provided based on the ability of each member to achieve the academic and collaborative goals for the activity. The idea is to reinforce the group based on each member demonstrating targeted academic and/or social behaviors.

1. Teachers could administer points for groups towards improving their group grade.
2. A special reinforcer could be given to each group for demonstrated interdependence (team) behaviors. The reward would be administered only if the teacher observed that all students in the group would engaging in the team behaviors.

Materials and Resources

The focus of this technique is to have students share materials and resources and work together to assure access for all members.

1. A limited number of materials can be distributed to each group, such as one box of crayons, a dictionary, or microscope depending on the activity.
2. Each group could receive one resource, such as a dictionary, encyclopedia, newspaper, or map, depending on the activity for group use.

Activity Structures and Roles

Activities can be structured so that members must rely on one another to complete the assignment.

1. Students may each have a role in a technique. For example, in a story problem situation one student may be the designated reader, one student could locate the pertinent information, another could compute the data with the assistance of a student using a calculator, and a final student could put the results into a group response to answer the question at hand. The idea is that each step of the activity is interconnected to the previous step so students must work interdependently.
2. Each student in a group could be given a different material that would be needed to complete the activity. For example, using a calendar to count by 5's, one student would

cut numbers from the calendar, one student would paste the numbers on a piece of construction paper in correct order, and another student would write the numbers using paper and pencil.

Individual Accountability

When all members of the group recognize that their performance affects the success of the group's progress, then individual accountability is evident. In other words, all individuals are accountable for their actions as they relate to the rest of the group and the group's success.

Ways to foster students' awareness of individual accountability include:

1. Having the group select the spokesperson to describe to the rest of the class what they have accomplished with their activity;
2. Selecting randomly one student from each group to demonstrate how their group solved a problem;
3. Distributing bonus points intermittently for positive interdependence, thus causing students to work to their optimum; and
4. Providing a primary reinforcer to each member in the group if one member is demonstrating cooperative behaviors at a given time.

Collaborative/Social Skills

Collaborative and social skills are important elements of cooperative learning because they represent the ways in which individuals interact and work collectively. Johnson and Johnson (1986) stated that decision-making, trust-building, communication, leadership, and conflict-management are important collaborative skills for students to develop. We would add social skills such as accepting and giving criticism and praise, listening, turn-taking, sharing, compromising, and being responsible for materials, tasks, and roles.

Because cooperative learning requires individuals to work together towards a common goal, collaborative and social skills *must be taught prior to placing students in cooperative groupings.*

1. Give students interpersonal problem situations with possible decisions. Have students select decisions and state why they made those choices.
2. Define trust. Have students list people they trust and state why. Have students describe why trustworthy behaviors are important. Give examples and nonexamples of trustworthy behaviors that are used in group work (e.g., people do what they way they will do, people take good care of others' property)
3. Have students play the Barrier Game, which emphasizes the importance of effective communication and direction-giving. Students could discuss the problems they encountered and types of communication that were used to achieve success.
4. Give students pictures of faces with various expressions (e.g., happy, angry, sad, puzzled) and state what emotions are being expressed nonverbally. Discuss why it's important to "read" these nonverbal cues that people send.
5. Provide conflict situations to which students can relate. Brainstorm ways that these situations could be solved.
6. Use the "think-aloud" technique in a contrived situation to demonstrate cognitive strategies for dealing effectively with conflict.
7. Brainstorm examples of praise that students could use when their peers are demonstrating cooperative behaviors.
8. Model the use of "I" messages and an appropriate way to accept criticism. Provide examples and nonexamples and opportunities for students to practice.
9. Model good and poor listening behaviors (verbal and nonverbal).

Once students have gained an understanding of collaborative and social skills, they can begin working in cooperative groupings. At this point, the teacher should circulate among groups and provide reinforcement for evidence of these skills.

Group Processing

Group processing is conducted after the cooperative activity occurs. Students then critically examine their group behavior by using an evaluation sheet and discussing their interactions. Time must be allowed for this element to satisfy the goal that students be able to identify those team, collaborative, and social skills that were effective and ineffective.

Teachers can construct group processing evaluation sheets. Depending on the age group, responses can be recorded using happy, sad, or straight faces; yes/no; a rating scale (e.g., 1-5); and so forth. Group members can self-evaluate their own behavior and the behavior of the group as a whole. Specific behaviors that need improvement can be targeted by the group for the next cooperative activity. The teacher should also evaluate groups and compare the results to those generated by the groups. This is critical in the early stages to ensure that students do not give themselves more credit than they deserve in hopes of achieving high marks. Such teacher-monitoring can then be faded as students gain proficiency in accurately evaluating their own behaviors. Intermittent teacher evaluations can continue, however.

Planning, Implementing, and Evaluating Cooperative Learning

Cooperative learning can result in effective student outcomes for students with disabilities only when it is carefully planned, consistently implemented, and continuously evaluated. Therefore, we provide a means for planning, implementing, and evaluating cooperative learning in this section.

Planning

As with any instructional activity, careful advanced planning is necessary to assure successful implementation of cooperative learning activities. Planning occurs in the areas of (a) curriculum, (b) instruction and materials, (c) student roles, (d) environment, (e) student groupings, and (f) management.

Curriculum

Teachers should begin planning by examining student IEPs. It is important to note what academic and social goals and short term objectives have been established for each child. Next, teachers examine the curriculum and related scope-and-sequence charts to determine appropriate instructional objectives for students. Obviously, curricular instructional objectives are based on students' current levels of performance in specific academic and social areas.

We are most concerned with the goal areas of mathematics, social and collaborative skills, and oral language development for the purposes of this paper. Examples of suggested scope-and-sequence charts for those areas are provided in Appendix A. The reader is referred to those charts to help identify appropriate instructional objectives based on IEP goals and short term objectives. In addition, teachers should be aware of the

content of the *Curriculum and Evaluation Standards* (NCTM, 1989) when selecting appropriate mathematical instructional objectives and activities for cooperative activities. Examples and descriptions of specific standards for mathematics instruction are found in Appendix A.

Instruction and Materials

We recommend that cooperative learning activities be used in two situations. The first situation would be as a guided practice activity as part of direct instruction. (See Appendix B for instructional procedures that are viewed as components of direct instruction.) In this situation, students need practice opportunities to achieve mastery with teacher monitoring of newly introduced skills or concepts.

The second situation would be as an independent practice activity. Here students understand the skill or concept and do not necessarily require constant teacher monitoring. Rather, continued practice with the skill to foster maintenance or to build generalization is appropriate.

As part of instructional planning, teachers must consider (a) how long the activity will occur (i.e., how many minutes), (b) how many activities will be necessary to teach or reinforce a skill or concept, (c) how frequently during the week activities will be scheduled, (d) when during the day such activities will occur, (e) how many weeks will be devoted to the skill or concept, (f) what the cooperative learning goals will be in academics, oral language, and social/collaborative skills, (g) how positive interdependence will be fostered, (h) how students will be held accountable for the activity, (i) how group processing will be evaluated, (j) what materials and resources will be needed, and (k) what activity the students will complete. The Cooperative Learning Lesson Plan sheet can be used to assist with planning (See Appendix B).

Student Roles

A major part of cooperative learning is assigning roles to students. Roles are important because they define appropriate actions and behaviors. They also provide participants with ownership in the activity. Suggested roles include: (a) leader, (b) materials person, (c) record keeper, (d) time keeper, (e) spokesperson, and (f) runner. Each role should be defined clearly, preferably listed on a chart or name holder (i.e., piece of construction paper folded in half lengthwise with role written on one side and responsibilities on the other). Roles should be rotated so students have opportunities for the various responsibilities. Additionally, roles should be taught and practiced in contrived situations. Again, the use of modeling, examples, and nonexamples are helpful for students to develop an understanding of the responsibilities associated with each role. Finally, as students are engaged in cooperative activities teachers can reinforce the group when appropriate role behavior is noted (e.g., record keeper writing notes, timekeeper keeping members on task because time is running out).

Environment

The nature of cooperative learning (i.e., students engaged in social and academic situations) warrants careful consideration of environmental planning. The idea is to ensure that students are in social groupings; that is, the furniture is physically situated so that students are looking at each other. Preferably students should work at tables; however, if that is not feasible then chairs or desks facing each other is suggested.

Student Groupings

A critical component of cooperative learning is grouping students, or selecting teams. Researchers (e.g., Andersen et al., 1988; Johnson & Johnson, 1986) suggest that heterogeneous groupings work best because higher-ability students can be paired with lower-ability students. Teachers must consider the academic, behavioral, and social strengths and weaknesses of each student. Sociograms are helpful in determining student perceptions of social hierarchies within the class. Based on these data and the academic, oral language, and social/ collaborative goals of the cooperative activity, student teams can be selected.

Teams can consist of form two to six students (Johnson & Johnson, 1986). When initiating cooperative learning activities, start with smaller groups until students learn how to work together within their assigned roles. Groups should be small enough so that each member has an active role and can access needed materials within a reasonable amount of time. Teams can stay together for one activity, a week, or a semester. Thus, several questions should be considered when designing student groupings:

1. What are my academic, oral language, and social/ collaborative goals for the cooperative learning activity?
2. What are each student's strengths and weaknesses in the identified academic, oral language, behavioral, and social/collaborative area?
3. How many students do I want on each team?
4. How many materials and resources do I have available?
5. Do I have a role for each group member?
6. How long will these cooperative groupings stay together?

Management

Effective management techniques are critical in any instructional setting, especially during cooperative learning activities. Teachers can address the following questions when planning their management program:

1. What will the rules and consequences be for cooperative learning activities?
2. How will students move to and from cooperative groupings (transition)?
3. How will materials distribution be handled?
4. What will students do with completed work?
5. How will inappropriate behavior be handled?

Implementing

Once planning has occurred, it's time to implement cooperative learning activities. Two important components are considered as part of the implementation phase. The first is direct instruction. Again, the reader is referred to Appendix B for information regarding recommended direct instruction procedures. When using cooperative learning as a guided practice activity, teachers would instruct and check for student understanding of presented material then move students into their cooperative groups for practice.

The second component is the delineation of the teacher's role. Following are suggestions for teachers when implementing cooperative learning:

1. Be sure furniture and materials are ready.
2. Tell students it's time for cooperative learning groupings.
3. Use transition techniques to move students into predetermined heterogeneous groupings. Reinforce groups for following instructions.
4. Tell students the academic, oral language, and social/ collaborative objectives (advance organizer).

5. Tell students how team behavior (positive interdependence) is an important part of cooperative learning.

6. Tell students how they will be held accountable for the activity.

7. Be sure student roles have been assigned.

8. Explain that group processing will occur at the end of the activity.

9. Explain the activity. Model if necessary. Check for understanding. Implement.

10. Circulate among groups (a) monitoring student understanding, (b) reinforcing appropriate team behaviors, (c) reinforcing appropriate social/collaborative skills, (d) praising students for doing their role responsibilities appropriately, (e) collecting data, and (f) providing further instruction if necessary.

11. Provide advance warning that activity needs to conclude.

12. Provide sharing time.

13. Have students engage in group processing. Monitor and reinforce responses. Have students target group behavior to focus on in next activity.

14. Clean up.

Examples of mathematics activities for cooperative learning groupings are presented in Appendix C.

Evaluating

Several techniques can be used to evaluate student progress. First, students can be held accountable for their individual behavior and contributions by having a group grade assigned which reflects everyone's efforts. The idea is for students to work collaboratively and do their best so that the group grade does not suffer. Second, individual tests can be conducted after a cooperative activity or the following day to be sure that each student is achieving progress with the academic objective. Third, a checklist can be developed that lists a series of social skills (e.g., listening, sharing, taking turns) and oral language skills (e.g., asking questions, contributing ideas) that are targeted for the cooperative learning activity. As teachers circulate and monitor students during group work, they can record frequencies of occurrences or anecdotal notes documenting specific concerns. Fourth, group effort and behaviors can be evaluated by the students during the group processing element of cooperative learning. Thus, several alternative evaluation techniques exist which can be used to ensure that students are making appropriate progress with the various objectives.

Introduction to Assistive Technology

The purpose of this section is to provide a brief introduction to assistive technology. We do so by discussing brieffly a key piece of legislation and then discussing a project in Texas that works to establish a consumer responsive, comprehensive, and statewide assistive technology delivery system.

Technology-Related Assistance for Individuals with Disabilities Act Amendments of 1994

The overall purpose of Public Law 103-218, the *Technology-Related Assistance for Individuals with Disabilities Act Amendments of 1994* (better known as the Tech Act), is to provide financial assistance to states and United States territories to assist them in developing and implementing a consumer responsive statewide program of technology-related assistance for individuals with disabilities of all ages. The Tech Act has provided many new opportunities for individuals with disabilities and their families to receive

appropriate assistive technology services and has placed considerable emphasis on being responsive to the needs of consumers. Although not restricted to educational opportunities, the principles of the Tech Act are certainly germain to maximizing an individual's education potential.

