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ABSTRACT

This research-based review discusses effective computer applications for students with mental disabilities. Most computer-based instruction currently in use is of a drill-and-practice variety, which is needed to develop fluency in basic academic skills. Studies conducted on math fluency indicate that when students are using counting strategies to solve basic math facts, computer-based drill-and-practice activities do not lead to fluent recall of math facts, but tutorial plus drill activities can lead to fluency. In the area of reading, the scope of existing research is too narrow to draw conclusions about the utility of computer-based practice in remediating overall reading deficiencies, but microcomputers are well-suited for providing extended practice that can lead to increased fluency in decoding skills. Spelling research shows that improved spelling (with an accuracy level of over 90 percent) can result if the computer-based program requires students to use long-term memory, limits the size of the practice set to 20 spelling words, spaces practice over three weeks, and emphasizes speed and accuracy. Use of computers in teaching of writing should include instruction in keyboarding, word processing and idea processing software, and task-specific strategies. Also examined are the use of computers to teach thinking and problem-solving skills, through use of LOGO and simulations. A discussion of computer-managed instruction and monitoring concludes the paper. (JDD)

Chapter Ten

Use of Computers

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OVERVIEW

Microcomputers have been an integral part of special education for the past five to seven years and researchers recently reported that the number of computers placed in special education classes is on the rise (Becker, 1986; Cosden & Semmel, 1987). Over the years, enormous claims and promises of enhanced learning and more normalized lives for disabled individuals accompanied this influx of computers into special education. There is no question that for people with physical and sensory disabilities, the computer successfully provides greater access to the world around them. One need only see a student with cerebral palsy using a sonic head pointer and a computer to communicate with other student and adults to understand the power that the computer offers these student. However, for the large number of student with mild to moderate mental disabilities, many of the promises of more efficient computer-based learning are unrealized. Although some empirical studies demonstrate learning advantages resulting from computer-based instruction, others have not. Thus, the equivocal nature of this research leaves many teachers, parents, and administrators confused and uncertain about the benefits of computer-based instruction.

Hopefully, this chapter will help you separate dreams from realities and provide a clearer understanding of effective uses of the computer. In writing this chapter, we attempt to make it different from any that you might have read previously. We believe that it is different in two significant ways. First, we drew heavily upon existing empirical research to determine what are the best practices in computer use instead of talking about the ways computer might be used. Second, because we focused on demonstrated effective uses, we limited our discussion to only a few applications and did not attempt to provide general discussions of classroom computer use. If readers desire a more generic discussion of computer use with this population, there are a number of books and book chapters that deal with the topic at this level.

The Effects of the Computer on Learning

Most everyone agrees, at least at a verbal level, that the computer is simply an educational tool. However, if one examines the research literature closely, it appears that many educators attribute much more innate teaching potential to the computer than they do to other instructional media such as books, overhead projectors, and chalkboards. In his review of research on media and learning, Clark (1983) argues convincingly that computers and other media serve only as delivery mechanisms for instruction and do not influence learning directly. Clark states, "The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 445). Clark goes on to point out that bad instruction, whether or not it is delivered by a computer, will not result in student learning. Conversely, well designed instruction will result in learning regardless of the medium in which it is presented. Thus, one must conclude from Clark's review that if the computer is to be an effective instructional tool, then it must be used as a delivery medium for well designed instruction. The remainder of this paper will examine research on different type of instruction presented through the microcomputer medium.

Computer-Based Instruction

In surveys that examined both elementary and high school special education programs nationwide, investigators consistently reported that most of the computer-based instruction currently in use is of a drill-and-practice variety (Becker, 1986; Cosden & Semmel, 1987; Rieth, 1986; Russell, 1986). As the name implies, computer-based drill-and-practice is designed to reinforce previously learned information and to develop fluency or automaticity in a skill. There is no question that the nature of the computer makes it ideal for providing endless practice in almost any curricular area. For example, the computer can provide hours of practice without getting bored or frustrated, and with appropriate software, the practice can be individualized and carefully monitored. Unfortunately, the purpose of computer-based drill-and-practice has been largely misunderstood and the instructional robustness has been oversold. As a result, drill-and-practice has come under a great deal of criticism.

Critics of computer-based drill-and-practice argue that the computer has become an expensive electronic worksheet and that the power of the computer is not being used (Carlson & Silverman, 1986); that the stimulus-response nature of drill-and-practice software makes students passive recipients rather than active initiators of learning (Turkel & Podell, 1984); and that workbooks can be used for drill-and-practice at a much lower cost (Garson, 1983). While all of the criticism stated above may be true, none address the important issue of why drill-and-practice is needed, that is, to develop fluency in basic academic skills.

