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ABSTRACT

This monograph reports the proceedings of the Multimedia Technology Seminar and consists of presented papers as well as summaries of demonstration and discussion sessions. Sessions covered the following topics: the role of learning theory in the development and application of multimedia technologies in special education; multimedia research in progress and issues related to conducting multimedia research; emerging technologies and how researchers can work with developers to use and direct these technologies toward special education applications; curriculum-based applications of technology for special education, including specific areas of need, concerns, and/or recommendations; research issues in different types of research environments; research questions and strategies for advancing both multimedia research and the multimedia knowledge base; and current research efforts, issues, and challenges and the future of multimedia technology for special education. An agenda and list of participants are included. References accompany the major papers. (DB)

PROCEEDINGS

MULTIMEDIA TECHNOLOGY SEMINAR

ANA HOTEL, Washington, DC
May 20-21, 1991

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Preface

The Multimedia Technology Seminar held May 20-21, 1991 in Washington, DC, was the final research seminar on technology hosted by the Center for Special Education Technology in 1991; and, the last in a series of technology seminars and symposia conducted for researchers over the past seven years. The focus of interactive multimedia instruction in special education was chosen based upon a survey of researchers completed in 1989.

The goals for the seminar included:

1. to update researchers on emerging multimedia technologies;
2. to examine potential applications of these technologies for special education populations; and
3. to identify research issues and implications for the design and use of these technologies in special education instruction and training.

The seminar agenda, designed to provide a forum for the exchange of information on issues related to new and emerging multimedia technologies, included sessions on the following:

- The role of learning theory in the development and application of multimedia technologies in special education.
- Multimedia research in progress and issues related to conducting multimedia research.
- Emerging technologies and how researchers can work with developers to use and direct these technologies toward application for special education.
- Education and curriculum-based applications of technology for special education, including specific areas of need, concerns, and/or recommendations.
- Research issues in different types of research environments.
- Research questions and strategies for advancing both multimedia research and the multimedia knowledge base.
- Current research efforts, issues, challenges, and future of multimedia technology for special education.

The proceedings document for the Multimedia Technology Seminar provides a record of the two-day meeting. The report consists of papers developed by the invited presenters as well as summaries of demonstration and discussion sessions. This document has been prepared to represent state-of-the-art thinking and to serve as a planning document for future research and development of multimedia technology for special education.

Integrated Media: Toward a Theoretical Framework for Utilizing Their Potential[1]

The Cognition and Technology Group at Vanderbilt[2]

Recent developments in computing and communication technology make it possible to link text, video, audio, and interactive computer programs in ways that were not possible only a few years ago. We refer to these multiple forms of linked media as *integrated media* (IM) rather than as *multi media* (MM). We prefer the term "IM" because it reminds us that our goal is to integrate media in ways that facilitate learning, which is different from the goal of simply multiplying the number of media available to learners. As we emphasize below, the availability of additional media does not guarantee more effective learning. Therefore, something more than "the more modalities the better" must guide the development of applications.

Our goal in this section is to discuss two general approaches to the design and study of IM applications and to relate them to current theories of learning and thinking. The first approach, the most common, represents the way that we began to develop and study IM applications. We call it the "curricular embellishment" approach because it involves beginning with an existing curriculum (or part of one) and embellishing it through IM applications. We discuss here the advantages of these IM applications for extending the traditional curriculum within the current classroom framework.

The major disadvantage of using IM applications to embellish existing curricula is that they reify a model of instruction that is being seriously questioned by policymakers, researchers, and practitioners. Thus, an increasingly large number of investigators argue that new theories of learning and development suggest the need for curricular materials and teaching practices that are quite different from those now available (e.g., Beck, 1991; Bransford, Goldman, & Vye, in press; Brown, Collins, & Guduid, 1989; CTGV, in press; CTGV, 1990, 1991a, 1991b; Lampert, 1990; Resnick, 1987; Resnick & Klopfer, 1989).

The second approach that we will discuss uses IM to "break the mold" of existing curricula and fundamentally alters the relationship among teacher, learner, and tools for teaching and learning. For example, we will discuss IM applications in which students (a) explore environments and generate issues and questions to be researched further; (b) produce knowledge rather than merely receive it passively; and (c) teach others rather than always waiting to be taught by someone else.

We begin our discussion with an overview of ways in which current theories of learning and memory can guide IM applications that embellish existing curricula. We then consider theoretical reasons for breaking the mold. Finally, we end the discussion by providing some examples of IM-based "break the mold" programs that are being implemented on an experimental basis in schools.

The "Curricular Embellishment" Approach

As noted, we began to explore instructional opportunities made possible by IM by studying the value-added of using IM to embellish a subset of an existing curriculum in some manner. Duffy and Knuth (in press) reported a similar experience as they began to experiment with IM. This approach quickly makes it apparent that IM offers exciting possibilities for improving learning. In the present section, we begin our exploration of new possibilities by discussing IM applications whose value is readily apparent—especially for providing the kinds of support that help teachers adaptively respond to a variety of individual differences in learning strategies and background knowledge. We then consider how these applications might be improved even further as theories of learning and thinking are explored in more detail.

Books That Talk, Define Vocabulary, Translate, and Illustrate

A "new look" in books has been made possible by IM technologies. As an illustration, imagine a classic story such as "Little Red Riding Hood." In book form the story consists of print plus illustrations. This is an excellent format for people who can read and who have acquired the background knowledge necessary to understand the story. For those who are not at this level, however, the book requires a person (mentor) to help with the reading and comprehension. This is not a problem when there is one mentor (e.g., parent) for one or two students. In typical classroom situations, however, it can be very difficult for teachers to help all the children as much as they would like.

New IM technologies make it possible to create books that provide many of the resources of an experienced mentor. In Discis books (1990), for example, the printed story and the illustrations are displayed on the computer screen and look like a book with pages. However, the reader can also select options such as (a) have the book read aloud in its entirety (relevant text is highlighted as the reading progresses); (b) have any word or phrase pronounced as requested (with the child reading the printed text the rest of the time); (c) have key vocabulary words defined as needed; and (d) have texts, sentences, or words translated into some other language (assuming that this language translation has been encoded into the program).

Clearly, IM applications such as these provide many potential advantages over traditional books. Nevertheless, such applications also raise questions about (a) potential dangers and (b) additional opportunities for improving learning. As these areas are explored, the literature on cognition and learning becomes increasingly helpful. We discuss several examples below.