During Congressional hearings to discuss the amendments to the Technology-Related Assistance to Individuals with Disabilities Act of 1988, several critical issues were identified.

- Technology is a powerful force in the lives of most U.S. residents.
- Technology can provide powerful tools to make performing tasks quicker and easier
- Assistive technology is a necessity that enables individuals with disabilities to engage in many tasks
- There exists already a substantial number of assistive technology devices
- Most states have technology-related assistance programs carried out under the Tech Act but in spite of their efforts, there remains a need to support systems change and advocacy activities in order to assist States to develop and implement consumer responsive, comprehensive statewide programs of technology-related assistance for individuals with disabilities of all ages;
- Notwithstanding the efforts of such State technology-related programs, there is still a lack of
  a. resources to pay for assistive technology devices and services
  b. trained personnel to assist individuals with disabilities to use such devices and services
  c. information among individuals with disabilities and other related persons about the availability and potential of technology for individuals with disabilities
  d. aggressive outreach to underrepresented and rural populations
  e. systems that ensure timely acquisition and delivery of assistive technology devices and services, particularly with respect to children
  f. coordination among State human services programs, and between such programs and private entities, particularly with respect to transitions between such programs and entities
  g. capacity in such programs to provide the necessary technology-related assistance
- Many individuals with disabilities cannot access existing telecommunications and information technologies and are at risk for not being able to access developing technologies
- There are sufficient incentives for commercial pursuit of the application of devices because of limited markets
- There is a lack of coordination among agencies at the Federal level that provide or pay for the provision of assistive technology devices and services

These and other findings provided Congress with the impetus to pass sweeping changes to the Tech Act, which was originally passed in 1988 as Public Law 100-407. As a result of these changes, the purposes of the Tech Act have been modified as follows:

(1) increase the availability of, funding for, access to, and provision of assistive technology devices and assistive technology services;
(2) increase the active involvement of individuals with disabilities and their family members, guardians, advocates, and authorized representatives, in the planning, development, implementation, and evaluation of such a program;
(3) increase the involvement of individuals with disabilities and, if appropriate, their family members, guardians, advocates, and authorized representatives, in decisions related to the provision of assistive technology devices and assistive technology services;

(4) increase the provision of outreach to underrepresented populations and rural populations, to enable the two populations to enjoy the benefits of programs carried out to accomplish purposes described in this paragraph to the same extent as other populations;
(5) increase and promote cooperation among State agencies, and between State agencies and private entities, that are involved in carrying out activities under this title, particularly providing assistive technology devices and assistive technology services, that accomplish a purpose described in another subparagraph of this paragraph;
(6)(a) increase the awareness of laws, regulations, policies, practices, procedures, and organizational structures, that impede the availability or provision of assistive technology devices and assistive technology services; and

(b) facilitate the changes of laws, regulations, policies, practices, procedures, and organizational structures, that impede the availability or provision of assistive technology devices and assistive technology services;
(7) increase the probability that individuals with disabilities of all ages will, to the extent appropriate, be able to secure and maintain possession of assistive technology devices as such individuals make the transition between services offered by human service agencies or between settings of daily living;
(8) enhance the skills and competencies of individuals involved in providing assistive technology devices and assistive technology services;
(9) increase awareness and knowledge of the efficacy of assistive technology devices and assistive technology services among--

(a) individuals with disabilities and their family members, guardians, advocates, and authorized representatives;
(b) individuals who work for public agencies, or for private entities (including insurers), that have contact with individuals with disabilities;
(c) educators and related services personnel;
(d) technology experts (including engineers);
(e) employers; and
(f) other appropriate individuals;

(10) increase the capacity of public agencies and private entities to provide and pay for assistive technology devices and assistive technology services on a statewide basis for individuals of all ages; and
(11) increase the awareness of the needs of individuals with disabilities for assistive technology devices and assistive technology services.

In order to accomplish the purposes of the Tech Act in Texas, the Texas Assistive Technology Partnership (TATP) was formed. The TATP is described in the next section.

Description of the TATP

In 1991, the University Affiliated Program at The University of Texas at Austin was awarded the Texas Assistive Technology Partnership (TATP) project by the National Institute on Disability and Rehabilitation Research (NIDRR) under the Tech Act. The TATP was established in 1992 to provide a statewide, consumer-responsive system for the provision of assistive technology devices and services to all Texans with disabilities. Assistive technology addresses such topics as seating and positioning, mobility, augmentative communication, computer access, adaptive toys and games, adaptive environments, and funding. As outlined in the Tech Act, the TATP is to carry out several systems change and advocacy activities.

Activity 1. Each state project will undertake initiatives that will provide for the development, implementation, and monitoring of State, regional, and local laws, regulations, policies, practices, procedures, and organizational structures, that will improve

access to, provision of, funding for, and timely acquisition and delivery of, assistive technology devices and assistive technology services.

Activity 2. Each state project will undertake the development and implementation of strategies to overcome barriers regarding access to, provision of, and funding for, such devices and services, with priority for identification of barriers to funding through State education (including special education) services, vocational rehabilitation services, and medical assistance services or, as appropriate, other health and human services, and with particular emphasis on overcoming barriers for underrepresented populations and rural populations.

Activity 3. Each state project should provide leadership in the coordination of activities among State agencies, in order to facilitate access to, provision of, and funding for, assistive technology devices and assistive technology services.

Activity 4. State projects should engage in the development and implementation of strategies to empower individuals with disabilities and their family members, guardians, advocates, and authorized representatives, to successfully advocate for increased access to, funding for, and provision of, assistive technology devices and assistive technology services, and to increase the participation, choice, and control of such individuals with disabilities and their family members, guardians, advocates, and authorized representatives in the selection and procurement of assistive technology devices and assistive technology services.

Activity 5. State projects will engage in the provision of outreach to underrepresented populations and rural populations, including identifying and assessing the needs of such populations, providing activities to increase the accessibility of services to such populations, training representatives of such populations to become service providers, and training staff of the consumer-responsive comprehensive statewide program of technology-related assistance to work with such populations.

Activity 6. State projects will engage in the development and implementation of strategies to ensure the timely acquisition and delivery of assistive technology devices and assistive technology services, particularly for children, unless the State demonstrates through the progress reports required under section 104 that significant progress has been made in the development and implementation of a consumer-responsive comprehensive statewide program of technology-related assistance, and that other systems change and advocacy activities will increase the likelihood that the program will accomplish the purposes described in section 2(b)(1).

Several components of the TATP that are designed to conduct such activities are described briefly here.

Policy Analysis

Texas currently provides numerous assistive technology services and devices for its citizens who have disabilities. Programs offered by the Texas Rehabilitation Commission, Texas Education Agency, Texas Commission for the Blind, and others assist individuals in accessing devices that increase their functional capabilities. Even so, there exist obstacles that impede efficient and timely service delivery to Texans with assistive technology needs. The TATP engages in policy analysis activities designed to effect systems change for providing a more efficient service delivery system.

Information and Referral

The TATP has developed a statewide Information and Referral (I&R) program, funded by the Texas Planning Council for Developmental Disabilities. Information is provided on a database of over 17,000 different assistive technology devices.

TATP publishes the *TATP Resource Guide to Assistive Technology for Consumers and Service Providers*, which is a directory of Texas assistive technology vendors and providers. The guide also lists national assistive technology resources and publications. In order to meet its mandate with regard to systems change, the TATP works closely with the Texas Information and Referral Project to ensure that existing I&R services across Texas are sufficiently well-versed on assistive technology to handle their incoming calls related to this subject.

Public Awareness

A basic premise of the TATP is that systems change occurs when people become better informed of their rights and of the services that exist for their benefit. The TATP participates in local, regional and statewide disability related activities to provide public awareness to ensure that all Texans have easy access to information about assistive technology devices and services. The TATP publishes a newsletter, the *TATP Focus*, which is available in English, Spanish, in Braille, or on tape.

Technical Assistance and Training

The TATP provides assistive technology technical assistance and training to help agencies and organizations comply with disability-related legislation. The TATP also provides technical assistance in the form of training activities that relate to the use of assistive technology in schools to promote IDEA, ADA, and Section 504 initiatives. A statewide Regional Consultation Network assists the TATP in its training activities, and the Peer-Professional Advocacy Network is charged with sharing assistive technology information among consumers, family members, and service providers.

Funding

One of the greatest challenges to persons with disabilities, their families, and service providers is accessing funds to purchase assistive technology devices and services. The TATP makes available *Funding Facts*, an Infosheet designed to provide information regarding existing funding sources that may be unknown to many. Numerous workshops on funding are held throughout Texas by TATP personnel.

Assistive Technology Use for Students with Disabilities

Before presenting a discussion of how assistive technology is used by students with disabilities, it would be helpful to define what is meant by terms related to assistive

technology. This is presented in the first section. Subsequent sections describe the use of assistive technology devices for students with particular disabling conditions.

Assistive Technology Terminology Defined

Two terms (i.e., assistive technology service and assistive technology device) related to assistive technology are defined in this section. Additionally, the term *auxiliary aid* is defined because it is becoming increasingly used to describe services and devices used to assist students. These include assistive technology services, assistive technology devices, and auxiliary aids.

Assistive Technology Service

According to federal guidelines, the term "assistive technology service" refers to any service that directly assists an individual with a disability in the selection, acquisition, or use of an assistive technology device. The term includes

- evaluating the needs of an individual with a disability, including a functional evaluation of the person in the individual's customary environment;
- purchasing, leasing, or otherwise providing for the acquisition of assistive technology devices by individuals with disabilities;
- selecting, designing, fitting, customizing, adapting, applying, maintaining, repairing, or replacing assistive technology devices;
- coordinating and using other therapies, interventions, or services with assistive technology devices, such as those associated with existing education and rehabilitation plans and programs;
- training or technical assistance for an individual with disabilities, or, where appropriate, the family of an individual with disabilities; and
- training or technical assistance for professionals (including individuals providing education and rehabilitation services), employers, or other individuals who provide services to employ, or are otherwise substantially involved in the major life functions of individuals with disabilities.

Assistive Technology Device

The term "assistive technology device" refers to any item, piece of equipment, or product system, whether acquired commercially, modified, or customized that is used to increase, maintain, or improve functional capabilities of individuals with disabilities.

Auxiliary Aid

An auxiliary aid is a service or device that allows a student to access information. Examples of the various types of auxiliary aids includes

- taped texts
- note takers
- interpreters
- student tutors
- television enlargers
- talking calculators
- electronic readers
- Braille calculators, printers or typewriters
- voice synthesizers
- assistance in filling out forms
- specialized gym equipment
- calculators or keyboards with large buttons
- reading device for library use
- raised-line drawing kits
- readers

According to the Office for Civil Rights (1991), institutions providing auxiliary learning aids to students need not provide the most sophisticated auxiliary aid available. Yet, the selected aid must meet the needs of the student and accomplish its stated purpose.

Specific Assistive Technology Devices for Student Use

Simply put, assistive technology allows students with disabilities access to what is inaccessible without such technology. In the last decade, Americans have seen a revolutionary increase in the availability of practical devices that have enabled users to do tasks more easily, more often, and/or with less effort. In the same way, assistive devices for individuals with disabilities have enjoyed a boon in development.

This section first presents the principles associated with matching assistive technology to the instructional setting demands and access barriers resulting from the student's disability. The remaining sections identify many devices, systems or techniques which assist individuals with disabilities both in the classroom and in their global environments (e.g., home, workplace). By no means does this overview cover the wide array of products and approaches which are on the market today. At a minimum, practitioners and consumers should be aware of the many possibilities for assistive technology solutions so they may begin to consider specific assistive technologies to meet their needs. For those who already have such knowledge, this section can describe specific assistive technologies for certain situations or identify some of the newest types of technology available.

Matching Assistive Technology to Instructional Setting Demands

The availability of assistive technology devices and services in the cooperative instructional environment often helps ensure that students with disabilities can be active participants in the learning process. Actually using assistive technology is the final step in a process that examines the instructional setting demands, targets related requisite abilities for meeting those demands, identifies disability-related barriers that impede the student's ability to meet the setting demands, and determines how the barriers can be overcome using solutions available along the assistive technology continuum.

Setting Demands

Setting demands relate to the instructional task at hand. For example, listening to a lecture is an instructional setting demand, as is reading a textbook or filling in a bubble answer sheet. Other setting demands include looking at overhead transparencies, watching a video, and taking notes. Considering setting demands is critical because students must bring to the settings requisite abilities for meeting the demands of the instruction.