The Importance of Fluency

Recently, research coming from the field of cognitive psychology emphasized the importance of fluent and rapid access of information on higher order skills. For example, Lesgold (1983) and Togesen (1984) believe that students with disabilities do poorly in reading and math because they have failed to master basic skills. Take, for example, the task of reading. Students who read along trying to sound out each word as they come to it have no idea what they have read by the time they get to the end of a sentence. The same is true in spelling. If students are trying to do creative writing but are having to stop to recall how to spell each word, their attention is overburdened and they are unable to engage in meaningful composition. Likewise in mathematics, if students must constantly calculate answers to basic math facts, they have difficulty when they go on to higher-level skills.

A number of research studies have been conducted recently to examine the effects of computer-based drill-and-practice on the development of mathematics, reading, and spelling fluency. From these studies we have learned much about how to use computer technology effectively for developing fluency in academic tasks.

Fluency in Mathematics

Basically, there are two ways to solve basic math problems such as 5+3 or 15-7. One is to commit the answers to memory and then retrieve them at the appropriate time. A second is to use some sort of reconstructive counting strategy (e.g. finger counting) to solve the problem when it is encountered.

For many years educators assumed that in order to make the recall of basic math facts fluent, a student need only to spend large amounts of time practicing these facts. With the introduction of the microcomputer, many educators viewed it as the best way of providing students with unlimited amounts of practice (Gagne, 1983). However, researchers who looked at the effects of computer-based practice on fluency development in disabled learners found that computer-based drill-and-practice seldom leads to mathematical fluency.

Virtually all of the studies that examined the use of math drill-and-practice software, regardless of the software used, reported that the programs fail to develop generalized math fluency (Christiansen & Gerber, 1986; Goldman & Pellegrino, 1987; Hasselbring, Goin, & Bransford, 1987; Howell & Graica, 1985; McDermott & Watkins, 1983). Generally, findings from these studies showed that the use of computer-based drill-and-practice with youngsters with mild disabilities lead to slight increases in speed when counting strategies are in use. A close examination of these data suggest any increases in speed can be attributed to students becoming more efficient at counting and not due to the development of automatic recall of facts from memory.

From a number of studies conducted on math fluency (Hasselbring, Goin, & Bransford, 1987), we concluded that when students are using counting strategies to solve basic math facts, typical computer-based drill-and-practice activities do not produce developmental shifts whereby students begin to retrieve answers from memory. We found that if a learner with a mild disbility has not established the ability to retrieve an answer from memory before engaging in a drill-and-practice activity then time spent in drill-and-practice is essentially wasted. On the other hand, it a student can retrieve a fact from memory, even slowly, then the use of drill-and-practice will quickly lead to the fluent recall of that fact.

It is important to note that the results from the above studies do not suggest that drill-and-practice should be abandoned. On the contrary, these findings suggest that the use of drill-and-practice for developing fluency should be done cautiously and that learning-handicapped students should only practice problems for which they are able to retrieve answers from memory.

Tutorial Plus Drill

Results from the drill-and-practice studies suggest that the key to making computer-based drill an activity that will lead to fluency is through additional instruction that will establish information in long term memory. Thus, instead of using the computer for drill-and-practice only, the computer should serve as a tutor during the acquisition stage of learning. Once acquisition occurs (i.e. information is stored in long term memory), then drill-and-practice can be used effectively to make the retrieval of this information fluent and automatic.

One early study that demonstrated the combined effect of tutorial plus drill on the math achievement of youngsters with mild disabilities was conducted by Trifiletti, Frith, and Armstrong (1984). Using a program called SPARK-80, these investigators found that 40 minutes of computerized tutorial plus drill per day was more than twice as effective as an equivalent amount of math instruction delivered by a resource room teacher. The computer group produced over twice the yearly gains in standardized math achievement when compared to the control group.

Trifiletti et al. attributed much of the success of this program to the fact that the program sequenced instruction carefully, emphasized fluency as well as accuracy, and used a data management system that involved a specific decision-making algorithm applied to student speed and accuracy data. Thus, the program decided when to move a student on in the program and when additional instruction was needed. The management system also kept a history of learning on each student thus removing this administrative burden from the teacher.

In a study similar to Trifiletti et al., we examined the effect of tutorial plus drill on the development of retrieval strategies on learners with a mild disability (Hasselbring, Goin, & Bradsford, 1987). In this study, we collected response latency data on more than 150 students with mild disabilities and nondisabled students ages 7 through 14. The students with mild disabilities were assigned to either a computer or contrast condition while the nondisabled students served as contrasts only.