Visual Support for Comprehension

An important area in which learning theory becomes relevant to IM development involves listening comprehension. Computer texts such as Discis books do an excellent job of helping students transform a task that requires reading into one that involves listening comprehension. Such books also support listening comprehension by providing definitions of unknown words and visual illustrations that accompany the stories on disk. Nevertheless, there is much more room for comprehension support than current IM applications provide.

Data indicate that there are large individual differences in listening comprehension and that many students who do not read also have poor listening-comprehension skills (e.g., Curtis, 1980; Juel, 1991). Furthermore, students with poor listening-comprehension skills in the early grades tend to be poor at these skills in later grades (Juel, 1991). Apparently, many approaches to instruction do not help students develop effective listening-comprehension skills.

One of the processes of effective listening comprehension consists of creating mental models of situations described in a story (e.g., Johnson-Laird, 1983; van Dijk & Kintsch, 1983). For example, imagine that children listen to a simple story involving a thirsty bird who is unable to drink from a glass of water because its beak is not long enough. The bird suddenly gets an insight and begins to put pebbles into the glass. When the water level is high enough, the bird is able to get the water in the glass. In order to understand this part of the story, children need to understand that pebbles raise the water level in the glass. We have worked with a number of young children who seem to have great difficulty imagining situations such as this unless they are given dynamic, visual support (Sharp, Bransford, Bye, & Goldman, in preparation).

Theories of comprehension and mental model-building are reviewed in a number of chapters so we will not elaborate on them here (e.g., Glenberg, Meyer, & Lindem, 1987; Johnson-Laird, 1983; McNamara, Miller, & Bransford, 1991; Morrow, Greenspan, & Bower, 1987; van Dijk & Kintsch, 1983). Mental-model theorists' perspectives differ somewhat; however, for present purposes, the important point is that an emphasis on mental-model construction provides a framework for thinking about ways to design IM applications that provide comprehension support.

One example of information that can support mental-model construction is the use of visual illustrations. Programs such as Discis books have purposely used the original illustrations of the stories that they computerize, hence their choice of which illustrations to use is straightforward. However, an extensive research literature on pictures and comprehension shows that pictures vary in their effectiveness and that many pictures found in books do not support comprehension.

For example, research has shown that decorative pictures, which do not provide information about the actual situations in a story, do not help children remember stories. An example of such decorative illustrations can be found in a storybook of Thumbellina, where the picture shows Thumbellina surrounded by fanciful vines and creatures from the story, but does not depict any particular scene in the story (Levin, 1981; Levin, Anglin, & Carney, 1987). In our view, decorative pictures fail to aid comprehension because they do not help children construct mental models of the actual story situation.

In contrast, when pictures illustrate actual scenes from a story, they improve children's memory for the story, especially if the pictures help organize complex scenes or parts of scenes that may be difficult to imagine (Levie & Lentz, 1982; Levin, 1981; Levin et al., 1987). Because mental models are in many ways like mental images (Miller, 1989; Sharp & McNamara, 1990), pictures that help children imagine what scenes in a story look like should help construct good mental models.

Research also suggests that pictures can act as frameworks for mental models, even if they do not depict all the information in a story. In a series of studies on partial pictures, children were given short stories or sentences accompanied by pictures that only illustrated part of the story information. For example, children were told, "One evening Sue's family sat down to eat a big turkey for dinner," and were shown a picture of the family seated at the table with the mother's head occluding the center of the table where the turkey was supposed to be. These partial pictures improved children's ability to remember the stories, including information that was not in the picture, like the turkey on the table (Guttman, Levin, & Pressley, 1977; Woolridge, Nall, Hughes, Rauch, Stewart, & Richman, 1982). Apparently, children were able to use the pictures as a mental-model framework onto which other information from the story could be added and imagined.

Other research shows that pictures have to be carefully constructed if they are to serve as mental-model frameworks for additional story information (Levie & Lentz, 1982). If a picture does not specify enough information about a scene, children may be unable to imagine the rest of the scene that is described by the story. For example, in one study children were given a story about a little girl who found a bird on some steps near her house. In the story, the little girl put the bird in her pocket and carried it into the house, shutting the door behind her. The picture accompanying the story showed the bird on some steps near the little girl, but did not show either the little girl's pocket or the house. As a result, the picture helped children remember that the bird was on some steps, but did not help them remember that the little girl carried the bird in her pocket into the house (Levie & Lentz, 1982). If the picture had contained more information, like the partial pictures described above, it might have served as an effective framework, even if it did not actually show the girl carrying the bird.

The research discussed above was based on the use of static pictures such as those seen in texts. In many instances, IM systems that show dynamic illustrations often provide much more support for comprehension than is possible through the use of static pictures. For example, hypercard stacks exist that allow users to "click through" the actual workings of a two-cycle engine. Given the goal of understanding how such engines work (as opposed to merely learning the labels for engine parts, for example), the dynamic model clearly seems superior to a mere static picture of the engine. Similarly, many models in science and other fields (e.g., of molecules and chemical bonding) become much clearer when presented with dynamic rather than static visuals.

Our earlier discussion of the literature on static pictures provides suggestions for ways whereby dynamic visual images can be used to their fullest advantage. For example, given a particular content area to be conveyed, it is useful to consider the kinds of mental models that are available to experts in the area and then ask about the kinds of visuals that might help students construct these models. When potential videos are evaluated from this perspective, it becomes clear that some will attract attention but not support mental model-building, whereas others will provide the kinds of support that leads to deep understanding and effective retrieval from memory of key information. Pilot data collected by our group suggest that different types of dynamic visuals provide differential support for young children's mental model building.

Promoting Knowledge Organization

The learning literature also suggests the benefits to IM developers of paying attention to the goal of helping students organize their knowledge in ways that promote retention and transfer (e.g., Bransford, Vye, Adams, & Perfetto, 1989; Chi, Feltovich, & Glaser, 1980; Chi, Glaser, & Farr, in press). Different designs for the computer interfaces used to help students gain access to knowledge have implications for the organization of the knowledge that they eventually learn.