Requisite Abilities

Each setting demands is accompanied by related requisite abilities. For example, listening to a lecture requires the ability to listen to the lecturer. The setting demand of reading standard textbooks requires several requisite abilities, among them visual acuity, decoding, and reading comprehension. Watching videos requires the student to see, hear, and perhaps take notes. For the vast majority of students, these requisites are present; but for some students with disabilities, the requisite abilities may be absent. In these cases, the disability-related barriers may impede the ability to meet the demands of the instructional setting, unless adaptations are made.

Barriers

When barriers are commonly discussed with regards to individuals with disabilities, it is usually in the context of architectural or attitudinal barriers. However, barriers can take a variety of forms; in this case, barriers are considered as disability-related obstacles that impede the ability to meet the demands of the instructional setting.

To illustrate, consider the case of the setting demand of reading a standard textbook. The requisite behaviors identified in the previous section included visual acuity, decoding, and reading comprehension. A student who is blind cannot access the printed word as it is presented in a standard textbook. The disability-related barrier, blindness, does not mean that the student cannot read the book, it simply means that the student cannot read the text in its current format. Thus, the obstacle is not insurmountable, it instead requires ingenuity to identify how the barrier can be overcome. As seen the in the next section, the solution to the obstacle can take the form of assistive technology.

Assistive Technology Solutions

When barriers or obstacles exist, there concurrently exists a need to problem-solve (i.e., derive a solution that will overcome the existing barrier). During problem-solving, participants consider a continuum of alternatives and select the one that is most appropriate for the given situation given the nature of the individual, the setting demands, and existing resources. For instance, a person with a mild hearing loss probably will not need expensive amplification devices in order to hear the lecturer. Perhaps simply having a seat in the front row will suffice. If so, then a "no-tech" solution is completely appropriate. If, however, the hearing loss is in the moderate range and some form of hearing amplification is in order, then a variety of solutions are available (e.g., infrared technology, FM amplifiers).

In similar fashion, a student who is blind needs some assistance reading standard textbooks. A "no tech" solution is to have someone read the textbook to the student. Such a solution may be problematic if the reader is unfamiliar with specialized vocabulary that appears in the text, and the solution does not allow for independence on the part of the student. Thus, a variety of technology solutions may be identified; ranging from the use of prerecorded publications (e.g., Books on Tape) to the use of scanners (i.e., devices that

mechanically "read" the text into a computer) and speech synthesizers (i.e., devices that mechanically read aloud the inputted text from the computer). The remaining sections provide an overview of solutions that exist for a variety of situations, both academic and personal.

These sections do not address every disability or cover every type of assistive technology. Nor do they address the important field of device fabrication that specifically meets an individual's need at work or at home. To comprehensively review assistive technology would take more space than warranted in this overview. For example, ABLEDATA (i.e., a computerized national database with information on disability-related consumer products) has information on over 15,000 commercially available products from more than 1,800 manufacturers.

The devices reviewed here range from simple "no-tech" solutions (e.g., printing letters on the palm to communicate with a person who is deaf-blind) to very sophisticated devices (e.g., computers that are activated by voice command). Devices and aids are categorized in this section by the type of disabilities potential users might have. (Note: Inclusion of a particular device in this material does not represent an endorsement of that product, nor does exclusion of a device imply any difficulty with the product.)

Assistive Technology for Computer Access

Computers can be very frightening for individuals who are not familiar with the new technologies involved. However, they do not need to be as complicated as many people believe since users do not have to know what makes the computer work. Once all the jargon is tossed aside, a computer system is not much more complicated than a television and video cassette recorder combination. Ever decreasing costs and incredible capacities to make work easier and play more fun, are making computers increasingly irresistible - and more difficult to avoid. And for individuals with disabilities, computers are the bridge to doing many things more easily or for the first time.

Computer access devices are available for the two most common computer operating systems: MS/DOS and Apple. MS/DOS is used on IBM and IBM compatible computers, while various Apple operating systems are used with Apple and Macintosh computer systems. While other computer systems exist, such as Commodore, there are few assistive or access devices for these machines. This section therefore concentrates exclusively on Apple/Macintosh and MS/DOS computers.

Adding adaptations to a computer depends on the needs of the user. Most individuals with disabilities need only minor modifications, if any, to be able to successfully use a computer. A small group of individuals with disabilities, however, need more involved, more sophisticated adaptations.

Creating a good fit between the user's needs and the technology available is essential if the user is going to be successful using a computer. The Texas Assistive Technology Partnership strongly encourages individuals who are considering the purchase of a computer system to obtain a comprehensive assessment of their abilities, preferences, and needs. It is also a good idea to consult with other users and with individuals who are knowledgeable about computers to obtain recommendations about the most appropriate computer system to purchase from among the many options available. The following discussions provide overviews of (a) personal computers, (b) keyboard enhancement mechanisms, (c) alternative input mechanisms, and (d) alternative output mechanisms.

Introduction To Personal Computers

Before discussing computer adaptations for individuals with disabilities, the following introduction to computers is provided in an effort to make the adaptations more understandable. Readers can use the accompanying illustration as a referent.

The *keyboard* is the part of the computer that looks and acts a lot like a typewriter. By depressing the keys, information and instructions are sent to the invisible "brains" of a computer.

The *computer monitor* is the television-type screen which allows computer users to see what they have typed or otherwise entered or "input". Monitors may be in black and white, a single color, or full color.

The *mouse* is another kind of *input* device which has one or more buttons on top of it. It is held by the hand on a desk top and is used to give instructions to the computer. As it is slid around on the desk top, the *cursor* on the *computer monitor* moves in the same way. By "clicking" the buttons on the mouse while the *cursor* is in certain places, the computer performs certain functions.

The *disk drive* is the part of a computer into which the *computer programs* are inserted to provide information or instructions to the computer. Internal disk drives are located inside the computer "box" and external disk drives are attached by cable to the computer.

The *central processing unit (CPU)* is the "brains" of the computer and is usually comprised of a single *computer chip* which controls everything else. The CPU is generally housed in the "box" in which the *hard drive, interface cards,* and other devices are installed, and to the outside of which are attached the *keyboard, printer* and other devices. (It should be noted that, as a colloquialism, many people have come to refer to the entire "box" as the CPU.)

The printer is an *output device* which is attached to a computer and which produces printed copies of text or graphics which have been entered *(input)* into the computer. Common types of printers include: dot matrix printers which produces text and graphics composed of many tiny dots of ink; daisy wheel printers which use typeface to make impressions through inked ribbons, like a typewriter; laser printers which produce text and graphics by a laser; inkjet printers which "spray" ink in the shapes desired; and braille printers which use a system of metal "pins" to produce braille print as raised dots on heavy paper.

Not shown on the picture are *computer programs* or *software*. *Computer programs* are a set of instructions, written in a language the computer understands, which allow the computer to perform a function or task. *Software* consists of computer programs which are stored on computer *disks* or *CD-ROM* and may contain games, instructional programs, word processing, data bases, spreadsheet, and a myriad of other types of programs. Software is also very often needed to adapt computer devices.

Keyboard Enhancement Mechanisms

With traditional computing, there are certain designated function keys such as "Shift," "Alt," and "Control," which, when held down together with another key, perform a certain function. For example, "Shift" and a letter produces a capital letter. Other keystroke combinations may be used to center a title or delete a word. Although these combinations ordinarily require two hands, with *latching devices* the keys can be pressed instead in sequence, for one-handed operation. Latching devices are available for both MS-DOS and Apple and come in software and mechanical applications.

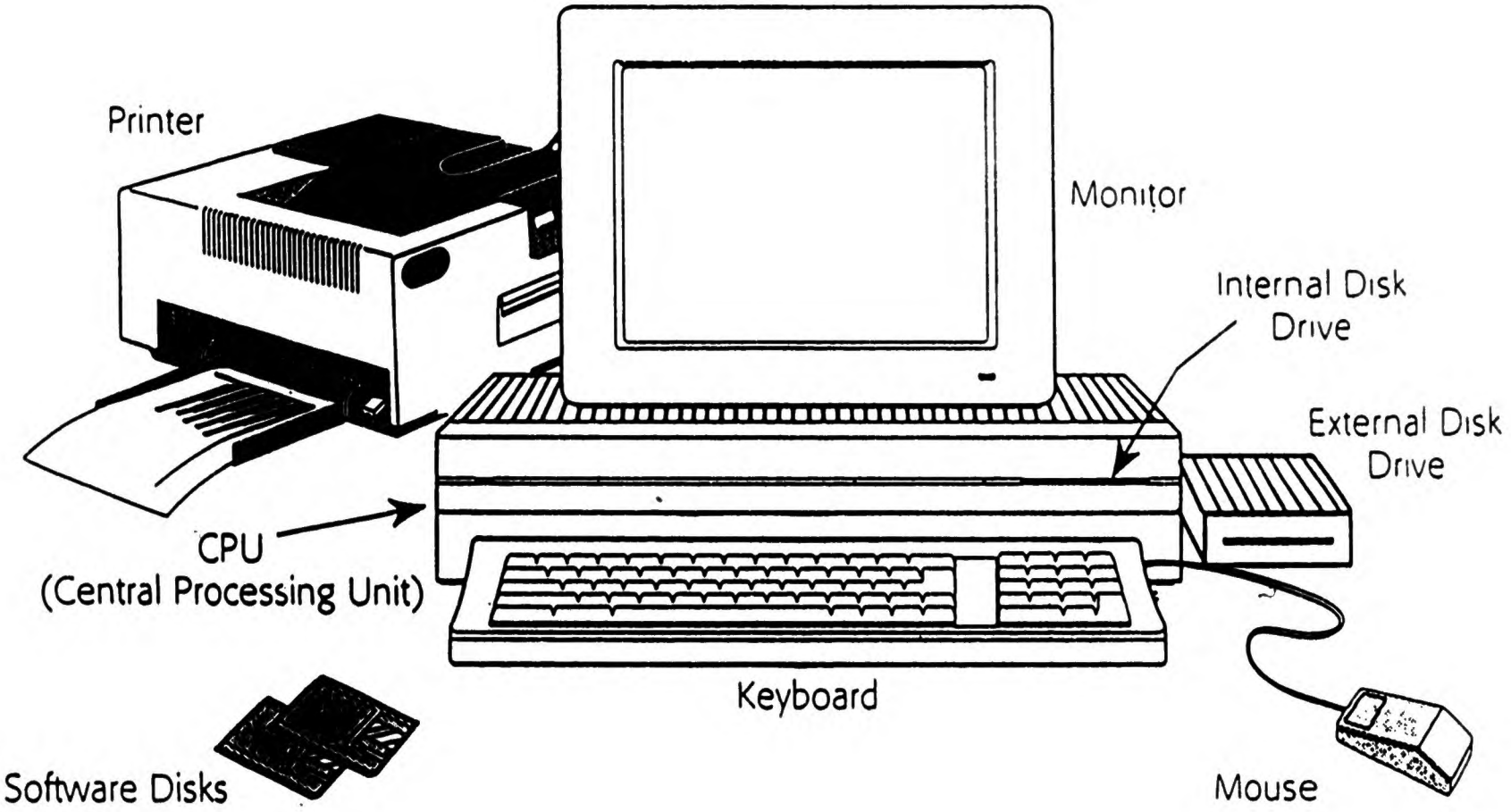

Figure 1. Components of a Computer

Keyguards fit over the keyboard and are usually attached with Velcro. They may be made with clear or opaque plastic and have holes over each key location. The keyguard prevents the user from inadvertently pressing more than one key at a time. Some keyguards come with mechanical key latches. Available in MS/DOS and Apple. ($100)

Moisture Guards and Keyboard Protectors are clear, flexible plastic covers that fit over a keyboard and protect them from dirt, dust, spills, or other foreign matter. Available in MS/DOS and Apple.

The *Adaptive Firmware Card* for Apple computers is probably the best known *keyboard interface* system. It enable various alternative input devices to be plugged into some Apple computers so that standard software can be run by people with various disabilities. *P.C. Serial Aid* is one brand of keyboard interface card for MS/DOS compatible computers, and *K-nex* is a brand used with the Macintosh computer.

Alternative Input Mechanisms

Mouthsticks, handsticks, and *headsticks* are used by individuals who have limited hand control. Mouthsticks are lightweight rods that have a soft tip for depressing keys on one end and a mouthpiece on the other end for holding it. Handsticks allow a person to push buttons with a stick when they have the ability for grasping but not for fine or finger movements. A headstick is usually mounted on a headband, with an angled rod that allows the user to see the keyboard and depress keys by lowering his/her head.

Word prediction programs are available in both MS/DOS and Apple. They are designed to save keystrokes by allowing a user to, for example, type "W" for the word "wonderful". The predictor program might suggest these options: 1. want; 2. water; 3. wish; 4. west; 5. weather. Then, by typing the second letter, "O", the predictor might suggest: 1. wonder; 2. wonderful; 3. won; 4. work; 5. worry. The user could then depress the "2" key and save six keystrokes and one space, since the predictor program advances one space at the end of a word. The program also advances two spaces after a period and will capitalize the next letter automatically.