The computer group received training on a specially designed computer program for developing recall strategies in basic addition facts. The software program, called Fast Facts, was based on principles of effective instruction. The design features included (a) a small set of initial information to learn, (b) emphasis placed on accurate and rapid responses, (c) new information interspersed with learned information; (d) emphasis placed on mastery learning; and, (e) an extensive data monitoring and management system.

The computer group received daily instruction using Fast Facts for developing recall of addition and subtraction facts. Following each session on Fast Facts the students received a brief period of drill-and-practice over the facts that the student could retrieve from memory. The combined retrieval training plus drill-and-practice averaged only ten minutes per day. The contrast groups received only the math instruction provided by their classroom teacher.

The results of the study showed that on the average, after only 49 days of using the math software, the computer group increased the number of facts that were recalled from memory by 19, a 73% increase over the pretest. During the same period, the contrast group of disabled learners showed no change on the number of facts that they could recall from memory and the nonhandicapped contrast students averaged only eight additional facts. Thus, the students with disabiilties developed fluent facts at a rate twice that of their nondisabled peers.

From this research, we have concluded that the combination of recall training plus drill is a powerful mechanism for developing fluency in disabled learners. Further, with sufficient training, students with mild disabilities should be able to develop fluency at a level commensurate with their nondisabled peers.

Conclusions

From the research on drill-and-practice, it appears that, by itself, computer-based drill-and-practice is ineffective for developing fluency in learners with mild disabilities if they cannot already retrieve a fact from memory. Students who come to a drill-and-practice activity using counting strategies to solve basic facts will leave the activity using counting strategies to solve those same facts.

On the other hand, if a student comes to the drill-and-practice activity being able to recall some facts from memory, albeit slowly, drill-and-practice on those facts will lead to fluency in a relatively short time. If a student is unable to retrieve a fact from memory, it appears that combination of retrieval training plus drill results in significant increases in fluency for mildly learners with mild disabilities. For a discussion of non-computer based activities that may assist a student in developing retrieval strategies, the reader is referred to an article in Teaching Exceptional Student (Spring, 1987), entitled "Effective Mathematics Instruction" (Peters, et al., 1987).

Fluency in Reading

There is far more information on the effective use of computers for developing fluency in mathematics than in reading, nevertheless, there is a research literature developing. One example of a developing literature comes from cognitive psychology. The cognitively oriented reading research has recently emphasized the importance of fluent decoding skills on good reading comprehension. In addition, there is a growing consensus that the primary reading difficulty experienced by youngsters with mild disabilities is at the word, rather than the text, level of processing. These two generalizations suggest that a primary emphasis of reading instruction for students with mild disabilities should focus around activities that will strengthen their decoding and word reading skills (Torgesen, 1986). Although the empirical evidence is somewhat limited, there have been several studies that support the use of computer-based practice activities for the improvement of decoding fluency and whole-word reading.

At the grapheme-phoneme level of decoding, Jones, Torgesen, and Sexton (1987) found that the use of a computer program called Hint and Hunt I (Beck & Roth, 1984), with learners with mild disabilities for 15 minutes per day over a ten-week period resulted in a 27% increase in reading speed. More impressively. the students receiving the computer practice showed an accompanying 20% increase in accuracy on a list of generalized words that were never practiced during the training. In contrast, the control group showed only a 4% increase in speed and a 5% increase in accuracy on these same words. Jones et al. concluded that practice with the Hint and Hunt I program led to a generalized increase in decoding skills, and not simply improvements in reading a limited set of practice words. Further, the fact that accuracy increased, as well as speed, suggested that improvements in speed were not simply the result of a change in the reading strategy to improve speed over accuracy.

The Hint and Hunt I program is designed to be used with Hint and Hunt II and Construct-a-Word I and II. In a study that examined the effect of the Construct-a-Word software, Roth and Beck (1984) found that the decoding skills of poor readers were increased by 25%, resulting in a 17% increase in sentence reading speed. In contrast, the control group showed a negligible increase in decoding accuracy and only a 3% increase in sentence reading speed. Similar results were reported by Spring and Perry (in press) when they examined the use of computer-based practice for enhancing the fluency of word analysis skills. Thus, from these studies, it appears that specific well designed training, provided via computer (e.g. practice in recognizing and analyzing words varying in medial and vowel combinations), is effective in increasing the fluency of phonological decoding skills in learners with mild disabilities.