The preceding issue becomes clearer by considering the present text, which is in print form. It has a number of headings and subheadings that the reader encounters in a linear order as he/she reads through the text. We could have provided an overview of the paper's structure in the introduction, allowing readers to see the text's overall structure. Nevertheless, unless he/she rereads, the reader would have seen the overall structure only once.

Imagine the present text in a very simplified hypermedia format. In this imaginary condition, the interface screen that appears to the reader is the organizational structure of the text (see Figure 1). By clicking on any aspect of that structure, readers can gain access to the relevant body of the text. After reading it, they return to the initial screen. This format offers a simple advantage compared to the linear format. After reading about each section, students return to the initial card and re-see the text's overall structure. Theories of knowledge organization and text comprehension (e.g., Chi et al., in press; van Djik & Kintsch,

1983) suggest that this organization helps later recall of the text content because the text structure is revisited frequently and can later function as a set of retrieval cues. Experiments conducted by Larkin and colleagues (1990) compared students' memory for a text presented in linear format to an organized hypermedia format analogous to Figure 1. Their data support the recall advantages of the hypermedia-organized text.

The structure illustrated in Figure 1 provides an organization that is specific to a particular text. In other instances, one can imagine creating interfaces that involve *general features*, which can help students develop schemas (e.g., Anderson, 1987; Bransford, 1984) that can facilitate comprehension of new information. For example, an interface for the kinds of stories used in Discis books might allow students to gain access to the text (perhaps for purposes of review or for presentation to others) by clicking on story categories such as "Hero/Heroine," "Villain," "Goal," "Goal Conflict," "Resolution," "Ending." Through repeated use of this interface to gain access to a variety of stories, we might expect all students to more quickly develop powerful "story schemas" (e.g., Anderson, 1987; Short & Ryan, 1984; Stein & Trabasso, 1982).

Similar advantages might derive from the use of powerful organizational schemes for studying expository texts that contain information about social studies, science, mathematics, and so forth. For example, general categories of information (e.g., social-economic conditions, political conditions, religious conditions, geographical conditions) are relevant for understanding a country and its people. By working with such structures to access specific texts, students should develop schemas that can help them continue to use such categories of information in order to learn and communicate on their own.

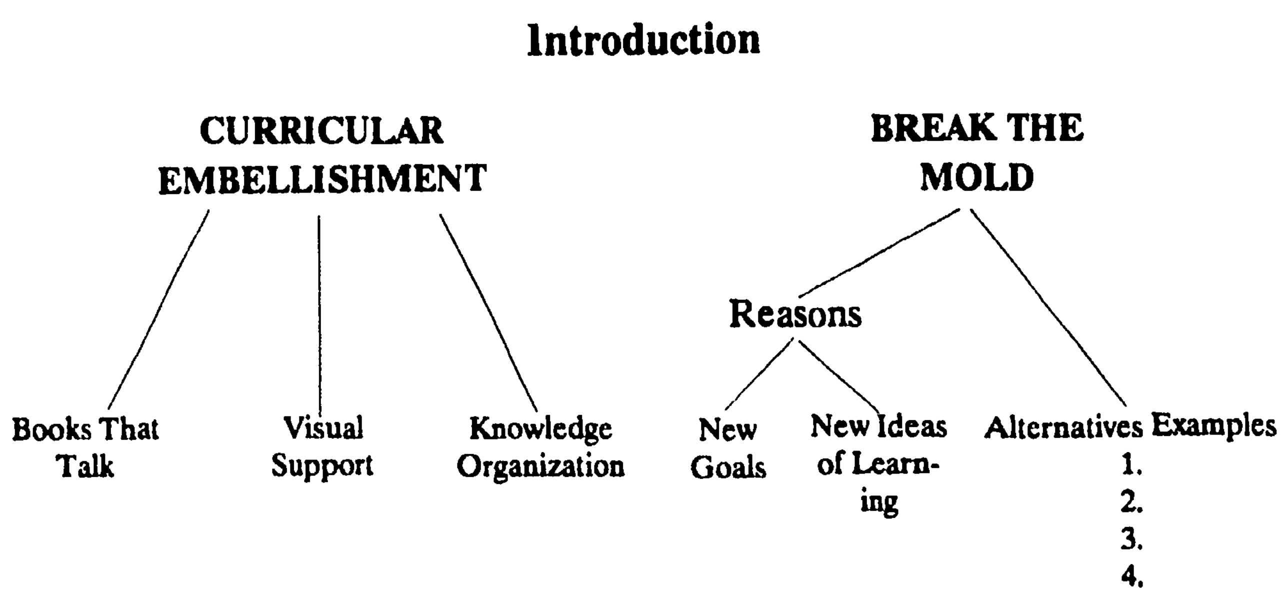

Figure 1. Organizational text structure.

Scaffolds versus Continuously Available Support

An important issue relevant to IM development involves the extent to which applications provide so much support that it hampers students' development as independent readers, visualizers, and learners. Theorists of human development such as Vygotsky (1978) and Wood (1980, 1988) emphasize the importance of continually assessing students' "zone of proximal development," the zone in which they are unable to proceed on their own but can make considerable progress given appropriate kinds of social and contextual support. Studies of language acquisition, for example, have shown that young children rely on extra linguistic support such as visual context, gestures, and tones of voice in order to comprehend (e.g., Bransford & Heldmeyer, 1983; Chapman, 1978). Parents and others (we'll call them "mentors") who communicate with children seem intuitively to understand the need for extra linguistic support; over time, however, they attempt to communicate without it (e.g., the mentors begin to talk about things that are not visually present). In short, the support provided by parents and mentors functions as a scaffold – it is provided initially, but is gradually removed.

In IM applications such as Discis books, the students control the amount of reading support that they can receive (e.g., having a text read to them). The danger is that at least some of them may overrely on that support and hence hamper their progress toward becoming independent readers. Similarly, if students always have access to dynamic visual images that support their comprehension, they may fail to develop their own internal mental model-building skills.

On the other hand, many theorists argue that one of the puzzles of development is that it often occurs in the absence of a well-defined need for improvement. For example, it is not clear that young children actually face an environmental need to improve their language skills because their parents would adapt their communication to the children's current needs. It is possible, therefore, that students will develop new skills and strategies whether the need to develop them is present or not.