The *Unicorn keyboard* is a programmable, extended membrane keyboard with 128 touch sensitive areas, or "keys", which are each almost one inch square. The areas can represent the traditional keys on a keyboard or be customized to meet the user's need. Any key or group of keys can be defined by the user to represent any string of characters up to 30 characters long. An adaptive firmware card or other means of keyboard interface is need to operate the Unicorn keyboard.

The *Touch screen* controls allow the user to enter words, draw graphics, compute math, and work puzzles and games by touching the screen. It is used in conjunction with an adaptive firmware card and can also allow scanning entry and speech output.

Headmaster is a *single switch keyboard modification*. It is a system that uses a headpointer on an Apple Macintosh computer (Mac) or an MS/DOS computer instead of the standard mouse and keyboard. An ultrasonic transmitting unit sits on top of the computer and sends signals to a headset the user wears. HeadMaster translates changes in the user's head position into changes in the cursor's position on the screen. Lightly puffing into a tube connected to the headset is equivalent to pressing the mouse button. When HeadMaster is used with ScreenTyper, a full keyboard is shown at the bottom of the screen. The user types in characters by pointing the cursor to the desired keyboard image and puffing into the tube.

A *Power Pad* is a 12 by 12 inch touch sensitive board which turns the Apple computer into a drawing, communication, and education tool. By using the Power Pad, children can learn to match colors, learn shapes, count, identify letters, and other pre-reading skills. Instead of using the standard computer keyboard, special software allows children to use bold, large print overlays that are placed over the Power Pad. The pad can be used to allow

children with disabilities to draw or to use the pad as a simple communication device. ($250-$400)

Some communication devices can also control computers. A *Light Talker*, for example, uses a light beam head pointer as an input device.

A *mouse* is another alternative input device for a computer. Most mice let you move a cursor on the screen to create graphics, specify points for data entry, rearrange text, and select menu commands. A mouse is a piece of hardware which usually requires a software program to operate. A mouse can save keystrokes for individuals who have difficulties with traditional keyboards. A *trackball* is an upside down mouse with the ball protruding from the center of a small box. The user moves the trackball manually to accomplish the same actions done by mice. A *footmouse* is similar to a trackball and is operated by foot movement. The base of the footmouse remains on the floor, and the cursor is moved by sliding the foot over the base in an up, down, left, right motion. A *joystick* can be used to function as a mouse. Often the units have a button on top and two on the side of the joystick that can be programmed to carry out a number of mouse-type functions or execute keyboard commands. ($50)

An *optical character recognition device* is a desktop reading system. A scanning device recognizes characters (letter, numbers, punctuation) from most types of printed text. Once the text is in computerized form, it can be loaded from the scanner into a computer system, where it can be manipulated by a word processor or displayed through a special output such as synthesized voice, refreshable braille, or braille printer. Depending on the scanning device used, the units can recognize most type styles including italics, underscoring, and boldface.

Braille Input Devices

Some Braille users may prefer Braille for computer input. A few of the options available are discussed below:

Braille note-taker -- Small, portable devices are available that allow Braille entry for taking notes. These devices have their own local storage and built-in text editors. Their input mechanism is a keyboard with six keys and a space bar which is used to enter either Grade I or Grade II Braille. In many cases, the information entered may be reviewed auditorily by having it spoken using a built-in speech synthesizer, the file may be transferred to a PC to be edited, or the file may be sent to a Braille printer for printing.

- What size is the portable Braille note-taker?
- How heavy is it?
- Does it have a battery or must it be connected to a power source? Is the battery rechargeable or replaceable? How long will the battery pack last? How is a low battery indicated?
- Is there nonvolatile memory so files that have been saved are not lost during battery failure?
- Can files from the PC be transferred to the note-taker device?
- Can files from the note-taker device be transferred to the PC?
- How easy is the file transfer mechanism?

- How large is the file storage capacity on the note-taker? Is it on micro-cassette, floppy disk, internal hard disk, or random access memory?

- Can the note-taker files be sent directly to a Braille printer?

- Does the device have built-in speech output capabilities?

- Are there any other functions the device can perform in addition to note-taking? For example, some devices offer date, time, or calculator functions in addition to word processing.

PC Braille input devices -- In addition to the portable Braille note-taking devices that can generate a file transfer to the PC, there are other Braille input devices designed to be connected to the PC for direct input. These devices may either replace the standard PC keyboard or be attached to the PC in addition to the keyboard. In addition, there are software packages available that will configure a PC keyboard so it can be used for Braille input. Once the software is activated, typically the home rows key become Braille dots 1 and 4 and the space bar becomes the chord key. Some packages allow both Grade I and Grade II Braille input in this manner. The software may be part of a package that is included with other Braille devices, such as a refreshable Braille display device, or it may be purchased separately.

- Can both the standard PC keyboard and the Braille input device be active? How easy is it to switch back and forth between the two?

- How is the device connected to the PC? serial port? keyboard connection? Is the proper port or connection available?

- If the standard PC keyboard is being used for Braille input, how easy is it to switch from Braille input to standard QWERTY keyboard input?

Optical Character Recognition (OCR)

Many students with disabilities benefit from the use of optical character recognition to convert print documents into a format usable to them. In some cases, there are OCR systems that can convert directly from print to spoken output using a speech synthesizer. In other cases, the OCR can convert from print to a PC file that may be read using a screen reader package and speech synthesizer, or by using a refreshable Braille display or a large print display device. Once the print material has been converted to a standard PC file, the full range of accommodation tools can be used to give the individual the preferred mode of access to the information. Several considerations for OCR follow.

Quality of printed material to be scanned -- Some OCR devices will adequately recognize only letter quality printed text. Others are able to scan and recognize draft quality text or poor quality copies of reproduced materials. At this time, optical character recognition of handwritten materials is not commercially available.

Format of printed material to be scanned -- Some OCR devices can only scan and recognize materials on a standard sized page that is printed in portrait format. Other OCR devices can also recognize materials that are printed landscape or sideways on a page. There are also differences in how different scanning devices are able to handle multi-column text. Prior to deciding on an OCR device, conduct a test scan and recognition of materials that are of the format and quality the user will typically be scanning.

Stand-alone speech output -- Some OCRs can give speech output of the printed material without actually being connected to a PC at all.

- Is there a need for speech output of printed text in a stand-alone mode versus through the PC?

Choice of scanners -- Some OCR devices are able to work with a number of different scanner platforms. Others are limited to one or two choices of possible scanners. If the department has already purchased scanners in the past and just needs to optimize the OCR capabilities for the individual, this may be a consideration.

User interface -- The OCR devices that are being marketed specifically for use by individuals who are blind have ensured that their user interface is not dependent on the user responding to visual cues on the scanner. Some of the OCR devices that are not specifically marketed to users with visual impairments may also be usable, but this should be carefully examined prior to purchase. In addition, the OCR devices specifically marketed to users with visual impairments usually have the user interface specifically designed to easily work with screen reader packages and speech synthesizers to give spoken output to the user.

Other considerations and questions :

- Does the scanner have an automatic page feed for multi-paged documents?
- How well can the scanner handle bound documents? Is the recognition satisfactory as the print nears the bound edge?
- Can several pages be scanned before the recognition effort begins, or must each section or page be scanned and recognized before moving on? In some cases, the OCR devices that allow several pages to be scanned before recognition occurs can save individuals time by allowing them to go on to another task while the recognition is occurring.
- How long does it take for a typical page to be scanned?
- How long does it take for a typical page to be recognized?
- How many pages can be scanned in one session? Is there a memory buffer limitation?
- Is portability of the unit a factor?

Speech Recognition

Speech input is a direct selection alternative that can be successfully used by many individuals who are unable to access the keyboard at all or have very limited use of the keyboard. As each word is spoken clearly and distinctly, it is recognized and presented on the computer screen. There are both low-end and high-end speech recognition packages available. Currently, both the low-end and the high-end solutions require a distinct pause between each word spoken for the speech recognition to be accurate. Current technology does not support accurate recognition at a normal conversational rate of speech.

The low-end solutions have a limited vocabulary set and each word must be specifically "trained" by the individual user. Several of the speech recognition packages have predefined overlays of commands that support rapid vocabulary training for use with popular word processing, spreadsheet, and database application packages. Within the limit of the active vocabulary at one time, the user can add words and their associated keystrokes

to the available vocabulary set. To make the functional vocabulary larger and run faster, some packages organize the vocabulary sets to correspond to the commands needed in a particular portion of the application.

The speech recognition system operates faster because it does not compare speech patterns of words that will never be used in that application module. The vocabulary training consists of going through a menu of the words and speaking each word three or four times to build a voice pattern for that word. These systems can be very effectively used in situations where a small vocabulary is needed, such as entering inventory codes into a database or speaking the commands within an application package. The inventory codes could be spoken as digits and letters. In some cases, the speech input may be much more error free than keying long alphanumeric strings, regardless of whether the individual has a disability. The high-end solution has a 30,000 word dictionary and the user can add other words and terms as needed. A user can successfully start using this system after specifically training only 10 to 40 words. The system continues to improve its match to the user's voice and "self-train" as the individual user speaks into the system and corrects the word selections the system displays.

Commands, typically consisting of a phrase, can be added to the dictionary and entered verbally. On the high-end system, typing speeds up to 35 words per minute can be achieved by experienced users who trained the system to their voice patterns. Individuals with significantly altered, but consistent, speech patterns can successfully train the speech recognition system to their voice. This is true for both the low-end and the high-end speech recognition systems.

Using the high-end system, the individual may have a significantly lower recognition rate initially to each word compared to the "standard" pronunciation dictionary. As users make corrections and continues to use the system, it will continue to self-train itself to their voice pattern just as it does with users with more easily understood voice patterns. Once trained, the speech recognition system can recognize the vocal commands of a user with a speech impairment with greater accuracy than individual listeners. The key to the successful use of the system is speech consistency. If an individual's voice changes significantly over the course of the day because of fatigue, several speech recognition packages offer the capability of storing multiple voice patterns. As the error rate for one voice pattern becomes unacceptable, the user would switch to their second "fatigued" voice pattern.

General Considerations

- What application programs will the user be using? Does the speech recognition package have any predefined vocabulary overlays for the commands needed by the application packages?
- What size vocabulary is needed?
- How easy is it to add words to the vocabulary set?
- Will the package allow several speech recognition templates to be stored for more than one voice, or more than one user?
- Does the user have consistent speech?
- How quickly does the user's voice tire?

Microphone Considerations

- How much background noise can be present without adversely affecting the speech recognition?
- Can the microphone be mounted so the user does not have to wear it or be tethered to the PC by a cord? Many wheelchair users who may not be able to independently put on and remove a headset microphone would like viable alternatives that will allow them freedom to leave the PC without assistance from another person. Is there a cordless microphone that can be used?
- Is there a voice command for turning the microphone on and off?
- How much disk storage is needed by the software? How much is needed by other application packages?
- Are the PC internal speeds and the speed needed by the speech recognition board compatible? What speed PC is required for the speech system to work? What is the maximum allowable PC speed at which the board functions properly? If the speech recognition board needs a slower clock speed than the PC normally runs, can the PC clock speed be slowed down? Most PCs have a utility for doing this, although it may be difficult to find the specific command needed in the user's manual.

Combinations

Many users with visual impairments may benefit greatly from using various combinations of the devices previously discussed in this section.

Large print and speech output -- Many individuals with low vision are able to read large format displays, but may not be able to read even this enlarged text over long periods of time without significant eye strain and fatigue. Adding speech output may significantly lengthen the time they could productively work on a given task. Many users will use speech output for reviewing material for content and switch to visual display for final editing or when the speech output is unclear or difficult to understand. For some individuals with a degenerative eye condition, it may be helpful to add speech output while there is still some degree of usable vision to help in the transition from dealing with the screen visually to dealing with it auditorily.

Speech and refreshable Braille -- Many individuals who are blind may benefit from using a combination of speech output and a refreshable Braille display. Speech may be the preferred means for reviewing text and the refreshable Braille for doing the final edit or reviewing items such as acronyms that may not convert well to speech output. Others may find speech output the preferred mode in one application and refreshable Braille in another. For instance, many programming languages use contracted words and numerous punctuation symbols that may be easier to understand using refreshable Braille. On the other hand, word processing tasks may proceed more quickly using speech output rather than having to constantly switch hands from the keyboard to the Braille display to type and review text. The key to all the accommodation solutions discussed is to involve the individual user throughout the decision process.

Other Alternative Inputs

There are several additional alternative input options for individuals that have voluntary muscle control over some part of their body. Some of these are described below:

- Morse code input, an encoding system, utilizes Morse code with added features to make it more adaptable for use with a PC.

Considerations

Mouse needs - If the application is dependent on the use of a mouse, are there keystroke equivalents to accomplish mouse movements? If so, can the Morse code system execute these keystroke equivalents?

