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ABSTRACT

Progress is reported on research conducted in school settings to investigate methods to help students--especially at-risk students--to acquire and use knowledge to solve problems. The methods incorporate principles of learning and instruction derived from basic research on cognition. Specifically, the research involves using microcomputer and videodisc technology in three ways: to develop fluent access to knowledge and skills; to integrate knowledge to support subsequent problem solving; and to help students to be producers, not mere consumers, of knowledge. The enhanced motivation that seems to result from use of these technological innovations is also discussed. (10 references) (JDD)

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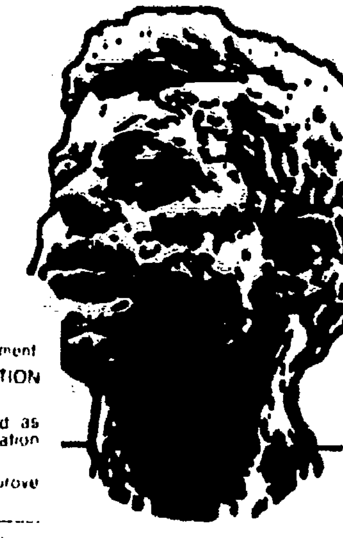

RESEARCH PROGRESS

John F. Kennedy Center

for Research on Education and Human Development
George Peabody College, Vanderbilt University
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The Use of Technology With Special Needs Students

Although the national educational system has always had students at risk for school failure, the challenge of educating students who have difficulty learning has become a matter of public debate and media attention. The absolute number of students at risk is increasing as our population changes. According to the American Council on Education, the majority of our children, 59%, will live with one parent because of divorce, separation, or death; already 4 million are latch key children and 14 million live in poverty. At the same time that our schools will serve increasing numbers of students at risk, U. S. competition in the world economy will demand ever-larger numbers of educated, skilled workers.

Kennedy Center investigators John Bransford and Ted Hasselbring* have been conducting research in school settings to investigate ways to help students—especially at-risk students—to acquire and use knowledge to solve problems. Incorporating principles of learning and instruction derived from basic research on cognition, they have used microcomputer and videodisc technology in three ways: to develop fluent access to knowledge and skills, to integrate knowledge to support subsequent problem solving, and to help students be producers, not mere consumers, of knowledge. Other Peabody College faculty members in a variety of disciplines, e.g., reading, math, and science education, have also contributed.

Fluency

While cognitive science research has identified general processes and strategies that underlie effective problem solving, they are only part of the story. Effective thinking and problem solving also require specific knowledge—accessed with fluency. Without fluency, our limited attention becomes overwhelmed.

Researchers have studied and compared experts in various domains, e.g., chess, physics, computer programming. Regardless of domain, one major aspect is the *rapid*, almost effortless, recognition of familiar patterns. A clear example of fluency is learning to drive a car. When we first begin to drive, we laboriously attend to every detail; later, as we become fluent, operating the car requires little conscious attention.

The power of fluency was illustrated in a video-based experiment by Bransford, Sherwood**, and Hasselbring (1987). A houseboat expert was asked for an appraisal of a houseboat that was represented as a 1980 Gibson boat with all the options. The expert viewed, only once, 10 seconds of video that panned the houseboat from front to rear. He noticed that the boat lacked all the options; its sliding glass door was inconsistent with the 1980 model and thus it may have been made before 1980. He also noted that it did not have standard Gibson rails, suggesting that the boat may have been damaged or repaired, and from the paint sheen concluded that it probably had been repainted. To those unfamiliar with houseboats, none of these points was evident. With training and unlimited time, we might have been able to check for relevant features yet still have problems when faced with the need for fast-action pattern recognition like that exhibited by the houseboat expert.

* Professor of Psychology and Professor of Special Education, Peabody College, Vanderbilt University, respectively. This research program has been funded by grants from the Office of Special Education Programs in the U. S. Department of Education (G008630134, G008300052, G008730072) and from the James S. McDonnell Foundation.