We need to carefully explore issues of how best to provide support for comprehension and learning. We suspect that there is a need to consider IM designs that function as scaffolds rather than always providing an option for full support. As an illustration, an individualized "data capture" program might be added to IM books that, over time, helps students see the gradual decrease in the reading and visual support that they need to request while working with a text. Alternatively, scaffolding programs might be designed that gradually remove support. This might be accomplished by using some form of artificial intelligence, or by designing programs that allow teachers to easily assess needs and modify the support to the student that the program provides.

Arguments in Favor of "Breaking the Mold"

There are undoubtedly many additional ways in which learning theories can enhance IM applications that embellish existing curricula. This approach to IM development represents a worthy goal that needs to be pursued, especially given the needs of learning handicapped children who too often are separated from their classmates because of their inability to learn without special support.

Nevertheless, current cognitive theory suggests that, in the long run, the curricular embellishment approach is insufficient and that we need to look for principled ways to "break the mold." Reasons for breaking the mold include the fact that the research community has begun to define new goals for learning and to provide new insights into the way people think and learn (e.g., AAAS, 1989; NCTM, 1989; Resnick & Klopfer, 1989). These ideas raise serious questions about the appropriateness of most current curricula.

New Goals for Learning

Resnick (1987) argued that, unlike earlier points in history, it is no longer sufficient to assume that a significant portion of our population can get by with routine basic-reading and computation skills that will last them a lifetime. Because of the increasingly fast-paced changes in society, all students need to become independent thinkers and learners who are able to "work smart," engage in lifelong learning, and contribute to an increasingly complex society (see also Nickerson, 1988). An especially important consideration is that students must learn to identify and define problems on *their own* rather than simply respond to problems that others have posed (e.g., Bransford & Stein, 1984; Brown & Walters, 1983).

As a simple illustration of the preceding argument, consider students who are eventually going to work on an assembly line. Modern managers want them to be able to identify opportunities for improvement and to generate strategies for reaching their goals. Further, in all areas of life, people need to become active contributors to an increasingly complex and diverse society rather than simply function as "trainees" who repeat a fixed set of skills that they have been taught to perform (e.g., Bransford, Goldman, & Vye, in press).

New Assumptions about the Nature of Thinking, Learning, and Instruction

Concomitant with new goals for learning are new insights into the nature of thinking, learning, and instruction. Several categories of insights are discussed below.

Knowledge and thinking. We now know that effective thinking is not simply a function of motivation and general thinking strategies; it is also a function of a great deal of well-organized content knowledge (e.g., Bransford, Goldman, & Vye, in press; Chi, Glaser, & Farr, in press). We also know that the mere accumulation of factual or declarative knowledge is not sufficient to support problem solving (e.g., see Anderson, 1987; Bransford, Vye, Adams, & Perfetto, 1989; Simon, 1980). In addition to factual or declarative knowledge, students must learn why, when, and how various skills and concepts are relevant (see Lesgold, 1988; Simon, 1980). If they do not, they will not spontaneously use knowledge to solve problems even though it is relevant (e.g., Bransford, Franks, Vye, & Sherwood, 1989).

Many years ago, Whitehead (1929) used to term "inert knowledge problem" in referring to the problem of acquiring knowledge that is not accessed even though it is relevant for problem solving. He also argued that traditional school practices tended to produce knowledge that remained inert. Findings from a number of studies illustrate the ease of producing inert knowledge (e.g., Bransford, Sherwood, Vye, & Rieser, 1986; Gick & Holyoak, 1980, 1983; Hasselbring, Sherwood, Bransford, Fleenor, Griffith, & Goin, 1988; Scardamalia & Bereiter, 1985). Further, knowledge is less likely to remain inert when it is acquired in a problem-solving rather than a factual-knowledge mode (Adams, Kasserman, Yearwood, Perfetto, Bransford, & Franks, 1988; Lockhart, Lamon, & Gick, 1988).

In addition to the fact that experts have acquired knowledge that is noninert because it is well organized and specifies appropriate conditions of applicability, we know that expertise involves more than the ability to solve familiar (to the experts) problems. Today's expert can easily become tomorrow's "also ran;" therefore, true experts need the skills to work on the cutting edge and hence deal with novelty (e.g., Bransford, Nitsch, & Franks, 1977). This means that they must have the patience to persevere despite complexity, that they must be able to monitor the degree to which they are making progress (which involves "metacognitive" skills), and that they must be able to learn new information that is relevant to their goals (e.g., see Brown et al., 1983; Schoenfeld, 1985, 1989).

Assumptions about learning and instruction. The concept of "transfer appropriate processing" ((Morris, Bransford, & Franks, 1979) provides a useful framework for thinking about the kinds of learning and instruction that can help all students reach the goal of becoming independent thinkers and learners. The basic premise of this concept is simple: In order to achieve particular outcomes, students must have the opportunity to engage in the kinds of activities that support such outcomes.

Despite the seemingly obviousness of the idea of "transfer appropriate processing," many instructional practices tend to violate it repeatedly. A few examples are listed below:

1. We claim that we want to help students learn to think deeply about subject matter, but we give them texts filled with vast amounts of superficial facts to be memorized, leaving students no time to explore a few topics in depth (e.g., Beck, 1991).

2. We claim that we want student to learn with understanding, yet we often overload our instruction with (a) decontextualized basic-skill and concept exercises that have to be mastered *before* students get to see potential applications of these basics (e.g., CTGV, in press); and (b) technical definitions and formulas presented in ways that fail to help stu-

dents link the technical knowledge with their intuitions (e.g., Clement, 1987; Minstrell, 1989; Resnick, 1987; Resnick & Klopfer, 1989).

3. We claim that we want our students to learn to find, define, and solve problems, but give them nothing but arbitrary problems that are uninteresting, unrealistic, and leave no room for problem posing on the part of students (e.g., CTGV, 1990; Porter, 1989).

4. We claim that we want to help students develop a sense of pride, responsibility, and curiosity. Yet, we spend from 12 to 16 years treating them as passive recipients of knowledge who are rarely given the opportunity to explore ideas of their own choosing, collaborate with others, and make contributions by presenting ideas to their classmates and teachers.

In our opinion, these discrepancies between goals and methods of instruction provide a strong argument for a "break-the-mold" rather than a "curriculum embellishment" approach.