Switch input -- Some users are able to control two keys or switches with one key being for dots and the other for dashes. Others need a package that will allow both dots and dashes to be generated from a single key or switch.

- Can a single key or dual key switch be used with the system?
- Can keys on the PC keyboard be used as the input mechanism?
- Has the Morse code set been expanded to include the extra keys on the PC keyboard? Does it have all the keys needed?
- Does the package allow for macros to be added?
- What input speeds can be achieved once the user has mastered the Morse code patterns?
- How does the system handle code errors?
- Is there a training component to the system to help the user master the Morse code?

- Infrared pointing devices consist of a receiver, a reflector, and associated software that may be used in place of a keyboard. The individual points the reflector at a picture of the keyboard being overlaid on the computer screen by the software used with the pointing device. Each letter or word can be selected directly and then appears on the computer screen.
  - If the application packages being used are dependent on the use of a mouse, are there keystroke equivalents to accomplish mouse movements? If so, can infrared pointing systems execute these keystroke equivalents?
  - Can the size of the selection keyboard displayed on the screen be changed?
  - Is the amount of time the individual must stay focused on the desired key adjustable?
  - How is the pointer device attached or connected to the user?
- Sip and puff systems are one of the popular interfaces for scanning systems. Other types of interfaces that may be used with scanning systems include muscle switches and joystick controls. The choice of interface device depends primarily on the users and their preferred method of control. A sip and puff interface allows the user to scan with one action, such as sip, and select with the other action, such as puff. If users are scanning a set of characters, they would sip to keep scanning; and then when they were at the character desired, puff to select the character. Many of the systems that can

utilize a sip and puff interface allow users to choose which action they want to be used for scanning and which for selection. Muscle switches employ the same principle with the voluntary tightening or loosening of a muscle being the scan or select controls. Switches can be set up for detecting eye blink or eyebrow twitch in addition to other muscle movements such as hand or finger movements. Joystick controls may be used by an individual with adequate control of finger movement or can be controlled by chin movements.

- If the application packages are dependent on the use of a mouse, are there keystroke equivalents to accomplish mouse movements? If so, can the scanning interface chosen execute these keystroke equivalents?
- Can the scanning rate be adjusted?
- How is the user attached or connected to the interface device? Is the interface device attached to the computer? Can the user move away from the computer and come back to the interface without intervention from another person?
- How large is the scanner the user must see? How easily can it be repositioned?
- Can the groupings being presented be changed? How easily?
- Can macros be added to the system? Or can an additional macro package be used in conjunction with the scanning package?

- Eye scanning packages are also now available that operate similar to a pointer system but do not require anything to be attached to or connected to the user. A camera focuses on the individual's eye and tracks the movements of the eye. As the person focuses on a screen of choices or a menu seen on a monitor, the system will display the selection on the PC screen. An individual who has no voluntary control of muscle movement at all, but can still focus their eyes, can control a computer.

Alternative Output Mechanisms

There are two types of *large print displays* which enlarge images on a computer monitor for individuals with low vision. The lower technology version enlarges type on the computer monitor screen by placing a magnifying lens over the screen. The second type uses computer software programs to enlarge type and graphics displays on the screen: some programs take a section of the screen and enlarge it (i.e.: the first three words in the first three lines will be enlarged); others take a portion of the text (i.e.: a sentence) and enlarge it on the screen; still others may be able to take a normal screen with white lettering on a dark background and reverse the image to dark lettering on a white background. Both styles allow users with limited vision to see their work on the screen. When selecting magnification devices for computer access, the Clearinghouse on Computer Accommodations (COCA) (1991) offers several issues for consideration. We provide them here for easy reference, and then we presnt alternative information on Braille output devices..

Magnified Display of Computer Screen Considerations

Level of Magnification

There are several software packages available that will enlarge the characters presented on the PC monitor from 2x to 8x. A few software packages provide levels of magnification up to 16x. There are also hardware based options that provide magnification levels from 2x to 16x. As the level of magnification used is increased, the numbers of characters that may be seen on the screen at any one time decreases.

- Does the magnification package work in support of other PC application packages or is it a stand-alone large text word processing package only?
- As characters scroll off the screen, is it done a letter at a time or a word at a time?

Font Styles and Choices

In addition to the size of the character being presented, the actual formation of the character is important. Some packages offer font or style choices, others do not.

- When looking at the enlarged character, does it have a clean line or a staggered, stair-step appearance? Which format is easier to read by the user with visual impairments?
- Are the characters uniformly shaped and spaced?
- How is the cursor presented? Is it easily found in a body of text or does it "get lost" easily? Various packages present the cursor as an enlarged bar, a blinking bar, an arrow or other special character taking the place of the letter at the cursor position, or a reverse video block with the letter in that position still visible.

Text or Graphics or Both

- In both the software and the hardware based products, configurations are possible that will support only text based information or text and graphics.
- For text only packages, what does it do if it encounters graphics? Does it revert to normal 1x size for graphics? Or does it lock the program or do something else?

Color

- Some packages fully support color, others give the user limited color choices, and others will present information in black and white only, regardless of the colors selected in the application program being used.
- Is color important to the user?
- Are there any special considerations such as color perception problems, a preference for reverse video presentation, a need for high or low levels of contrast, or adjustments needed for brightness?
- Will the color setting options of the enlargement package override application package color settings, conflict with them, or default to the application package color selections?

Screen Review

- Many of the enlargement packages, both hardware and software, allow for a screen-review mode that gives the user the ability to "wander" around the screen without actually moving the application cursor. This is particularly important when using application packages that present a full screen of information, but do not allow the application cursor to be moved over the entire screen (e.g. instructional screens that keep the instructions "protected" and allow input and cursor movement in a small block).

- How easy is it to move into the "review" mode?

- How is the review mode controlled - by arrow keys, other keys, a mouse, by other means?

- To review a large section of text, does the user need to constantly hold down a key or can the package continue scrolling across lines and move down the screen by itself?

- As characters scroll off the screen, is it done a letter at a time or a word at a time? Is it a smooth motion or a "jump" on the screen?

- When exiting the review mode, is the user returned directly to the cursor position?

- Does the review mode provide a means for the user to spatially orient the "window" of information currently being reviewed relative to the entire screen display?

- Can the screen output directed to a hardware enlargement product also be directed to a standard PC screen? Alternately or simultaneously? Is simultaneous presentation needed to help with system troubleshooting if problems are encountered?

- Some software application programs do not use the system cursor, but write directly to the screen to increase the speed of the program. The actual system cursor is then "parked" off the screen. Some of the accommodation packages work by querying the system cursor for the last updated screen position. If this combination exists, then either the application program needs to be configurable to use the system cursor instead of the software cursor, or the accommodation package needs to be configurable to track the software cursor instead of the system cursor.

Magnified Display of Hard-Copy Material

Some of the considerations mentioned above, such as the level of magnification needed, the need for text or graphics to be magnified, and the need for color, apply when discussing the need to see existing print or hard-copy materials in an enlarged format.

Light requirements -- Some closed circuit magnification devices require that more light be directed at the hard-copy than others. This can be an important consideration for an individual with a light sensitivity problem. The brightness and positioning of the room lights may also need to be taken into consideration.

Portability -- Several of the closed circuit magnification devices are quite large and not easily transportable. There are also a few small devices that can be used with a small screen when traveling and then attached to a larger screen in the office.

Orientation -- Some systems are able to "flip" or re-orient the image being magnified on the screen. This is helpful when reading materials that have different print orientation on the same page, such as a flier that is fully opened or a document that is too large and must be flipped and viewed in segments.

Reverse video -- Some systems are able to present the magnified image in reverse video so it is white letters on a black background rather than the more typical black letters on a white background. There is a strong preference for reverse video by some individuals.

Viewing table -- Some magnification systems provide a manual or an automatic viewing table or platform for the hard-copy materials to be placed on, others do not. Does the platform have a way to secure the hard-copy materials? Is manual movement too uneven and jerky to provide easy reading of the material in enlarged format?

For an automatic viewing table:

- What are the control options available -- joy stick? foot pedal? mouse?
- Automatic return at the end of the line?
- Variable speed adjustment for the rate of movement?
- Ability to change the margins easily?

Enlargement of Computer Generated and Hard-Copy Material Combinations

Some magnification systems can be used for both viewing what is on the computer screen and for viewing hard-copy materials being magnified by a special camera. Some of these systems will allow the user to toggle back and forth between computer input and hard-copy input being seen on the same monitor. Other systems will allow input from both the computer and the magnification camera to be seen simultaneously in enlarged format on the same screen. This is referred to as "split-screen" mode.

- Does magnified hard-copy material need to be compared with magnified computer display information (e.g. reading a letter received and writing the reply)?
- Does the user prefer seeing the two outputs on the same screen or would two separate screens side-by-side be preferred?
- Can the entire screen be alternately set to computer generated enlargement and hard-copy enlargement?
- How easily can the mode of use be changed?
- In split-screen mode, can the user select how much of the screen is devoted to each, or is this preset?

Braille Devices

Prior to beginning the more technical description of Braille device alternatives, a short discussion of the use of Braille may be helpful. As mentioned in Section II, although many people assume all individuals who are blind know Braille and are proficient Braille readers, this is not the case. Only about 10 percent of the adult blind population in the U.S. are Braille readers. Many people who have lost their vision later in life may never learn to read Braille or may never achieve a level of proficiency with Braille that would enable them to easily access information in this format. Some medical conditions that may

eventually contribute to blindness also cause sensory deficits in the fingers that prohibit the individual from being able to discriminate the Braille dots well enough to read Brailled materials. For individuals who are proficient Braille readers, Braille still may not be the format of choice for all materials. For instance, a college level dictionary may require several bookshelves to store the numerous volumes of 3" binders once it has been printed in Braille. Each page of printed text will roughly translate to three pages of Braille printed text. Standard Braille paper typically holds only 24 lines per page and 40 cells, or characters, per line. Many people also do not realize that there is not a single version of Braille.

There are several different types of Braille that are used, depending on the subject matter being discussed. The Nemeth code Braille used for mathematics is different from the Braille used for standard text. Some individuals may be proficient in one of the Braille codes, but not necessarily in them all. Even when referring to the standardly used Braille for reading text materials, the individual may prefer what is referred to as Grade II Braille over Grade I Braille. Grade I Braille refers to a direct translation, letter for letter, of printed English text into a 6 dot Braille character. Special Braille characters are used to indicate capitalization and numbers. Grade II Braille is a shorthand version of Grade I Braille. Grade II uses contractions for commonly used letter combinations such as "tion" or "th." For example, the word "nation" is formed by using the letter "n" and "a" followed by the single cell contraction for "tion." In Grade II Braille the letter combination "tion" would be represented by a single Braille cell rather than by four Braille cells. This is one simple example.

Grade II Braille translation rules are quite complex. In addition, Braille text typically follows different formatting rules than printed text. For example, most Braille paragraphs are indented only two spaces and no lines are skipped between paragraphs. These Braille II contractions and format differences assist the user in reading faster and reducing the volume of printed Braille output.

To further compound our discussion of Braille, there is also a computer Braille version and a newer 8 dot computer Braille. Computer Braille includes new Braille symbols used to represent the special characters unique to the computer. For example, a computer generated carriage return is represented by two cells which indicate a "control M" which is the computer code for a carriage return. The 8 dot Braille is gaining in popularity among Braille reading computer users because it allows special character attributes such as uppercase or bold to be identified in the same cell as the letter itself. This is particularly popular with computer programmers working with programming languages that are case sensitive. The same word written in uppercase letters versus lowercase letters may not be understood by the computer at all or may actually execute a different command from what was intended. Now that there is a basic understanding of a few of the issues and complexities involved when referring to Braille, some of the technical considerations for Braille output devices will be addressed.

Braille Printers/ Embossers Considerations

Speed -- Speed of the print output is a primary consideration for many users and also one of the primary determinants of the price of the Braille printer. Many of the printers considered to be a personal Braille printer average 20-40 characters per second (cps). This is significantly lower than the speeds most computer users are accustomed to with standard text printers. There are also medium speed and high speed Braille printers available. The price for printers that produce 120-170 cps is significantly higher than the personal Braille printer. High speed Braille printers typically are used in an in-house Braille production site for a number of users or for individuals having a unique need for a large volume of material to be Brailled on a consistent basis.

Print quality -- The formation of the Braille character is different from printer to printer. Prior to purchasing a Braille printer, users should obtain for review a sample of text produced on that printer. Some Braille readers may be more comfortable with the Braille produced from one model than another.

Noise level -- Braille printers can be quite noisy and may be disruptive in some work settings if proper noise abatement is not planned. Many Braille printers have a sound screen of some kind, but an additional noise hood may be useful.