** R. D. Sherwood, Associate Professor of Education and Chair of the Department of Teaching and Learning, Peabody College, Vanderbilt University.

Fluency in Academic Tasks

The preceding example illustrates the importance of fluency in nonacademic tasks, but there are numerous examples in the classroom as well. Students who must slowly sound out each word as they read have little idea what they have read. If students are trying to do creative writing but must stop to recall how to spell each word, they have little attentional capacity left for the writing.

Recent research supports the idea that fluency in basic math skills is necessary for achievement in mathematics. For the past several years, Hasselbring, Goin*, and Bransford have been studying the development of mathematical fluency by learning handicapped students. Fluency is defined as the relatively effortless, errorless retrieval of basic math facts from memory.

The researchers conducted a large-scale assessment to determine fluency levels for addition facts. They compared learning handicapped students ranging in age from 7 through 14 years with regular education students matched for age, race, and gender. Several differences between the two groups were found. At 7 and 8 years, learning handicapped students were 20% less accurate than their nonhandicapped peers. By age 9, however, the discrepancy between the two groups was reduced to about 5%, and this level was maintained to at least age 14. If one were assessing performance relative to accuracy of response, these at-risk students would appear to be performing satisfactorily.

A different pattern emerges when one measures the fluency of students' recall of math facts. (Responses were considered fluent if students could answer within 3/4 of a second.) By age 7, nonhandicapped students can fluently recall more facts from memory than can their learning handicapped peers. What is more striking is that this discrepancy increases as age increases (see Figure 1). Thus, as learning handicapped children get older, they fall further behind their nonhandicapped peers in the ability to recall facts from memory fluently. Later research indicated that this discrepancy in fluency was consistent across addition, subtraction, multiplication, and division operations.

These findings suggest that once learning handicapped children find a strategy that is successful (usually counting), they do not continue a normal developmental progression and shift to a more efficient strategy. In turn, this suggests that with appropriate and sufficient amounts of instruction, learning handicapped children can develop fluency in basic math facts.

Beyond Drill and Practice

Conventional wisdom held that if computer-based drill and practice were used with learning handicapped students and used enough, they would give up counting strategies and recall this information from memory.

* L. Goin, Program Coordinator, Learning Technology Center.

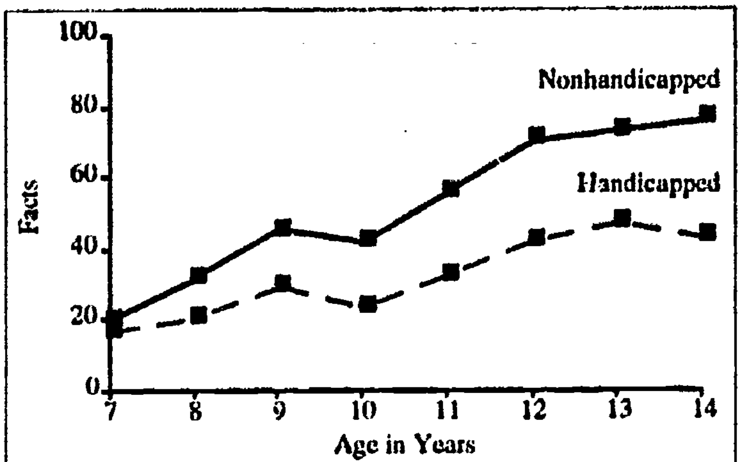

Figure 1
Comparison of the number of fluent addition facts by age for handicapped and nonhandicapped learners

Hasselbring and colleagues examined the effect of commercial computer software on developing fluency of addition facts. They found that this form of drill and practice had no effect on developing fluency in learning handicapped students unless those students had already dropped their attachment to a counting strategy. They concluded that the key to making drill and practice an activity that will lead to fluency is additional instruction—prior to drill and practice—that establishes a declarative knowledge network to replace dependence on counting strategies.