Assumptions about intelligence and everyday cognition. Another aspect of learning theory that has important implications for instruction involves the suggestion that our concept of intelligence needs to be broadened considerably (e.g., Gardner, 1983; Sternberg, 1985). For example, there is a growing realization that scores on an IQ test may predict performance in typical academic settings, but not in everyday settings. Concepts of "practical intelligence" (Neisser, 1976; Sternberg & Wagner, 1986) are more important for understanding everyday, nonschool achievement. In addition, studies of everyday cognition (e.g., Lave, 1988) have documented many of the ingenious ways by which people adapt to their environments.

An article written almost 50 years ago (Corey, 1944) provides an illuminating perspective on the need to consider differences between "everyday cognition" and school environments.[3] Entitled "Poor Scholar's Soliloquy," the article provides a personal account from a student (we'll call him "Bob") who is not very good in school and had to repeat the seventh grade. But when you look at the kind of learning that Bob is capable of achieving outside of school, you get a very different impression of his abilities.

One part of Bob's soliloquy discusses the fact that the teachers do not like him because he does not read the kinds of books that they value. His favorite books include Popular Science, the Mechanical Encyclopedia, and the Sears and Wards catalogs. Bob uses his books in the context of pursuing meaningful goals. Thus, he says of his books: "But I don't just sit down and read them through like they make us do in school. I use my books when I want to find something out, like whenever Mom buys anything second hand I look it up in Sears or Wards first and tell her if she's getting stung or not" (p. 219).

A little later, Bob explains the trouble he had memorizing the names of the presidents. He knew some of them, like Washington and Jefferson, but there were 30 altogether and he never did get them all straight. He seems to have a poor memory. Then he talks about the three trucks his uncle owns and the fact that he knows the horsepower and number of forward and backward gears of 26 different American trucks – many of them diesels. Then he states: "It's funny how that Diesel works. I started to tell my teacher about it last Wednesday in science class when the pump we were using to make a vacuum in a bell jar got hot, but she said she didn't see what a Diesel engine had to do with our experiment on air pressure so I just kept still. The kids seemed interested, though" (p. 219).

Bob discusses other areas of his schooling like his inability to do the kinds of (arbitrary) word problems found in the textbooks. Yet, he helps his uncle solve all kinds of complex trip-planning problems when they travel together. Bob also mentions the bills and letters he sends to the farmers whose livestock is hauled by his uncle and notes that, according to his aunt, he made only three mistakes in his last 17 letters – all of them commas. Then he says: "I wish I could write school themes that way. The last one I had to write was on "What a Daffodil Thinks of Spring", and I just couldn't get going" (p. 220).

Bob ends his soliloquy by noting that, according to his Dad, he can quit school at the age of 15 and he feels like he should. After all, he is not getting any younger and there is a lot of stuff for him to learn!

Bob's soliloquy is as relevant to the 1990s as it was in the 1940s. It highlights the fact that many students seem to learn effectively in the context of authentic, real-life activities, yet have great difficulty learning in the decontextualized, arbitrary-task atmosphere of schools. Luckily for Bob's children, a number of researchers are beginning to focus on the nature of authentic learning and to raise serious questions about typical school curricula and tasks (e.g., Brown et al., 1989). Some ideas about new approaches to curricular design that are made possible by IM technologies are discussed next.

Possible Alternatives to Decontextualized Curricula

Our goal in this section is to consider some alternatives to decontextualized, fact-filled curricula that provide few opportunities for students to collaboratively explore, invent, and think deeply about issues (e.g., Beck, 1991; Bransford, 1984). One view of an alternative framework comes from researchers who are beginning to emphasize the importance of anchoring or situating instruction in meaningful problem-solving environments analogous to the apprenticeship environments that were available to Bob (e.g., Brown et al., 1989).

Effective apprenticeships offer a number of advantages that often are not available to students in classrooms. For example, consider the experiences of graduate students who have the opportunity to work closely with an excellent mentor and a research team. First, the students usually learn in the context of meaningful research goals (e.g., to understand the processes of comprehension, to design a better bridge) and hence know why they need to acquire new information. Second, they collaborate and make contributions by coming up with ideas, teaching others (including their mentors) about areas in which they are especially knowledgeable, collecting data, helping to communicate results, and so forth. Third, they have the opportunity to experience the process of continually clarifying and revising ideas rather than simply being exposed to the end products of others' explorations. Fourth, they *collectively* experience the human side of knowledge acquisition and communication endeavors, including victories, disappointments, and the value of mutual support. Finally, such students are helped to identify both their strengths and weaknesses and, thereby, to gradually clarify their career goals.

Unfortunately, it is not feasible to place every student in a series of real apprenticeships with one or several mentors. During the past several years, members of our technology center at Vanderbilt have been exploring ways to use IM technology to simulate some of the advantages of apprenticeship learning in the classroom. The basis of the approach is to begin by creating semantically rich "anchors" that illustrate important problem-solving situations (e.g., CTGV, 1990). These anchors create a "macrocontext" that provides a common ground for experts in various areas, as well as teachers and students from diverse backgrounds, to explore issues and communicate in ways that build collective understanding (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; CTGV, 1991b; McLarty, Goodman, Risko, Kinzer, Vye, Rowe, & Carson, 1990; Risko, Kinzer, Vye, and Rowe, 1990).

Macrocontexts are problem-rich environments that can be used to integrate concepts across the curriculum and in which meaningful, authentic problems can be posed and explored. One benefit of organizing instruction around collaborative exploration of problem-rich environments is that it enables students to understand the kinds of problems and opportunities that experts in various areas encounter as well as the knowledge that these experts use as tools. Another benefit is that it provides a common ground that allows students to share a set of common experiences while simultaneously exploring specific areas of personal interest. After researching these areas, students have the opportunity to communicate the results of their explorations to their fellow students, teachers, and parents. In short, they have the opportunity to generate knowledge rather than merely receive it from someone else.

The general idea of organizing instruction around meaningful issues has a long history. For example, Dewey (1933) discussed the advantages of theme-based and project-based learning. Similarly, in the 1940s, Gragg (1940) argued for the advantages of case-based approaches to instruction — approaches that are currently used frequently in areas such as medicine, business, and law (Williams, 1991). Written scenarios (e.g., Lipman, 1985; videos — e.g., Bank Street College 1984) and hands-on projects (e.g., Tinker, 1991) can function as macrocontexts that make learning active and meaningful and provide a common ground for collaborative exploration.