Paper -- Braille printers usually use a heavier weight paper than standard printers. The heavier weight paper holds the dots longer, even after being read several times or put into a binder with other pages of print. There are several weights and sizes of Braille paper available. When buying a Braille printer, be sure to ask the proper size and weight of paper that should be used. Some Braille printers can use standard weight form feed paper for draft printing. This lighter weight paper will not hold the dots for very long like the heavier weight Braille paper. Using an improper weight of paper can cause some printers to jam. Another consideration with Braille paper is that it is less easily obtained than standard printer paper. Some paper should be ordered when the printer is initially ordered, and then proper stocks of Braille paper should be kept on hand based on the usage level.

Portability -- Most Braille printers are rather heavy and, therefore, not very portable. There are a few smaller Braille printers that may not be adequate for every day office use, but may offer a more portable solution for travel situations. There are also Braille printers available that are designed to be easily packed for travel or shipment even though they are still rather heavy.

Printer buffer capacity -- Depending on the nature of the materials that will typically be printed on the Braille printer, the size of the print buffer may be an issue. Most Braille printers have a relatively small printer buffer. Many of the PCs in use today can send information at a much higher rate of speed than the printer can produce output. This may result in the printer being unable to print the entire document if it is lengthy. This problem can easily be solved by adding a printer buffer between the PC and the Braille printer. The buffer would hold the printer file information and feed it to the Braille printer as it is ready to accept it, just like it would work with a standard text printer.

Maintenance -- Braille printers, like any other mechanical device, can develop problems and should be covered by a maintenance contract. The return or repair policy should be looked at carefully to determine what type of maintenance is appropriate. The availability of a loaner printer and the estimated time for repair should be investigated, because many facilities may have only the one Braille printer available.

Printer status -- As with standard text printers, the printer status needs to be conveyed to the user and the user needs to be able to direct the printer to change the status (e.g. off line to on line, form feed, line feed).

- How is the status communicated to the user? Braille, spoken message, tones?
- How does the user change the status? Toggle switches, software direction, control keypad?
- Are status messages displayed in a format a sighted user also could understand?

Graphic output -- Some Braille printers are able to provide a tactile graphic drawing capability. These tactile graphics usually are rather simple line drawings without a great deal of detail. For some individuals, this feature may be important.

- How easy is it to convert the printer from printing Braille text to a tactile graphic?
- How difficult is it to get the PC file into the proper format for producing a tactile graphic?

Connection to the PC -- Some Braille printers allow either a parallel or a serial connection to the PC. Others are specifically one or the other, but do not allow the user a choice. Before purchasing the printer, users should determine that the proper port needed is available on the PC. The proper cables with the correct connectors should also be purchased.

Other considerations -- Some individuals may need to have both a text printer and a Braille printer attached to their PC. Many Braille users have a text printer sharing the PC printer port with the Braille printer using a switch box. This enables them to print text copy for dissemination to sighted individuals and Braille copy for their own use.

Braille Translation

Prior to a file being sent to the Braille printer to be produced in Braille, the file needs to be translated into Braille. Several important Braille translation considerations follow.

File format -- Software Braille translation packages typically need the file to be translated to be stored as an ASCII text file. Because most of the word processing packages used in offices today have the capability to save a file in ASCII format, this may not present any difficulties. Some Braille translation packages are available that can translate files directly from the word processing format of several commercially available word processing packages to Braille without requiring the intermediate step of converting the file to an ASCII text file.

Software or hardware translation -- In the past, all Braille translation was software-based. Now there is also a hardware-based option for Braille translation. The hardware-based Braille translation device may offer a relatively easy Braille translation solution in both PC and non-PC computer environments.

Features -- Some Braille translation packages offer a number of different options to customize the Braille document printing. Depending on the types of documents being converted to Braille, the individual may or may not need all the customization features offered. In some cases, purchasing a more limited, but easier to learn and use, package may offer an advantage to the individual.

Document conversion and Braille familiarity -- The choice of Braille translation devices may depend on whether the person actually translating and producing the Braille document is a Braille reader. In some cases, the document is being produced in Braille by a sighted, non-Braille reader as a service of that organization serving clients that are Braille readers. An example would be production of a Braille version of a training manual or the program for an agency-wide meeting. The non-Braille reader will not be familiar with all the complex rules for Braille translation and probably will need a simple-to-use package that will produce acceptable Grade I and Grade II Braille without significant user customization.

Refreshable Braille Display

In addition to printed Braille output, there is also the capability for a refreshable Braille display of computer screen contents. The refreshable Braille display consists of a row(s) of Braille cells. Movable pins go up and down in each cell to change the dots used to form the changing Braille characters. This capability allows a Braille reader to access the information being displayed on the screen in a more dynamic manner than is possible by reading only printed Braille output. Several important issues are provided for the reader's consideration.

Number of cells -- Refreshable Braille devices may be purchased in configurations ranging from 20 cells to 80 cells, providing a dynamic window of screen contents that is 20, 40, or 80 characters long. Depending on the nature of the work being done, some individuals may need the full 80 cell display that would allow them to easily read across the entire computer screen without having to perform any additional manipulations. Other individuals may find a 20 or 40 cell Braille display to be adequate. The price of refreshable Braille displays rises appreciably as the number of Braille cells is increased.

6 dot Braille versus 8 dot Braille -- In addition to determining the number of Braille cells needed, the user must determine whether a 6 dot Braille format or an 8 dot Braille format is preferred. As mentioned previously, the 8 dot Braille format may have several advantages for many individuals once they have adjusted to reading the new 8 dot format.

Cell formation -- The formation of the Braille cell and how it is presented may be different on various brands of refreshable Braille devices. This can be due to the way the pins move and change, the spacing of the pins, or the spacing of the cells. One device may form Braille characters that may be easier for the user to read than another device.

Cursor location -- Refreshable Braille devices vary in how the location of the application cursor is displayed. In some cases, the cell where the cursor is located is indicated by all dots being raised. This would then "hide" the letter being represented in that cell. In other cases, the cursor is indicated by the pins of that cell constantly going up and down. This allows the user to determine the letter in that cell and know the cursor location, but may contribute to earlier wear on the pins. With 8 dot Braille, the cursor may be indicated by one of the additional 2 dots present.

Review mode -- Most refreshable Braille displays give the user a capability to review the screen contents without having to actually move the application cursor. This is particularly needed when screens contain protected areas that do not allow the application cursor to be moved into a certain location. In many cases, screen status information may be in one of these protected areas and needs to be accessed. A review mode provides this capability and is also important when writing long documents. The user may need to read and review material already written before continuing the composition of new material.

- How easy is it to move in and out of the review mode?

- In non-protected areas of the screen, is there a mechanism for moving the application cursor to the area being reviewed at that point?

Redundant visual notification -- Many refreshable Braille displays have a method of visually indicating the screen information being displayed in Braille format on the refreshable Braille display. This is particularly useful for any sighted individual that may need to review text with the individual using the refreshable Braille display. The sighted individual then knows what information is being presented on the Braille display and then

can be sure they are both reading the same thing. The visual notification can take several forms. Some systems have an external device that will display in text format what is being displayed in Braille. Others will indicate on the computer screen, by reverse video or a blinking bar, the section of screen contents being displayed in Braille on the refreshable Braille display.

Screen Reader Systems

Many students with visual impairments can access the information shown on a computer screen by listening to the screen contents being spoken instead of reading the visual output being displayed. This screen reading capability typically consists of a combination of a speech synthesizer working together with a screen reader package. The screen reader portion of the system is the software that allows the individual to direct what portion of the screen should be sent to the synthesizer. The speech synthesizer is the hardware device that converts the ASCII character code of the selected words and paragraphs into spoken output. In most shared office settings, individuals using synthesized speech to access their computers will wear headphones to ensure privacy and minimize disruption.

Speech Synthesizer

Speech synthesizers differ primarily in voice quality, size, and price.

Speech quality-- Some speech synthesizers have a very monotone and mechanical sounding voice output, while others have a more modulating and human sounding voice. Initially, the more human sounding voice may be more easily understood. Within a short period of time, however, the less human sounding speech synthesizers can also be readily understood by most listeners. The quality of speech output needed by the individual user is influenced by several factors.

- How often and for what length of time is the person going to be using synthetic speech to access their computer each day?

- How familiar is the information that the person will be listening to? Is it routine or does it cover a wide range of unfamiliar topics?

- Does the individual have any hearing loss that would make a certain synthesizer or voice much more understandable than another?

Speech buffer -- Some synthesizers store a "buffer" of information before they speak. In some cases this will result in several lines of text being spoken even after the "speech off" command has been given. For some individuals, this does not pose a problem; for others, it is one of the primary considerations in their choice of synthesizers.

- If the synthesizer buffers the text to be spoken, is there an option to allow the user to empty the buffer and have the speech output stopped quickly?

Speech rate -- Most speech synthesizers allow the user to change the speed of the spoken output by using their screen reader software. Some synthesizers have a broader range of possible speech speeds than others. For experienced users, being able to adjust the rate to a very fast pace enables them to auditorily scan a document rapidly as they listen for key words or phrases to indicate they have found the desired portion of text. To listen to the particular segment located by auditorily scanning, the rate of speech output is reduced.

Internal or external synthesizer -- Speech synthesizers may either be a board placed inside the PC (internal) or a separate piece of equipment cabled to the PC (external). The availability of a board slot for an internal speech synthesizer or the appropriate parallel or serial port for an external speech synthesizer may play a role in the final decision of which synthesizer should be purchased. There are some laptop PCs with internal speech boards available for individuals who need that level of portability.

For hardware configuration and software compatibility considerations, see the "General Hardware Configuration and Software Compatibility Considerations" listed at the beginning of this appendix.

Screen Reader Software

In addition to the synthesizer considerations listed above, there are several factors to be considered when choosing the screen reader software that will direct output to the speech synthesizer. Because there are several screen reader packages to choose from, this can often be one of the toughest choices for a computer user who has a visual impairment. Most of the commonly used screen reader packages being used in offices are packages that work with standard PC application software. In the past, many of the screen reader programs were self-contained word processing programs. These programs limited users in their ability to exchange information with their co-workers in an office setting. Now, there are many screen reader packages available that work in conjunction with PC application packages to give speech output. Many screen reader packages offer similar capabilities in terms of being able to direct output to the synthesizer a letter at a time, a word at a time, a specific line, or a screen at a time. Although there may be differences in the actual features of each screen reader package, one of the biggest differences is in how these capabilities are controlled and accessed by the user through the speech control keys. Several considerations apply.

Application package being used -- One of the primary considerations in choosing a screen reader package is the application packages the screen reader package will be used with. In most offices, everyone is using the same application software so that files and information can be easily exchanged. In most cases, individuals with a disability will receive the greatest benefit from their accommodation software if they are able to continue to use the same application packages as their co-workers. Knowing the application packages being used will help determine which accommodation features are important. The screen reader package chosen should be the one that has the features necessary to allow it to work best with the application software being used in the office. Some of the things to know about the application packages are:

- What keys on the keyboard are used to control the application package?
- Is the application software word processing, spreadsheet, database, communications, terminal emulation, or a special program?
- Are any of the application packages or systems interface packages graphic- based rather than text-based?
- Screen reader packages work well with most text-based packages, but they may not work at all with graphic-based packages. Some application packages allow the user to select text or graphics mode.

Synthesizers supported -- Not all screen readers will support all of the speech synthesizers currently available. Before purchasing the screen reader software, users need to know

which synthesizer they anticipate using. Once this decision has been narrowed to one or two acceptable options, the screen reader manufacturers can easily confirm if their package will work with that particular synthesizer. The screen reader packages often have different files that must be installed in the setup process, depending on which synthesizer it will be working with. This is similar to other PC software that needs to be properly configured to the type of printer being used with the software.

Speech control keys -- Another consideration is which keys are used to control output being sent to the speech synthesizer.

- Are the function keys used for screen reader control? Some packages use the function keys on the standard keyboard. This may cause some initial confusion if the application packages being used by the individual also use the same function keys. In most cases, the screen reader package gives the user the ability to remap the keys and develop alternatives to using the function keys. The drawback then is that the manual no longer matches the users' key combinations for commands. The screen reader packages also have methods to "share" the function keys with the application package. The user may have to hit a key that directs the screen reader application to ignore the next keystroke and pass it through to the application program. In essence, this option would just add a few keystrokes to execute application package commands, but otherwise not interfere.

- Are standard keyboard keys other than the function keys used for screen reader control? Several screen reader packages use special keystroke combinations from the standard keyboard to execute speech synthesizer controls. The users would need to learn the combinations needed to execute the functions they use most often.

- Are the key combinations easy to perform or do they require awkward hand positioning?