Hasselbring and Bransford developed a software program for fluency training that incorporated several design principles derived from the cognitive and effective teaching literature. The program individualizes instruction for each student based upon an initial assessment of a student's level of fluency. Nonfluent facts are targeted for recall training to develop the declarative network. Students work on a small set of nonfluent facts that are interspersed between facts they can already recall from memory. Fluent facts are used as "spacers" so that the amount of time between presentations of the target fact is gradually increased, increasing the potential retention of the new information.

Standard drill and practice programs rarely limit the amount of time to respond, thus allowing students to fall back on their counting strategies. In contrast, the recall training employs a controlled response time to help students relinquish their use of slow counting strategies.

Finally, the program carefully controls a student's movement from recall instruction to drill and practice. As soon as a student is able to retrieve the answer to a target fact consistently within the controlled 1.25 seconds response limit, that fact is added to the student's set of drill and practice facts.

The experimental program was found to be successful with learning handicapped children. One study examined a group of 160 mildly handicapped and nonhandicapped students ages 7 through 14 years. The handicapped students were assigned to either a computer or contrast condition; the nonhandicapped students served as contrasts only. The computer group received retrieval training plus drill and practice averaging only 10 minutes per day. The two contrast groups received only the math instruction provided by their classroom teacher.

The results of the study are shown in Figure 2. After 49 days of using the math software, the handicapped-experimental group showed a 75% increase in recall of facts compared to pretest. During the same period, the contrast group of handicapped learners showed no change, and the nonhandicapped students averaged only 8 additional facts. Thus, the handicapped-experimental group developed fluent facts at a rate twice that of their nonhandicapped peers.

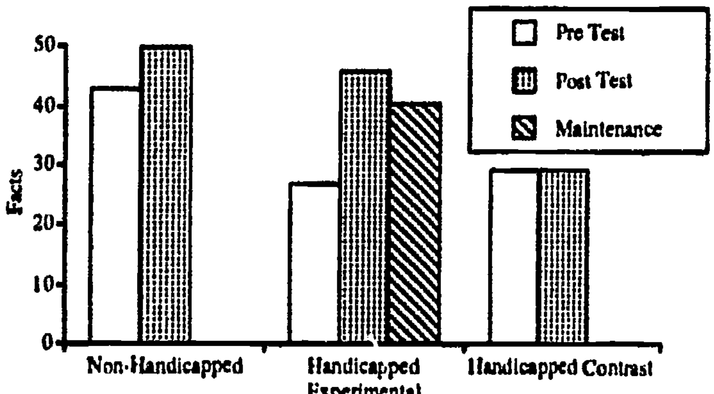

Figure 2
Comparison of pre, post, and maintenance data for non-handicapped, handicapped-experimental, and handicapped-contrast groups in study involving software program for fluency training in addition facts

This research suggests that the combination of recall training plus drill is a powerful mechanism for developing fluency in handicapped learners. However, one must be cautious and not assume that fluency will automatically lead to the development of higher-order math skills. Instead, such linkages will have to be developed through a mediation process with teachers providing links between this new learned information and higher-order skills.

While this research focused on learning handicapped students, the principles identified are generalizable to traditional school groups. Nonhandicapped students under age 10 had less than 50% of their basic math additional facts automatized and they did not reach the 80% level even at age 14. Therefore, the value for *all* students of some type of intervention to increase math fluency appears clear.

Creating Shared Contexts for Learning

Microcomputer and video technology can create semantically rich contexts for problem solving and discovery. During their first four or five years of life, children are effective learners who acquire concepts, language, and motor skills rapidly and easily while learning in everyday contexts. Research on conditions that make children's early learning so successful indicates that one major advantage involves learning in the context of meaningful, ongoing activities. Children learn best when they and a parent, or another mediator like a teacher, share a context that can be mutually explored. Once children enter school, learning tends to be decontextualized.

The idea of a shared context is not new; preschool educators have emphasized its importance for years. Susan Gray*, one of the pioneers of early childhood education whose Early Training Project in the 1960s was a precursor of Head Start, has discussed the importance of teaching in the context of real world environments. As an illustration, she notes that grocery stores are an excellent context for teaching about categorization and other aspects of literacy. By learning in context, children can see the need for various procedures and skills.