The goal of making learning more exciting and meaningful is related to analyses of some of the advantages that experts enjoy when they are introduced to new ideas and concepts that are relevant to their areas of expertise. Thus, theorists such as Dewey (1933), Schwab (1960), and Hanson (1970) emphasized that experts in a certain area have been immersed in certain phenomena and are familiar with how they have been thinking about them. Therefore, when introduced to new theories, concepts, and principles that are relevant to their area of interest, these experts can experience the changes in their own thinking that these ideas afford.

For novices, however, the introduction of concepts and theories often seems like a mere presentation of new facts or mechanical procedures to be memorized. Because the novices have not been immersed in the phenomena being investigated, they are unable to experience the effects of the new information on their own noticing and understanding. Since novices are not able to see the broad-range implications of the new information, it seems much less exciting, and is less likely to be evaluated from a variety of points of view.

Organizing instruction around problem-rich macrocontexts also provides opportunities for group work such as collaborative learning. In cooperative groups, students have the opportunity to form communities of inquiry that collaboratively discuss and explain and, hence, learn with understanding (e.g., Lipman, 1985; Palincsar & Brown, 1984, 1989; Vygotsky, 1978). Of course, cooperative learning groups also offer potential disadvantages. Salomon and Globerson (1989) and Goldman, Cosden, and Hine (in press) discussed pitfalls in the implementation of groups in classrooms. Various degrees of structure and training are needed to help groups work effectively (e.g., McDonald, Larson, Dansereau, & Spurlin, 1985; Spurlin, Dansereau, Larson, & Brooks, 1984).

Illustrations of Programs That Are Organized around Macrocontexts

In this section we will discuss some attempts at breaking the traditional instructional mold by situating (anchoring) instruction in video-based macrocontexts that can be explored in conjunction with a variety of IM applications. Many of these examples use simple levels of technology that can be embellished through additional IM tools. Nevertheless, they suggest alternatives to typical curricula that tend to be decontextualized, fact-oriented, and rarely encourage deep explorations of issues.

The Adult Literacy Project

One project conducted by members of our center focuse the use of IM technology to help adults who are nonliterate. Part of this program can b iewed as using IM technology to embellish traditional literacy curricula; part of it breaks the mold.

The "curricular embellishment" part of the adult literacy program involves its fluency-training component. The goal of this part of the program is to help learners become sufficiently fluent at reading key sets of words so that the act of decoding is relatively free of attentional demands (e.g., see Bransford, Golin, Hasselbring, Kinzer, Sherwood, & Williams, 1988; Perfetti, 1985; Torgesen, 1986).

Through the use of IM technology that includes a speech-recognition system, the adult learners train a computer system to recognize how they pronounce each word in a preselected set of words. The computer then displays words to be read aloud as quickly as possible and keeps track of reaction times. When sets of words are read with a latency that reaches a predetermined fluency threshold, words are assumed to be learned, and the learner is presented with new words. Initially, the fluency training is organized around the 400 most frequently used words in the English language. As new words are introduced in the comprehension part of the program (to be explained below), they can be added to the fluency training component.

The part of the adult literacy program that breaks the mold is the comprehension component. The program does not attempt to teach reading by using decontextualized texts. Instead, consistent with our center's focus on anchored instruction (e.g., CTGV, 1990), the adult literacy program uses video to introduce adults to content that they have indicated as interest learning. In one module, the learner begins with a video on cholesterol and good health (this is a topic that many adults who could not read expressed an interest in learning). Another video provides information about how to videotape one's children for identification purposes in case they are lost. Any type of content can be used as an anchor, so the program is very flexible.

Following exposure to a video-based anchor, the adult learners are asked to read sets of three "discrepancy" passages that describe various aspects of the information communicated in the video. There are many possible sets of discrepancy passages for each anchor, varying in reading level (e.g., in the sophistication of the vocabulary and sentence structure). Adults receive specific sets of discrepancy passages depending on their reading skills.

Two of the passages in each discrepancy set purposely contain errors; the third is correct. The adults read all three passages in order to find the errors and identify the correct passage. This activity serves two important functions: (a) it involves a great deal of rereading of the same text elements, which enhances fluency for word recognition; and (b) it provides a way to monitor the degree to which the adults are reading for meaning rather than merely "word calling." Preliminary data from the program show that many adults do not initially read for meaning. After working with the discrepancy passages, however, they soon actively evaluate each passage as they read.

The adult literacy program is not designed to be a stand-alone program that works independently of a human mentor. Instead, its purpose is to help mentors work more efficiently and effectively with the adult learners. This is often difficult to do in typical adult learning programs where one mentor may work with a number of different students in the context of conventional texts.

The Young Sherlock Project

The Young Sherlock project is a multimedia literacy project designed to help middle-school students acquire important literacy skills while also learning relevant curricular content. The content areas targeted in the program involve concepts in language arts and social studies (e.g., see CTGV, 1990).

The program was based on the assumption that narratives on video can be used effectively as focal contexts for inquiry by students and as springboards for inquiry in other media (i.e., text) and content domains. We refer to these video contexts as "macrocontexts" because they are intended to stimulate learning over an extended period of time (i.e., several months), and can be used to integrate learning across content areas that are separate in most school curricula. This particular program is called "Young Sherlock" because it is anchored initially on the movie (on videodisc), The Young Sherlock Holmes. A secondary anchor, Oliver Twist (also on videodisc), was also used.

Video- rather than text-based macrocontexts were selected for several reasons. As we discussed earlier, appropriately designed video helps students form a better understanding or "mental model" of the information than they might otherwise form if the source material was text. When source material is in text form, students often have difficulty constructing mental models because they lack knowledge about the concepts described therein or because decoding text is effortful, leaving them with few mental resources that they can use to comprehend the information more deeply. Presenting information on video makes it more likely that good and relatively poor readers alike will share a rich and common context for instruction. In addition, by making information more accessible, we hope to pique students' interest in the content and motivate them to explore it further by consulting other related sources in text. We further assume that students will be better prepared to read related text after having constructed a mental-model framework from the video.