Since the effects of computer practice at the decoding level appear to be so beneficial to learners with mild disabilities, one would naturally conclude that whole word recognition would also benefit from the same practice. According to automaticity theory, fluent readers decode text automatically, thus they are able to read without expending attentional resources in decoding individual words. Fluent readers often have good comprehension because attention is available to process meaning. Conversely, poor readers must expend attentional resources to decode each word, as a result, their reading speed is slow and comprehension is more difficult. According to Samuels (1979), accurate but nonfluent readers have developed decoding skills but they need more practice before they become automatic. Thus, the use of a repeated reading method where the student re-reads the same passage several time gives the student the necessary practice. Theoretically, fluency and comprehension increase with each reading of a single passage and improvements are carried over to new passages.

In testing this theory, Rashotte and Torgesen (1985) used a computer to present learners with mild disabilities with reading passages containing various amounts of word overlap via the computer (note: although a computer was used to present the text passages, it appears that the passages could have been presented using more traditional procedures such as ditto sheets). The results showed that when the passages contained many of the same words, gains in reading speed were increased. However, it was also revealed that when the stories had few shared words, repeated reading was no more effective for improving speed than an equivalent amount of non-repetitive reading. Although the advantages of repeated reading were found to be equivocal, the authors reported that the students liked the repeated reading regardless of the degree of improvement. Roshotte and Torgesen felt that students enjoyed this exercise because the repeated reading of the same passage gave students the impression that their reading was becoming more fluent.

Conclusions

From the existing research, it appears that microcomputers are well suited for providing learners with mild disabilities with the kind of extended practice that can lead to increased fluency in decoding skills; however, the effectiveness of developing whole word fluency is yet inconclusive. Overall, the scope of the existing research in reading is clearly too narrow to draw any general conclusions about the utility of computer-based practice in remediating the overall reading deficiencies. Such a conclusion must be based on research extending over a longer range of time and focused over a much broader range of reading skills.

Fluency in Spelling

The ability to spell has been described as a much sought-after, but frequently unattained, outcome of language arts instruction for student with learners with mild disabilities (Larsen & Hammill, 1976). Like mathematics and reading, researchers and teachers alike have attempted to use computer-based drill-and-practice to develop both accuracy and fluency in spelling. The results of these attempts have been mixed.

In a study comparing a computerized drill-and-practice program to a traditional "say-write-check" procedure, Fitzgerald, Fick, and Milich (1986) found over a five-week period there were no differences between the computer and traditional forms of practice. However, as expected, both the computer and the traditional method were superior to a no practice condition. The investigators concluded from this research that the computer practice was at least equal to the traditional method.

A closer examination of the results, however, suggests that neither the computer nor the traditional practice methods were overly successful since the percentage of correctly spelled words over the five-week treatment period averaged only a little over 60%. This low level of mastery would suggest that both the computer and traditional forms of instruction were ineffective in developing spelling accuracy let alone fluency. A description of the instructional sequence employed by the software used in the study lends support to this conclusion. The instructional sequence consisted of having the student type each word three times: (a) copying from a model on the screen, (b) typing after the model was removed, and (c) entering the word into a sentence.

The software used in this study, like most other spelling software, required that the student only access the correct spelling from short-term memory. Thus, the practice that was provided with this program was very different from the terminal task of recalling the correct spelling of a word from long-term memory, a skill that is required when one engages in a writing task, for example. Thus, one alternate conclusion to the Fitzergald et al. study is that the instruction methodology was ineffective in developing retrieval of correct letter sequences from long-term memory, and the results that were obtained had little to do with the use of technology.

Findings similar to those reported by Fitzgerald et al. have been reported by a number of other researchers. For example, McDermott and Watkins (1983) reported no differences between computer-based and conventional remedial spelling instruction over a one-year period for learning disabled youngsters. Likewise, Haynes, Kapinus, Malouf, and MacArthur (1984) found no significant differences between computer and traditional spelling instruction on either mastery or retention of the spelling words. Further, after four days of practice on only five words, the students averaged only three correct spellings. From these studies one must conclude that instructional methodologies in spelling that fail to develop the retrieval of correct letter sequences from long-term memory are ineffective whether they are computer-based or not.

In a series of studies beginning in 1981, Hasselbring and his colleague began investigating the "voice presentation" of words via computer in combination with "imitation plus modeling" feedback. This methodology differs from most computer-based and traditional spelling instruction in two important ways. First, the student is presented with the word auditorially, thus no visual model is presented so that short-term memory cannot be invoked to spell the word; long-term memory must come into play. Second, when a word is spelled incorrectly, the computer imitates the student's error by showing the student's incorrect spelling, followed by a model of the correct spelling so that a comparison can be made.