In the classroom, teachers try to help students relate new information to previously acquired knowledge. However, unlike parents, teachers often do not know which experiences are relevant for a particular child. With the tools of videotape and random access videodisc, teachers can create contexts that teachers, children, and, ultimately, parents can share. Video technology cannot substitute for "hands-on activities" in various real-world contexts. Nevertheless, it offers some advantages since, unlike a field trip, it can be replayed and reviewed as often as necessary.

Shared Context in the Middle Schools

Bransford, Hasselbring, and colleagues' initial work in this area has involved the use of segments from existing movies on videodisc to provide contexts for teaching problem solving. One context involves the first 12 minutes of *Raiders of the Lost Ark.* Indiana Jones goes to a South American jungle in search of a golden idol. While students initially see it as an adventure, it involves considerable problem solving. For example, there is evidence that Indiana Jones planned ahead; he took maps, arranged for a plane to pick him up, had appropriate supplies in his backpack, and knew to put sand into a bag before he reached the idol. By re-examining the videodisc, teachers can help students discover this evidence for themselves.

Raiders has also been used to teach estimation and measurement in problem solving. For example, how would one determine if a person could jump a pit as wide as the one Indiana has to jump? While it would help to be able to measure the pit, it is useless to measure it on the screen. Using the video, a teacher can introduce the idea of relative measurement, taking Indiana Jones as a standard. Assuming that he is about 6 feet tall, students can estimate that the pit is 12 feet across, because it is 2 Indianas wide.

Using *Raiders*, Bransford and Hasselbring have conducted studies with math-delayed fifth and sixth graders who are 1 to 2 years behind their peers in school. The purpose was to contrast typical methods of learning to solve word problems with an approach that emphasized the qualitative

* Professor of Psychology Emerita and Kennedy Center Investigator.

aspects of the problem first and added numbers to the word problems only after children understood the relationship of the problem components.

Two types of pretests were administered to two randomly assigned groups. One pretest included only word problems in the *Raiders* context and the other had problems unrelated to this context. Performance was poor on both tests. As expected, simple reference to a context used for entertainment was ineffective. The context referred to had to be used in a teaching mode. During the instruction phase, one group was taught in the context of the movie. The other group was taught one-on-one, giving them feedback but taught out of context.

Posttests included some problems that had to do with *Raiders* (contextualized) and some that did not (decontextualized). The videodisc group did well on both parts, but the second group performed only slightly better than they had before the teaching. Students in the videodisc context received a great deal of guidance and feedback; the video-based context was only a part of the treatment. It appears to be an important part, however, because it can help students understand the nature and interconnections of problems they are trying to solve.

A similar contextualized approach to instruction has been used to teach science. The initial studies in this series took place with college students who were given a number of passages frequently read in science classes. One group just read passages, as they are typically asked to do in a class. The other group was provided with a videodisc context from *Raiders*. A sample is the golden idol problem. Indiana Jones tries to replace the golden idol with a bag of sand. Students were asked to estimate how heavy the idol would be if it were solid gold. Facts about density, which the students then read to solve the problem, indicate that gold is extremely dense; a gold idol would weigh almost twice as much as a lead idol of the same volume. Students were able to estimate that the solid gold idol would weigh at least 60 pounds and the bag of sand only about 11 pounds.

The video group recalled information better and scored higher than the control group, which was given problems out of context. Additionally, in n even more important test, students were put in new problem-solving situations to see if they would spontaneously use the knowledge learned earlier. Even larger differences were found between the performances of the video and nonvideo group. These findings involving college students have been replicated with both fifth- and eighth-grade students with similar results.*

Video technology allows teachers to set up a context in which all the students can share. It allows multiple examinations of the situation, especially when learners are having difficulty. Overall, it appears to allow the knowledge obtained from the video-based instruction to be *used* in other problem-solving situations, rather than remaining inert.