- Is an additional keyboard or control interface used for screen reader control? Some screen reader packages use a special keypad that is attached to the computer in addition to the standard PC keyboard for controlling the output sent to the speech synthesizer. Users that are new to computers and have limited keyboarding skills often like this configuration because they feel it is "safe." They are comfortable making key selections from the add-on keypad because they know they are not going to inadvertently hit a stray key and destroy their data or cause a problem on the computer. For users that are good touch typists and comfortable with a keyboard, the need to remove a hand from the standard keyboard to control the speech output may slow them down and be a distraction. In addition, the external keypad will need a serial or parallel port for connection to the computer.

- Are the key combinations easy to perform or do they require awkward hand positioning?

Review mode -- Most screen reader packages offer a way to review the screen contents without actually moving the PC cursor. This is particularly important on screens that have a portion "protected" and do not allow the PC cursor into that section of the screen. It is important to look at how easily one can switch back and forth between the PC cursor tracking mode and the review mode.

Reading windows -- Many of the screen reader packages have a method of setting up several reading "windows" that the user can control. These may be useful if there is a status line that the user may need to periodically check or a specific part of the screen that is

used for error messages. In some cases, the window can be set up to speak its contents automatically whenever there is a change, such as an error message being displayed, or the *insert on* or *caps on* indicator showing on the screen. Sometimes, the user will want the window to be read only when directed by the user. One example is the cursor location given in many word processing packages. If the cursor location window was being read each time the window information changed, it would be read as each and every keystroke is entered and the cursor moves from position to position across the screen. If a user needs reading windows, a few things to look at are:

- How easily can windows be defined?
- How many different windows may be defined?
- How are the different windows accessed?
- Can some be read automatically and others read only on command?

Identification of attributes -- Most screen reader programs allow the users to choose whether they want things such as uppercase to be identified, punctuation to be read, blank lines to be read or skipped, line numbers to be read or not identified, and so forth. There are several ways different screen readers may choose to identify uppercase letters. Some screen readers actually direct the synthesizer to say "upper" and the letter, others have the synthesizer use a different tone of voice or pitch to identify uppercase from lowercase. The users needs to determine which method they prefer and its importance when weighed with other considerations. Some screen readers also use pitch variations to identify to the user when information is presented on the screen in reverse video or in specific colors. This may be important depending on how the application packages being used display special information on the screen such as identification of text to be underlined, italicized, or bold faced. This may also be important in determining how easily a spell checking program may be used.

Help mode -- When first learning any new package, easy access to a help function is quite useful.

- Does the package have an on-line help function?
- How detailed is the explanation of each of the screen reader functions and control of those functions?

- How easy is it to access the help mode and then to return to the active mode or review mode?

> *Explanatory Note*: Because the screen reader is always used in conjunction with a speech synthesizer, it is easy for the individual first exploring these capabilities to fail to distinguish the performance of the speech synthesizer from the performance of the screen reader program. Often, people comment they liked how screen reader A sounded better than screen reader B. When commenting about the voice output or quality, the individual is really focusing on which synthesizer is being used at the time, not the screen reader. In many cases, screen reader B may be able to direct output to the same preferred speech synthesizer as screen reader A. When looking at the screen reader package, the user needs to concentrate on how the output is directed to the synthesizer and the features available for customizing that interface to their needs, not the voice quality of the synthesizer that may be in use at the moment. Although it is difficult to initially separate these two distinct decisions, doing so will result in a more optimal solution for the user.

Assistive Technology for Hearing Impairments

People who have hearing impairments can be divided into two groups: those who are deaf and those who are hard of hearing. Deafness, or profound hearing loss, have hearing impairments that are "so severe that they have little useful hearing even if they have the use of hearing aids" (Smith & Luckasson, 1992, p. 383). On the other hand, people who are hard of hearing are able to process some information from sound, usually through the use of a hearing aid. Hearing devices can either increase the sound for a hard of hearing user (amplification) or use another means to communicate sounds to individuals who are deaf through printed words, vibration, or flashing lights (signaling). Two categories of devices are listed in this section: (a) amplification aids; and (b) signaling devices.

Amplification Aids

Today there are a wide variety of *hearing aids* to meet specific student needs. Some aids are small, in-the-ear devices, while larger, more powerful aids can have a receiver worn in a chest pocket, connected by wire to a molded ear piece. Hearing aids can be used to provide general amplification, amplification of certain tones, or to block out background noise or specific tones. A professional assessment is required to determine the appropriate device for a person with a hearing impairment.

Amplification systems can help students who are unable to hear regular classroom lectures with normal amplification. Two basic types exist. In *wired systems*, an amplification unit is attached to the lecturer's microphone and is connected by wire to a headset worn by the students. The other type is the *wireless infrared system*, which sends an infrared signal to the headset. Both amplification systems can be used with groups of students. Lecturers use a microphone and their voices are transmitted to the listener's headsets or earpieces.

A *Pocket Talker* is a personal amplification system that is equipped with an amplifier, microphone, mini-earphone, and listening extension cord. The microphone is placed near the sound source or is held by the lecturer, and the listener adjusts the volume to a suitable level.

Signaling Devices

Signaling devices are used to alert a person with a hearing impairment that a specified sound is occurring. *Closed captioning* allows words spoken by individuals on a video or on television to be displayed at the bottom of the television screen or monitor, but only to individuals who have decoders on their sets. This enables individuals who are deaf or hard of hearing to access news programs, videos, and a wide variety of television programs. An increasing number of videos are closed captioned and are noted as such in most video guides. Decoders may be purchased separately or as a built-in feature of some television sets. Although most closed captioning is done during the production of a video, *real time closed captioning* is captioning done concurrently with speech. This is done primarily for television shows or speeches that are aired live.

Some students have *hearing ear dogs*, which serve as mobile "ears" for a person with a hearing impairment. While labeling them "assistive technology" might be stretching the definition, these specially trained dogs provide an important service for students who are deaf or have hearing impairments. They alert their owners to such sounds as approaching emergency vehicles on the street or a knock at the door. Hearing ear dogs are welcomed everywhere.

Assistive Technology for Visual Impairments

Visual impairments are classified as either legal blindness or partial sightedness (i.e., low vision). Legal blindness is defined as occurring when visual acuity [is] measured as 20/200 or worse (i.e., what people with perfect vision see at 20 feet appears as though it were at least 200 feet away to a person with a visual impairment) in the better eye with correction, or peripheral vision (i.e., left to right field of vision) is no greater that 20 degrees. Partial sightedness is a less severe visual impairment and occurs when visual acuity is between 20/70 and 20/200.

Students with visual impairments range from those who need some magnification to those who are unable to read standard size print without magnification to those who have no light perception. Other students with visual impairments may instead be able to see only straight ahead but not to the side, or only to the sides but not straight ahead.

So-called "low vision" devices and techniques are designed to magnify or increase the size of images or objects so they can be seen by individuals with impaired vision. For individuals with little or no useful vision, other devices are available to communicate visual information by alternate means, such as voice or braille. This section lists two categories of devices: (a) vision aids; and (b) other devices and services.

Vision Aids

For individuals with limited vision, *good lighting and good contrast* are essential for reading a printed document or viewing an image or object. Low-glare paper also helps. The National Federation for the Blind maximizes contrast in its large print materials by using buff colored paper and sans serif print type, because sans serif print consists of straight block letter with no curly-cues or fading on a letter's end points.

By legal definition, *large print* is considered to be any print larger than 14 points or 1/4-inch tall. Today, most computer printers have print types large enough to produce "large

print". Copy machines can also be used to enlarge materials if necessary. A sample of various sizes of large print using a popular sans serif font (i.e., Helvetica) appears below.

This is 12 point sans serif print.

This is 14 point sans serif print.

This is 18 point sans serif print.

This is 24 point sans serif print.

Print and other images may also be magnified in a number of ways for students with limited vision. The appropriate type of magnification depends on the student's mobility, comfort with technology, and numerous other factors earlier identified.

Magnifying lenses come in an assortment of powers and are available with or without light. A 2x lens magnifies an object to twice the size of the original, a 3x lenses magnifies an object to three times its original size, and so on.

CCTV (Closed Circuit Television) magnifies any image, whether it be the newspaper or a birthday card. A TV camera is positioned over a flat surface where the image to be enlarged is placed. The camera captures the image and displays it on a screen. Some CCTV's use black and white screens where the images can be reversed. For example, a newspaper article could appear with black letters on a white background or white letters on a black background. This change in contrast makes it much easier for some individuals with limited vision to read. Color units and portable CCTVs are also beginning to appear on the market.

Other Devices And Services

Most people are aware of the *Talking Books Service* that provides voice recordings through public libraries of printed materials ranging from reference works to college textbooks. *Recordings for the Blind* will record specific materials (e.g., college text books) upon request at no charge. The materials to be recorded must be provided to them three to six months in advance. Talking Books and Recordings for the Blind are available to all individuals whose disability interferes with their ability to read. Originally designed for individuals with visual impairments, these services are now provided to individuals who have difficulty turning pages or who have reading disabilities.

A low-tech option for many students who have severe visual impairments is to make *audio tape recordings* of items such as textbooks or class notes. Standard tape/cassette players are readily available in most colleges and can provide a good substitute for the pen and paper used by sighted individuals for these purposes.

Braille print may be produced by computers, by a *braille slate and stylus*, or by *mechanical braille writers*. Although computers are the preferred method for producing long Braille documents, the portable nature of the latter two make them more suitable for taking or making notes in Braille or writing short documents. The Braille slate consists of two hinged "plates" that serve as a guide for making Braille dots on paper placed between the plates. The top plate has a series of rectangular holes in the shape of Braille cells, and the bottom plate has six (or eight) indented dots corresponding to each Braille cell on the top plate. The stylus is similar to those used in non-automated voting booths. To use the slate and stylus, the user punches the stylus through the holes in the slate, as necessary, to create braille symbols in each cell. The mechanical braille writer is a small typewriter-like device

with two rows of keys. Another portable device is the *Braille label-maker*, which is small and used only to make labels.

Text reading systems scan printed text, recognize the characters, and translate the printed text into a computer file. Once the text is in a computerized form, it can be converted to large print or Braille, or can "read" to the user in a synthesized voice. The *Kurzweil Reader* is one example of a stand alone system. Other systems use computers and require special computer programs and a scanning device.

Refreshable Display Systems consist of a computer with a refreshable Braille display. Refreshable Braille is a plastic device that has space for up to 80 Braille cells, where the six or eight dots in each cell consist of "reeds" that can be electronically raised and lowered in different combinations to form all the Braille characters. Text on a computer screen can then be translated to this device, line by line or word by word, so that an individual can read the text on the screen. This device allows a user privacy and quiet and is ideal when a user is in too noisy an environment to use voice output or for individuals who prefer braille to other forms of "reading."

The *Optacon II* is a portable*tactile reader* that gives the user direct access to printed material. The user scans printed material by slowly moving a hand-held camera (about the size of a cigarette lighter) across the page. The camera "reads" the printed letters and then translates the letters to a vibrating tactile display of the characters. The user rests a finger on the display and is able to feel the shape of the letters move underneath his/her finger.

Assistive Technology for Communication Disorders

Communication encompasses the many ways we express ourselves to others and receive information from others. It involves writing, speaking, and using gestures, and may take other forms, such as art or musical expression. Individuals with communication disorders have considerable difficulty making themselves clearly understood, generally because of neurological or mechanical disabilities involving the voice. Other types of communication disorders include difficulty in composing one's thoughts or in understanding what is said by others.

This section specifically examines *augmentative communication devices* that aid or augment communication for individuals with speech disorders . Augmentative communication devices do not necessarily replace speech, but rather expand people's ability to make themselves clearly understood. No single communication device or system from among those available can serve the needs of all people with speech disorders. In fact, many individuals require multiple communication systems in order to meet varying needs and to maximize their ability to communicate. Although augmentative communication devices were originally designed to assist individuals with speech disorders, many of these devices can also be used to assist or re-educate individuals with other types of communication disorders. Three categories of devices are listed in this section: (a) direct and indirect selection language systems, (b) voice output communication aids, and (c) other speech aids.

Direct And Indirect Selection Language Systems

Communication displays consist of a series of symbols that are arrayed on a variety of apparatuses including boards, books, folders, cards, wallets, and lap trays. The symbols selected for the displays are those that are or will be most used or needed by the student and his/her communication partner(s) and which can be understood by both the user and the

communication partners. Symbols used can be mixed and matched to include photographs, line drawings, color pictures, picture symbols, letters/numbers, and/or words.

Communication displays are "low-tech" solutions appropriate for users who are able to point at the symbols on the display (direct selection) using a finger, hand, toe, foot, elbow, or directed eye-gaze; or the symbols may be accessed with a pointing stick attached to a hand, foot, mouth, head, and so forth. While these systems are available commercially, most are developed and constructed for a specific individual.