Studies that have used this computer-based approach have been quite successful in developing high levels of spelling accuracy in learners with mild disabilities. In two single-subject studies using this methodology, Hasselbring (1982, 1984) reported an accuracy level over 90% for the students when they were presented with a twenty-word spelling list each week for three weeks. Follow-up studies using groups of learners with mild disabilities with alternating treatment designs have been even more impressive.

Hasselbring, Donovan, and Zimmerman (1987) reported that the voice-based spelling intervention described above was significantly better than traditional spelling instruction that includes, say-write-check methodology. Using an alternating treatment design, Hasselbring, et al. reported that when the computer intervention was employed, students averaged over 30% more correctly spelled words than when they used the traditional procedures. From these studies it was concluded that the use of voice-based and imitation-plus-modeling intervention was successful because students developed the ability to retrieve information from long-term memory as opposed to more common spelling instruction that requires only the use of short-term memory. These conclusions are supported in research conducted by Rieth (in preparation) where he used a "DEC-Talker" to present spelling words to learning handicapped youngsters. As in the Hasselbring et al. studies, Rieth's subjects were required to recall correct spelling from long-term memory, resulting in high levels of mastery on spelling post-tests.

Conclusions

The conclusions that can be drawn from the research on computer-based spelling instruction parallel those from reading and mathematics. That is, the computer-based practice should be instructionally sound and resemble as closely as possible the terminal skill that the teacher wants to develop in the student. For example, in spelling, there is no evidence to suggest that practice in unscrambling words or typing a word that is flashed on the screen will lead to improved spelling. The computer-based practice should require the student to use long-term memory to be successful in the task. Other important characteristics of effective computer-based spelling practice include limiting the size of the practice set of words, spacing practice over days rather than having the student practice for the same total time in one or two sessions, and emphasizing speed as well as accuracy.

Word Processors and Writing

Much has been written with respect to the use of the word processor for improving the writing skills of student with mild disabilities. Frequently authors laud the characteristics of word processors with respect to the positive effects they have on the writing process for learners with mild disabilities (Goldenberg, Russell, Carter, 1984; Hagen, 1984). Most often such things as the ease of text revision, production of a clean readable text, and a sense of authorship are mentioned as attributes of word processors that lead to improved writing. However, until recently, very little was known about the effectiveness of using word processors with students with disabilities. The following set of studies begin to provide some insight into this area of microcomputer-based instruction.

Writing Instruction

Morocco and Neuman (1987) conducted a two year observational study on the use of word processors with learners with mild disabilities. The authors observed that when teachers worked with students with disabilities on word processors, they brought three basic approaches to writing instruction: (a) they collaborated directly with student in eliciting content for their writing (substantive instruction); (b) they provided students with procedures for generating instruction (procedural instruction); and (c) they directly taught skills or knowledge about writing rules (direct instruction).

Morocco and Neuman reported that although the teachers in their study used all three types of writing instruction, they most often used substantive instruction. The teachers frequently took part in the writing process by eliciting ideas from the student. The authors reported that while this approach was useful to overly anxious students during the initial stages of the writing process, overall it develops a learned helplessness by making students overly dependent on the teacher for helping them determine what to say next. The investigators reported that the use of word processors encourages the substantive approach to writing instruction by making the student's text more public thus making it easier for the teacher to direct the composing process.

Morocco and Neuman concluded that students were most successful when teachers used a procedural approach to writing instruction. By providing students with strategies for generating ideas during writing, the students could generalize these procedures to other writing situations. In all cases that they examined, teachers' use of substantive instruction was less effective than the use of procedural instruction for getting students to generate ideas and produce a first draft.

Although Morocco and Neuman concluded that procedural writing instruction was most successful for teaching writing to learners with mild disabilities, it is not known whether the students would have been less successful had word processors not been used. This question was addressed in a recent study by Ellis (cited in Ellis & Sabornie, 1986). Ellis compared student writing under three conditions: (a) handwriting; (b) word processor; and (c) word processor plus idea processor (outlining program). Prior to receiving any specific writing instruction, the students were told to take a position and defend it. Following this task, the students in all three conditions were given a specific seven-point strategy for defending a position in writing.

The results of the study showed that prior to the strategy training there were no differences between the handwriting and word processor conditions. However, the word processor plus idea processor produced more positive results. Following strategy training the students' writing improved under all three conditions with the word processor plus idea processor again showing the best results. Ellis conducted that generic strategy training (e.g., outlining) was better than no training, however, specific strategy training was superior especially when paired with the microcomputer.