* The Learning Technology Center's "Jasper Woodbury" problem-solving series is based on the principles derived from the *Raiders*-based research. See Cognition & Technology Group at Vanderbilt, 1990.

Students as Producers

A third aspect of using technology is that it can help students become producers of information rather than just consumers. One exciting development involves multimedia compositions that combine text, graphics, and videodiscs. Bransford and Hasselbring and colleagues at Vanderbilt's Learning Technology Center have developed a simple-to-use program called "Producer." Students as young as fifth grade have created interesting stories using video from films. One set of sixth-grade girls used segments of *Raiders* to create a story called "Snake Shop," an advertisement for their mythical store. In a more traditional academic application, students used *Star Wars* to write science-related stories about light.

Several aspects of students' uses of "Producer" are noteworthy. First, classmates are extremely interested in one another's presentations. Teachers have been surprised at the level of attention and subsequent discussion. Second, the quality of students' productions has been good and their creativity has surprised teachers. Third, students seem highly motivated to create such products.

Improvement in student products requires effective teaching and practice followed by feedback. The exciting aspect of multimedia composition is that it enhances students' motivation to create and present interesting products. Furthermore, the act of finding scenes relevant to themes develops skills of problem identification, problem generation, and pattern recognition—aspects of problem solving that may be lacking in traditional instructional settings. Additionally, video segments can be used to generate novel and interesting word problems in math classes, to illustrate word definitions, or even to stimulate discussions of ethical situations.

Motivation

Large-scale studies of technological innovations are needed, especially projects that emphasize the areas of fluency, contextualized learning, students as producers, and enhanced motivation. In the studies discussed above, students' motivation to continue to learn seemed to increase, although formal measures were not conducted.

One project involving all four components is focused on the turn of the century and uses the film *The Young Sherlock Holmes*, set in the 1890s in England. After first viewing it as entertainment, students return to individual scenes to study how the film depicts social, technological, economic, political, scientific, and geographical information. They are encouraged to question the accuracy of information in the film and to understand the context from a variety of perspectives. After becoming fluent in their knowledge of Victorian England, students link this experience to other settings in the same period: *Hello, Dolly,* illustrating New York, and *Oklahoma.* Students can also use *The Young Sherlock* videodisc to produce their own stories. For example, students have devised news teams, with an economic "journalist" reporting on the economic conditions in the 1880s and a "society editor" reporting on social events.

Another project *River Adventure* involves the creation of a videodisc context for teaching mathematical and scientific thinking. The video depicts a family who has won the use of a houseboat for a week and must make decisions about how much water, fuel, and other supplies to carry, as well as how to navigate the houseboat down the river through locks and at different speeds. One of the project goals is to develop a set of design principles for creating environments through video that facilitate problem finding as well as problem solving and allow instruction across a variety of domains.

In addition to the development of large-scale attempts to combine the various aspects of technology, there is a need to develop affordable software that can easily be used by teachers and students. Recently the Learning and Technology research group has developed "Vanderbilt Vision Maker," which is easier to use than "Producer" and requires much less expensive hardware. They also are developing "fluency" software that incorporates cognitive-based design principles for use in any domain.

Finally, it is critical to develop programs that can help teachers learn to use technology more effectively. Several Vanderbilt research groups are using videodisc technology to enhance preservice teaching.

Technology can be used to help all students, especially students who are at risk of school failure. The data from these projects and from others nationwide afford a merger of recent knowledge about cognition, instruction, and culture with new technologies to develop instructional systems. These afford the opportunity to make significant changes in the way the teaching and learning process is thought about and carried out in school. It is not the technology itself but this merging of information from many disciplines with technology that can make a difference.

About Research Progress

This series describes research conducted in the John F. Kennedy Center, one of twelve national centers for research on mental retardation and related aspects of human development, and is supported in part by Grant No. HD15052 from the National Institute of Child Health and Human Development.

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Note: This report is based on Bransford and Hasselbring's March 1988 presentation in the Kennedy Center's Research Colloquia on Human Development and their article in the *Peabody Journal of Education* cited above.