Individuals who are unable to utilize a direct selection technique may be able to use indirect selection through a *switch and scanning system* that allows the appropriate symbol to be selected from a number of automatically displayed options. This system requires an electronic augmentative communication device that is programmed to perform a scanning function and that is adapted to use a switch. The cursor on the screen of the augmentative communication device automatically moves at an adjustable speed among selected symbols, boxes, or other specified areas/options on the screen, stopping at each one long enough for the user to indicate whether it should be selected. The user makes a selection via a switch that is activated in the manner in which the user has the best and most consistent movement (e.g., finger, hand, arm, head, mouth, eyelid, directed eye-gaze, knee, foot, or with pointers attached to the hand, head, mouth, foot, etc.).

Voice Output Communication Aids

Voice Output Communication Aids (VOCA) are high technology aids that include dedicated portable electronic augmentative communication systems and personal computers that have adaptations to provide communication assistance. Both approaches allow the user to produce synthesized speech and generally permit the use of many more symbols than manual communication displays.

Dedicated VOCA devices have drawings, pictures, letters, or words on the symbol display; and assign any message to a display symbol. For example, 26 of the "symbols" could be letters of the alphabet, allowing words to be spelled. Other "symbols" could include often-used phrases such as, "Hi;" "My name is...," "I'd like to order a sausage and anchovy pizza," "Please," "My address is...," "Yes," "No," and words such as *he*, *she*, *if*, *but*, *who*, *what*, and so forth. *Direct selection VOCA devices* include "All Talk," "IntroTalker," "SpeechPac," "Talking Notebook," "Touch Talker," and the "Wolf." *Scanning VOCA devices* include "EvalPac," "Light Talker," and "ScanWolf."

With computer adaptations and/or special computer programs, standard personal computers can be used as augmentative communication systems. *Adapted computer-based VOCA* include computer keyboard adaptations like the "Power Pad," "Unicorn Board," and "Touch Window," as well as such products as switch interface devices, speech synthesizers, and computer programs that enable computers to perform such functions as scanning and voice synthesis.

Assistive Technology for Learning Disabilities

Learning disabilities are defined by the National Joint Committee on Learning Disabilities (1988) as follows:

> Learning disabilities is a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical abilities. These disorders are intrinsic to the individual, presumed to be due to central nervous system dysfunction, and may occur across the life span. Problems in self-

> regulatory behaviors, social perception, and social interaction may exist with learning disabilities but do not by themselves constitute a learning disability. Although learning disabilities may occur concomitantly with other handicapping conditions (for example, sensory impairment, mental retardation, serious emotional disturbance) or with extrinsic influences (such as cultural differences or insufficient or inappropriate instruction) they are not the result of those conditions or influences. (p. 1)

Students with learning disabilities (LD) constitute the largest category of students with disabilities. Their auxiliary aid requirements will depend on the nature of their specific learning problem (e.g., reading, mathematics). For students with LD in reading, they can utilize devices similar to those described earlier under visual impairments (e.g., recorded textbooks, scanners and screen readers). Students with severe writing disabilities can use the voice recognition software that allows for inputting information to the computer via spoken language. Note takers might also be needed. In addition, there are thousands of technology-based products available for remediation of academic deficiencies related to learning disabilities (e.g., computer software targeted to remediation of deficient skills in algebra, typing and keyboard tutors). Sone of these are described here.

Computers and Software

Computers and software are commonly used to benefit persons with learning disabilities. The computer provides a multi-sensory approach with visual cues; auditory cues through voice or sound prompts; and tactile cues through the keyboard, touch screen, or other alternate input mechanisms. The computer can be especially helpful because the student can proceed self-paced. The computer can also provide feedback so the student can measure progress. It is non-threatening and non-judgmental and can provide a successful learning experience.

Software is available for a variety of skill areas (e.g., language arts, math). Some programs make use of a number of instructional methods such as instruction and drill, drill and practice, tutorial, educational game and strategy building. Some of these products are discussed here by content area (Reminder:.Inclusion of the software programs does not constitute an endorsement.

Language Arts

Speed Reader

Publisher: Davidson & Associates
19840 Pioneer Ave.
Torrance, CA 90503
Hardware: Apple IIe, IIc, IIgs; IBM PC

Speed Reader is designed to improve reading speed, comprehension, and retention for individuals from 14 years old and above. The program includes six types of reading exercises: warm-up exercises with letters; warm-up exercises with words; eye movement exercises; column reading lessons; reading passage lessons; and timed reading tests. Each session is self-paced and takes 20 to 30 minutes on the computer to complete. The program includes an editor that allows students to enter their own reading material. Additional data disks are available which contain more selections at specific reading levels from fifth grade reading level through college reading level.

Word Attack

Publisher: Davidson & Associates
19840 Pioneer Ave.
Torrance, CA 90503
Hardware: Apple, Macintosh, IBM, Commodore

The focus of this program is on word identification and vocabulary development; thus, it is most appropriate for students who require drill and practice in these areas. The program allows for customizing; therefore, individual student word attack and vocabulary development levels can be addressed. There are 675 words and nine difficulty levels. The format is an arcade game.

Homework Helper-Writing

Publisher: Spinnaker
201 Broadway
Cambridge, MA 02139
Hardware: Apple, IBM, Commodore

This software program assists students with the components of writing such as generating ideas, developing an outline, and writing drafts. A checklist is included that identifies areas (e.g., grammar, moving text, punctuation, spelling) to consider when revising and editing a paper. This program is especially useful for writers who need to develop good writing skills and the organization skills necessary to write well.

Predict It

Publisher: Don Johnston Developmental Equipment, Inc.
1000 N Rand Rd. Bldg. 115
P.O. Box 639
Wauconda, IL 60084-9903
Hardware: Apple IIe, IIc/c+, IIgs; Note: For speech options, the ECHO Speech Synthesizer can be used. A printer can be used to print out the written product.

The Predict It software program is designed for students who need to write stories, compositions, and research papers. This word processing program "predicts" what the author wants to type. The program contains approximately 1500 words to assist authors in creating a written product. Grammatical and/or letter probability prediction factors are used to generate author-intended words. The author can select the predicted word or continue typing his or her own word.

Bank Street Writer III

Publisher: Scholastic
P.O. Box 7501
2931 East McCarty St.
Jefferson City, MO 65102
Hardware: Apple IIe, IIc, IIgs; IBM PC

Bank Street Writer III is designed for students who are learning about word processing skills. This word processing software program has a 20-, 40-, and 80-column display, an extensive word spell checker, and a thesaurus with a 50,000 word dictionary. The program contains an interactive tutorial and pull down menus for easy access to menu options. The documentation includes specific directions for introducing word processing to students and contains activities and handouts.

Talking Text Writer

Publisher: Scholastic Software
730 Broadway
NY, NY 10003
Hardware: Apple IIe, IIc, IIGS; Speech synthesizer

This program can be used effectively with students who would benefit from auditory feedback of their typed text. This word processing program is good for those with severe reading problems. It has a synthesized speech option which enables users to hear typed text.

Write This Way/LD

Publisher: Interactive Learning Materials
Also available from: Cambridge Development Laboratory, Inc.
86 West St., Waltham, MA 02154
Hardware: Apple IIe, IIc.

Write This Way/LD is appropriate for students who require spelling and grammar assistance when writing. This individualized word processing program provides students with learning disabilities the opportunity to write without worrying about the correctness of spelling and grammar. A built-in spelling and grammar check can be used at any time of the writing process where logical choices are offered for identified errors. Sample lessons, activities, and teaching strategies are included for instructors.

Mathematics

Alge-Blaster Plus!

Publisher: Opportunities for Learning, Inc.
20417 Nordhoff St. Dept. RB7
Chatsworth, CA 91311
Hardware: Apple IIe, IIc, IIGS

This tutorial program is intended for students who (a) are having trouble in their required algebra classes, (b) need review in basic algebra skills prior to enrolling in college algebra classes, or (c) are preparing to take standardized exams that include algebra. The Alge-Blaster Plus software program focuses on understanding the algebraic process and developing skills to solve problems. It is designed to supplement classroom instruction or as a review for students taking a College Board Exam or higher-level math course. The fundamental steps that students must learn are presented in sample problems followed by practice application opportunities. Algebraic terms and properties are introduced and defined, and practice activities and quizzes are provided. The student controls the pace of instruction and can review any of the steps during a lesson. An on-line help menu provides

information on key strokes, lists algebraic terms and definitions, and gives hints for solving problems.

Homework Helper: Math Word Problems

Publisher: Spinnaker
201 Broadway
Cambridge, MA 01239
Hardware: Apple (48K), Commodore (48K), IBM (128K).

Homework Helper is appropriate for older students who are in need of assistance with solving word problems using algebraic equations. The emphasis of this program is on problems students encounter in the prealgebra or algebra I curricula with a focus on creating and solving word problems. Tutorials in the different categories of word problems are provided showing a solution process for each category. A step-by-step process of translating sentences into equations is introduced followed by assistance in solving the word problems. There are three levels of difficulty for each category and an on-screen algebra calculator, which solves the equations and explains the solution processes.

Money Management

Publisher: Marshware
Also available from: Cambridge Development Laboratory, Inc.
86 West St., Waltham, MA 02154.
Hardware: Apple IIe, IIc.

This program is designed for students who need to work on planning personal finances. Instruction and practice in financial management are provided. Individuals practice with credit cards, loans, mortgages, and retirement resources. A calculator is included in the program.

Study Skills

Typing Tutor 5

Publisher: Simon & Schuster-Computer Software Division
One Gulf & Western Plaza
NY, NY 10023
Hardware:

This software is intended for students who need to learn how to type. It is a good program for students who have little or no previous experience with typing or computers. Typing Tutor 5 simulates real-life typing experiences and determines which keys the student needs to practice at a specific level. Student progress is monitored and lessons designed accordingly. The pacing of the program is individualized to specific student levels of progress.

Typing Tutor III

Publisher: Simon & Schuster-Computer Software Division
One Gulf & Western Plaza
NY, NY 10023
Hardware: Apple IIe, IIc, IIGS

Typing Tutor III is appropriate for students who need to learn how to type and have no typing experience. This typing tutorial develops typing skills in students with little or no typing experience. It has four levels of difficulty, records the keys learned and being taught, and provides words-per-minute tests.

Test-Taking Made Easy

Publisher: MCE, Inc.
Also available from: Cambridge Development Laboratory, Inc.
86 West St., Waltham, MA 02154
Hardware: Apple, IBM; Printer.

This program is intended for use with students who require practice with test-taking skills. Emphasis is placed on hints, rules, and suggestions for developing more effective test-taking skills. The program is designed to be interactive and offers feedback to guide individuals through the activities. A printout of individual achievement is provided.

The Test Taker's Edge

Publisher: Sunburst/Wings for Learning
101 Castleton St.
Pleasantville, NY 10570
Hardware: Apple, IBM PC

The focus of this program emphasizes self-testing techniques which students can practice including matching, true/false, multiple choice, and completion. Students are tested and then analyze their test results. The program format can be adapted to a wide range of subject areas. Two data disks are already prepared: Vocabulary, grades 6-12 or Social Studies, grades 7-12 comes with the program. Step-by-step prompts facilitate the creation of new files and the documentation is clear and easy to follow.

Skills for Successful Test Taking

Publisher: MCE, Inc.
157 South Kalamazoo Mall
Suite 250
Kalamazoo, MI 49007
Hardware: Apple, IBM PC and PS/2

With this program, the focus is on improving students' test-taking skills through an interactive learning activities and discussions approach. The tutorial format stresses test preparation, following directions, and test-taking attitudes. The program includes a pre- and post-test and the reading level of the material is Grade 6-7. Skills for Successful Test Taking is part of the Making the Grade Series which includes Study to Succeed and Building Memory Skills.

Building Memory Skills

Publisher: MCE, Inc.
157 South Kalamazoo Mall
Suite 250
Kalamazoo, MI 49007
Hardware: Apple, IBM

This software is appropriate for secondary level students and adults who need to learn effective techniques for remembering information. Individuals will learn about attention, interest, organization, practice, association, and visualization as ways to enhance memory skills. The format is interactive and the program includes a pre- and post-test. Students must be able to read at the sixth grade level.

Study to Succeed

Publisher: MCE, Inc.
157 South Kalamazoo Mall
Suite 250
Kalamazoo, MI 49007
Hardware: Apple, IBM, PC and PS/2

This program was designed for students who are college bound and require assistance with study skills. The content focuses on an analysis of the individual's present study skills. It uses the SQ3R technique to help students improve reading comprehension and presents segments on listening, and note taking skills. Individuals can plan their own study schedules and learn about their most effective studying techniques.

Summary

Researchers have shown that cooperative learning can be an effective instructional structure to teach and reinforce skills and concepts. Careful planning is necessary to ensure that the elements of cooperative learning are addressed and that the student and teacher roles are defined clearly. Cooperative learning can be used as part of direct instruction during either guided or independent practice. Evaluation of student work, individually and collectively, will assist in determining the effectiveness of cooperative learning activities in helping students achieve and maintain mastery of skills and concepts.

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