Revising

It is commonly assumed that the use of the word processor will lead to improved writing since the revisions process is made much simpler. For example, when revising a text, students no longer have to erase or recopy. However, from the small amount of data collected thus far it appears that this assumption may not be true. MacArthur, Graham, Skarvold (1986), Neuman and Morocco (1986), and Vacc (1987) all found that when using word processors, students tended to focus more on revisions that made the writing technically correct rather than revisions that enhanced the quality of their writing. The researchers reported that this type of revision led to writing with shallow ideas and insight. Both research groups concluded that while the use of word processors may facilitate the mechanics of revision since students are more willing to make changes when recopying is not required, the use of word processors does not necessarily lead to greater sophistication in the revision process.

Keyboarding and Word Processor Efficiency

A common complaint voiced by teachers using word processors for writing instruction is that students' lack of familiarity with the keyboard and word processor software interferes with the writing task. The fact that students do have difficulty with keyboarding and word processing software has been shown in several research studies. For example, from their studies of the writing process, MacArthur, Graham, and Skarvold (1986), as well as Neuman and Morocco (1986) suggest that keyboarding skill is vital to the success of writing when using a word processor. MacArthur et al. found that typing efficiency was highly correlated with length, quality, and story structure. Neuman and Morocco concluded from their research that students should be given daily keyboarding instruction if a word processor is to be used effectively as a medium for teaching writing.

Conclusions

Results reported by Morocco and Neuman as well as Ellis have clearly demonstrated the importance of procedural or strategy instruction for teaching writing to students with mild disbilities. Further, it appears that task-specific strategies are superior to generic strategies for developing writing skills. It is still unclear, however, what role the word processor should have in the overall writing process. From the research by Ellis, it appears that the computer's ability to handle both word processing and idea processing software is a key variable in writing instruction. Nevertheless, more research is needed before a clear understanding of the relationship between the writing process and the computer can be drawn. Finally, skill in keyboarding and word processor use should be included as an integral part of the writing process.

Thinking and Problem Solving

A number of authors have suggested that the computer is a powerful tool for the development of thinking and problem solving in students with disabilities (Maddux, 1984; Schiffman, Tobin, & Buchanan, 1982; Russell, 1986). Probably the most publicized way of developing problem solving skills has been through the use of interactive programming languages, the most prominent being LOGO.

LOGO

LOGO was originally developed as a computer-based learning environment in which student could learn computer programming, problem solving, and mathematical thinking. The LOGO learning environment is based on the developmental psychology of Jean Piaget. Although LOGO is generally thought of as a language for non-handicapped student, the philosophy of LOGO developers has been "no threshold, no ceiling". Thus, any student, including those with mental disabilities, should be able to learn LOGO. Much has been written concerning the use of LOGO with various handicapping conditions. Wier, Russell, and Valente (1982) make the following statement about using LOGO with disabled students:

> The LOGO experience is often the first in which disabled students tackle problems which require them to initiate solutions, try them out, respond to feedback, and decide whether to change track or to persist - all those things that tend not to happen in the dependent situations that typify their lives and most of their schooling.
> (p. 347)."

One feature of the LOGO language that seems to be especially adventitious for students with mild disabilities is "turtle graphics". With turtle graphics, the student programs the turtle (a small triangular object) to move around the screen and construct geometric and graphic designs. Wier and Watt (1981) believe that this use of the computer has specific positive outcomes on the student. They suggest that:

1. Fine motor skills are improved (through the typing).

2. Short-term memory is developed (while students learn to use a typewriter keyboard and the various logging in and programming procedures.

3. Students learn to spell the commands.

4. Students develop direction-giving and direction-following skills.

5. As they gain skill and experience in the use of LOGO, students can move from concrete to more abstract levels of thinking.

Although much has been written about the virtues of using LOGO with populations with disabilities, we have far too little empirical data to make any conclusive statements about the advantages or disadvantages of using LOGO with students with disabilities. As Torgesen (1986) points out, all of the evidence thus far on the use of LOGO with students with disabilities is anecdotal, and even the evaluations of LOGO with non-disabled youngsters is ambiguous. Thus, at the present time, t re is little evidence that LOGO is as useful for the development problem solving skills in individuals with mild disabilities as its proponents would like us to believe.