Details of the Sherlock project are described elsewhere (CTGV, 1990; Kinzer, Risko, Rowe, & Vye, 1989; Risko, Kinzer, Goodman, McLarty, Dupree, & Martin, 1989). For present purposes, the important point is that Sherlock provides an alternative to traditional social studies and reading curricula. By beginning with a video environment to be explored by students, Sherlock allowed even poor readers to contribute to class discussions. Furthermore, students were motivated to research various aspects of the video (e.g., to learn more about Queen Victoria, the restrictions on women who lived during that time), and hence did a great deal of reading, writing, and communicating to fellow class members. The extended time spent working with the Sherlock and Oliver Twist videos also made it possible for students to specialize in particular areas of interest (e.g., Queen Victoria) and be able to develop indepth expertise (see Beck, 1991). Some classes were also able to publish their ideas in an integrated-media format that allowed them to add text, sounds, and pictures to their products plus use the computer to control relevant video.

Data indicate that students in the Sherlock curriculum were able to improve their abilities to write interesting stories, use targeted vocabulary, comprehend stories that were relevant to the Victorian era in history, and develop rich mental models of what it was like to live at a particular time in history (see Bransford, Vye, Kinzer, Risko, in press; Risko et al., 1990). In short, as in the adult literacy program, video-based environments can be used in ways that enhance rather than hurt literacy skills (Bransford, et al., 1989).

The Young Children's Literacy Project

The Young Children's literacy project is only about six months old and represents a synthesis of the Adult Literacy and Sherlock projects. Its major focus is on young children (kindergarteners and first graders) who are at-risk of school failure. Our initial studies with these children indicate that many of them have great difficulty retelling stories presented to them verbally, but do much better when provided with dynamic visual support that helps them build mental models of the story events (see also Johnson, 1987). Basically, this aspect of our initial data supports the arguments made earlier about the importance of providing appropriate visual support to enhance listening comprehension.

We also noted earlier that it may be dangerous to continually provide visual support for stories because students may come to overrely on such support and, therefore, fail to develop their own mental-model building skills. So, part of the goal of the Young Children's project is to use a scaffolding approach (e.g., Vygotsky, 1987) to the development of these skills. One such approach that we are taking is to verbally describe situations and then have the students help us evaluate which of several dynamic visual events illustrates the verbal description. This is a very motivating task for the children (analogous to being a moviemaker) and seems to give them a good idea of what it means to imagine with precision. We are also doing the reverse; namely, beginning with video and having students choose the correct verbal rendition. This is analogous to the "discrepancy passages" task used in the adult literacy program described above. The eventual goal is to enable children to engage in "representational literacy" activities without any support from us.

Further plans for the Young Children's project include two important types of additions. The first is to move from listening comprehension to reading and hence use some of the ideas that underlie the adult literacy program. A second direction is to create our own video anchors that provide a context for understanding the values of activities such as reading, writing, and systematic scientific inquiry. By creating a series of such anchors, we hope to help young students develop the skills and the knowledge structures (schemas) that will make it easier for them to continue to learn on their own in later grades.

The Jasper Woodbury Problem-Solving Series

Another project in our center that attempts to provide alternatives to traditional text-based curricula is the Jasper Woodbury Problem-Solving Series. The video-based anchors used in the Jasper series are based on a specific set of design principles that make it easier for teachers to teach complex, generative problem posing and problem solving (CTGV, 1991). The anchors are also designed with special links to help students make connections to other aspects of the curriculum (science, history, etc.) and to their everyday environment. Specially developed IM "publishing software" makes it easy for students to research these links, publish them in an integrated media format, and share them (through telecommunications) with other Jasper sites around the country.

Participants in the Jasper project are also experimenting with a special teleconference-based "challenge series" that provides an opportunity for students to make additional connections between their experiences with Jasper and other issues, and that allows them to assess for themselves how much they have learned. The Jasper project and the theory and design principles that underlie it are described in detail elsewhere (see CTGV, 1990, 1991a, 1991b, in press).

Summary and Conclusions

Our goal in this chapter was to discuss ways in which research and theory in the areas of learning and cognition can guide the development of integrated media systems. We began our discussion by exploring how IM technology can be used to embellish existing curricula. For example, we described some excellent IM products (e.g., Discis books) that go beyond typical texts, noting that their many advantages are quite obvious. Nevertheless, other issues related to IM development are more subtle, yet nevertheless important. We discussed ways that the research literature can help us think about these issues in more detail.

Our major argument was that the full implications of exploring existing theory and research cannot be appreciated by simply using IM technologies to embellish existing curricula. Based on the cognitive literature, we see a need to develop principles for "breaking the mold." We provided some reasons for doing this and discussed examples of work going on in our center that suggest possible alternatives to typical text-based curricula. The major characteristic of these alternatives is that they drastically reduce the amount of the time that students spend receiving already-discovered information (from teachers or texts) and, instead, provide problem-rich environments that can be explored and discussed by students. Many other examples of alternative problem-rich environments are currently being developed and studied by others (e.g., Bank Street College, 1984; Lipman, 1985; Tinker, 1991). As new principles for breaking the mold begin to emerge from research, we hope that the result will be major advances in learning for all students.

Author Notes

1 For a similar and independently formulated view, see Glenberg and Langston (in press).

2 Members of the Cognition and Technology Group at Vanderbilt (CTGV) who contributed to this paper were John Bransford, Laura Goin, Susan Goldman, Ted Hasselbring, Jim Pellegrino, Diana Sharp, and Nancy Vye.

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Examining the Cognitive Challenges and Pedagogical Opportunities of Integrated Media Systems: Toward a Research Agenda[1]

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A glance at almost any recent issue of journals or magazines dedicated to instructional technology reveals the excitement and hope generated by the newest of technologies often referred to as *multimedia*. Multimedia, or *integrated media*,[2] can be defined as the linkage of text, sound, video, graphics, and the computer in such a way that the user's access to these media becomes nonlinear and virtually instantaneous.

Researchers have suggested several reasons for the potential power of integrated media with regard to learning. One of these reasons is that integrated media represents a way to make computers more compatible with human cognitive processes because, like humans, the storage format is nonlinear (e.g., Dede, 1987). Another major reason is that multiple representations of information in various formats (e.g., as text, as visuals, as auditory events) have been found to lead to better retention and retrieval (e.g., Paivio, 1969).

While agreeing that integrated media offers potential new and exciting instructional options, we wish to emphasize that integrated media does not represent a theory of learning. Rather, it merely serves as a delivery system for instruction. Consistent with this basic philosophy, we further believe that integrated media information systems are only as powerful as the learning theory and instructional design principles they instantiate. As Clark (1983) pointed out, "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). Therefore, if we are to capture and benefit from the power that rests within integrated media, we must move beyond the all-too-prevalent assumption that "if it uses integrated media, it must be good."