Simulations

Computer-based simulations have long been recommended for teaching problem solving to students with disabiities (Goldenberg et al., 1984). In a simulation, the computer can model or recreate a real-life event that cannot be carried out easily in a traditional teaching environment. Simulations allow the student to vicariously experience such real-life events as space travel, homesteading in the 1800's, conducting a science experiment, or living as prey or predator in a food chain. Much has been written about the virtues of using simulations with learners with mild disabilities. For example, simulations can be used to introduce a sense of realism into what are often frustratingly abstract subjects for the learner with a mild disability. Further, computer simulations provide for the active participation rather than the passive role often taken by the handicapped learner. Dangers often associated with many real-life experiences can be eliminated. Real-life time periods can be compressed or expanded to meet learning requirements; at the same time, simulations offer a substantial cost reduction over many real-life experiences. Simulations also allow the learner to make low-risk decisions and receive feedback in the form of simulated consequences. Finally, the same event can be experienced more than once with the details slightly changed, thus allowing the learner to evolve more effective strategies over a series of attempts.

Certain guidelines are established for the appropriate use of computer simulations. Instances where simulations are most appropriate as a substitute for real-life experiences include:

1. when the learning objectives are complex and students are unlikely to be able to develop the needed skills in a real-life environment (e.g. work skills);

2. when the time scale of the real-life event is too long or too short to allow efficient learning (e.g. money management);

3. when the real-life experience involves danger or high cost (e.g. driver training); and

4. when the real-life event cannot be carried out in a normal teaching environment (e.g. voting).

Many simulations are described as programs for developing decision making, which is unquestionably an important aspect of problem solving. For example, in one of the most popular simulations, Oregon Trail, students must make numerous decisions as they interact with the simulation. Joiner, Silverstein, and Ross (1980) described the Oregon Trail simulation as follows:

> Oregon Trail simulates a settler family's journey by covered wagon, from Missouri to Oregon. Budget allotments must be made before the journey; the settlers' survival hinges on the judicious allocation of funds for clothing, medicine, supplies, ammunition, food, and emergency cash. Settlers can periodically choose between hunting for food, stopping at a fort (purchasing expensive supplies), or moving on. Hunting is simulated with the space bar on the keyboard (rifle) which fires bullets at a deer running across the screen. The settler may select the degree of perception and eye-hand coordination required to kill the running deer, or attacking bandits. Hailstorms, breakdowns, illnesses, injuries, and bandit attacks take their toll on the settlers and their resources. And, if their marksmanship or planning is inadequate, the family will not survive. (p. 36)

Although Oregon Trail is enjoyed by students and teachers alike, several noted authorities on thinking and problem-solving believe that students can solve and master a simulation such as Oregon Trail without developing effective problem-solving skills (Bransford, Stein, Delclos, & Littlefield, 1986). Bransford and his colleagues argue that decisions made in many simulations can be based mainly on trial and error guessing rather than on systematic analysis of the available information. The danger that simulations will encourage trial and error responding is increased by the fact that, initially, students have very little information about the simulations and hence are reduced to guessing. Bransford et al. argue that a more effective procedure would be to teach information-gathering skills by first helping students consult external sources of information that could assist them in making more rational decisions during the simulations.

Woodward, Carnine, and Collins (1986) used the approach advocated by Bransford et al. in a series of simulation activities in health-related areas. They randomly assigned subjects to either a simulation group or a conventional instruction group. Both groups received initial instruction in health-related problem-solving skills. The simulation group then received additional instruction using a computer simulation that consisted of (a) initial modeling of the problem-solving routines, (b) guided-practice using simulation games, and (c) independent practice using simulation games. The conventional group received review activities presented by a resource teacher.

The results of the study indicated that the simulation group was superior to the conventional group on measures of problem solving in the areas of diagnosing health problems, prioritizing them as to their effects on a persons longevity, and prescribing appropriate remedies.

Conclusions

Computer simulation can be used to extend the boundaries of the traditional teaching environment in a safe and cost-effective manner. Although computer simulations provide the student with disabilities with learning opportunities often not possible in traditional learning environments, some caution must be observed. As Bransford et al. point out, people often fail to use appropriate concepts and strategies because they do not realize that this information is relevant. Teaching methods that bridge relevant pieces of information must be be used to increase the probability that appropriate inforamtion will be used in improve decision making and problem solving through computer simulations. Although it appears that simulations may produce improved problem solving, this is likely to occur only when prior information is provided and can be used as part of the simulation.

Computer-Managed Instruction

The successful planning and management of instruction for mentally disabled student is based upon sound decision-making. Making successful instructional decisions requires that for each individual student a teacher must know when an instructional plan should be changed, as well as what kind of change must be made. Unfortunately, most teachers have not been trained adequately in the decision-making process. As a result, the act of making decisions is often uncounscious and arbitrary (Shavelson, 1973, 1976).

In recent years, the technology of decision-making has been improved through the use of data-based instruction (DBI) procedures. DBI procedures employ regular monitoring of students' performance under different instructional programs. The purpose of this monitoring is to provide a data base from which individualized instruction programs can be developed empirically. Using data-based instruction procedures, teachers (a) select long-term goals, (b) design measurement systems that correspond to those curricular goals, (c) routinely monitor student progress toward the goals using the measurement systems, (d) use the database to evaluate the effectiveness of the educational program, and (e) modify instruction as needed to ensure goal attainment (Fuchs, Fuchs, Hamlett & Hasselbring, 1987).

Research on the effectiveness of data-based instruction has indicated that this methodology is quite promising for improving student achievement. For example, Fuchs and Fuchs (1986) conducted a meta-analysis of 21 controlled studies that evaluated DBI procedures. The results of this analysis indicated the use of DBI procedures significantly increased the academic achievement of students whose teachers used these procedures. From these findings, one can expect that students whose instructional programs are monitored using DBI procedures achieve significantly more than students whose programs are not monitored using a DBI approach. A secondary finding of this meta-analysis was that when teachers were required to employ specific data-based decision rules, student achievement was greater than when data were evaluated using teacher judgement. Further, when data were graphed, effect sizes were greater than when data were simply recorded.

Fuchs and Fuchs concluded from their meta-analysis that the use of DBI procedures within special education reliably increase student academic achievement and that the effects may be enhanced when teachers use specific data-based decision rules as well as graphed data displays. Despite the apparent effectiveness of DBI procedures, all indications are that teachers are reluctant to employ them. In a national survey of LD teachers, Wesson, King, and Deno (1984) found that, although teachers believe that DBI procedures are effective, they do not use the methodology because it is too time consuming.

Computer-Based Monitoring

In an attempt to make data-based instruction less time consuming and easier for teachers to implement, a number of developers have proposed the use of microcomputers for implementing DBI procedures (Fuchs, Deno, & Mirkin, 1983; Hasselbring & Hamlett, 1985; Walton, 1986; West, 1984). Basically, these monitoring programs have been designed to assist teachers in storing, graphing, and analyzing student performance data. One such computer program that has been used successfully in special education is AIMSTAR.

AIMSTAR

AIMSTAR is an integrated set of computer programs that are designed to assist teachers in storing, graphing, and analyzing student performance data. To use AIMSTAR, the teacher creates a student data file. Descriptive information about the student's instructional program, the program objectives, and teaching procedures are included. Following each teaching session, the teacher enters student performance data into the computer. For example, the number of correct and incorrect responses exhibited by the student and the amount of time required for the student to complete the trials. AIMSTAR then stores this information, allows the teacher to graph the student's data, apply data-based decision-rules, and produce a printout giving the status of the student's instructional program with recommended changes when appropriate.

It should be noted that AIMSTAR does not eliminate the need for teacher intuition and judgement in planning instruction. Rather, it supplements teacher judgement by providing additional empirical data and analytic procedures. Special education teachers using this technology are able to respond more flexibly and effectively to changing student needs and produce greater student growth through this use of technology.

SUMMARY

In this chapter we have provided a discussion of effective computer applications for learners with mentally disabilities. We have attempted to make this chapter different from most others by focusing on applications that have a demonstrated empirical base. All of the applications described in this chapter have shown potential for enhancing the delivery of instructional services to learners with mild disabilities. It must be remembered, however, that the use of microcomputers will contribute to the needs of learners with mild disabilities only when the strengths of the technology are capitalized on and the inappropriate applications are minimized.

Although schools are purchasing computers in large numbers, there are still too few computers to allow computer-based instruction to be an integral part of every learner with a mild disability's education. Given this as a reality, we would like to close with two important principles that should guide your use of microcomputers with this population. The first principle is that computers be used for presenting information that cannot be duplicated by less expensive means. Although this may seem intuitively obvious, many of the current uses of the microcomputer are no different than activities available in books or other printed forms. In this chapter we have attempted to present applications that, for the most part, capitalize on the unique features of the computer. The second principle is one of educational priority. Although there are many areas in which students with mentally disabilities need instruction, a tool as expensive and potentially powerful as a computer should be focused on the most important needs first. Thus, in combination, these principles suggest that not every student should be provided with computer-based learning and that many of the latest computer fads should be bypassed in favor of more well established learning programs. Although focus on more complex academic skills may be more exciting and intellectually challenging for teachers, the best research suggests that the most powerful and immediate impact on the learning of students with mild disbilities is through the use of computers to develop mastery and fluency of basic academic skills.

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