Challenges and Opportunities of Integrated Media

Imagine the impact of a text-based presentation of information using only static pictures compared to an integrated media presentation complete with text, moving video, audio, and nonlinear linkages of information. To the learner, these two systems are quite different. We believe that, in addition to *pedagogical opportunities* that can make learning more efficient an effective, the integrated media presentation also creates *cognitive challenges* that, in some instances, increase barriers to learning. Our goal at the Vanderbilt Learning Technology Center is to examine both the *challenges* and the *opportunities* from the perspective of mildly handicapped students who are attempting to learn. We encourage other researchers to join in this endeavor.

In the remainder of this paper, we will first identify some of the challenges presented to learners using integrated media and then discuss some of the opportunities that integrated media learning environments offer. In no way do we consider these issues to represent an exhaustive list. On the contrary, the issues that we have identified merely serve as a starting point for a more comprehensive research agenda.

Cognitive Challenges

Navigation

By definition, an integrated media system is nonlinear and, therefore, allows movement in many directions. As a result, integrated media environments create a major challenge by requiring the user to navigate through "information space" without getting lost. This presents a challenge to all learners, but it may be especially serious for learning handicapped students, who often have less practice with broad, goal-oriented learning tasks (e.g., writing reports based on several books and articles) and more practice with smaller subtasks such as word attack skills.

Using integrated media successfully requires goal directedness as well as the ability to create a mental map, both of which are often lacking in learning handicapped children. Shasta (1986) suggested that movement through integrated media systems is underconstrained. When using an integrated media system without cognitive control structure, therefore, behavior tends to become entropic, goal-lost, impulsive, and distracted by the browseables offered by the system. So how will students with learning handicaps keep track of where they are in an information space in which thousands of modes of text, graphic images, and pictures reside? And how can the systems be designed so as to keep students moving toward a goal?

In response to these questions, the spatial database management techniques pioneered by Negroponte's Architecture Machine Group at MIT (Negroponte, 1979, 1981) offer some possible solutions. In these systems, topological maps provide an external representation of the overall structure of places to go in the system, while marking the user's current place. It appears that this type of aid can be built into systems to prevent students with learning problems from becoming goal-lost and disoriented within the vast information spaces of integrated media systems.

Unless students with learning problems can navigate successfully through integrated media space, their chances of being able to access and link information in any useful way are greatly reduced. Navigation through integrated media systems offers a serious challenge to disabled learners and offers researchers with a fertile area of investigation. Researchers should begin to focus on this important issue immediately.

Focused Attention

All humans are distractible to a certain degree, and children with learning problems appear to be especially distractible. As a result, their attention is likely to be easily captured by prominent integrated media stimulus arrays, making goal-directed activities difficult to maintain. Thus, evidence shows that some users of integrated media systems are easily distracted and lose their goal orientations (Halacz, Moran, & Trigg, 1987).

Distractibility problems appear to be exacerbated by the use of the two-screen integrated media systems, where one screen is used for presenting text and graphics, the other for video. The obvious drawback to this type of system is that it requires the user to move back and forth between the two screens as relevant information is presented, thereby increasing the potential for becoming distracted and goal-lost.

At the present time, the primary reason for using two-screen systems is cost. For example, the hardware cost of moving to a one-screen system on a Macintosh integrated media station is approximately $1,000. Thus, it is not surprising that two-screen systems are the rule, rather than the exception. However, if one-screen systems offer significant advantages to the disabled learner, the added cost may be justified. Although we recognize that there are situations when a two-screen system is desirable, in other situations, we believe that the two-screen system may interfere with learning.

We believe, therefore, that it is important for researchers to examine the effect of one- versus two-screen presentation systems. Specifically, are there inherent disadvantages in having the student shift attention between two screens, compared to presenting all information on a single screen?

In addition to examining one- versus two-screen systems, research should begin to examine the spatial layout of one-screen systems. Because one-screen systems reduce the available presentation space, it is important to understand how information should be presented so as not to overwhelm and distract the learner. At the same time, the presentation space should not be so sterile that it prevents the learner from making important linkages between the information being presented.

Pedagogical Opportunities

In addition to examining ways to help learning handicapped students cope with the challenges inherent in integrated media presentations noted above, it is important to explore the effects of several opportunities for powerful instruction made feasible in integrated media learning environments — especially, if learning handicapped students are helped to overcome the obstacles represented by the previously discussed challenges. Specifically, we recommend examining the pedagogical opportunities offered by integrated media in the following areas:

- Developing vocabulary and reading vocabulary
- Anchoring instruction in meaningful contexts
- Fostering generation of knowledge

Developing Vocabulary and Reading Comprehension

One of the most exciting features of integrated media is that it allows information to be presented through a variety of media. Nevertheless, nearly every integrated media system in existence relies heavily on text, making it necessary that students be able to read in order to benefit from instruction. Since virtually all students enter special education with a history of reading failure (Mastropieri & Scruggs, 1987), integrated media environments that are heavily text based are not ideal.

Integrated media environments provide an opportunity to help learning handicapped students work their way through difficult text and acquire new skills of word recognition and meaning. Results of cognitively oriented research with mildly handicapped students indicate that these youngsters experience the greatest amount of difficulty at the word level of processing (Rashotte & Torgesen, 1985). Therefore, activities that strengthen word reading skills will be beneficial to these learners. We recommend that researchers examine features that can be built into integrated media systems that will assist learning handicapped students in extracting meaning from text within the information system.

One approach that appears to offer promise in this area is the use of visual images to support and embellish word meaning and comprehension. Take for example a student reading a passage about the relationship between cholesterol intake and the buildup of plaque in one's arteries. The passage has little meaning to a reader who has no understanding of arterial plaque. The reader may look up the word *plaque* in the dictionary and find several meanings: plaque (plak) n. 1. A wall tablet inscribed to commemorate an event 2. A thin, transparent film on the tooth surface 3. A deposit of fatty or fibrous material in a blood vessel wall.

Based on this definition, the reader may or may not understand the meaning of plaque. Using an integrated media system, on the other hand, the learner could be presented with a video clip showing open-heart surgery where plaque — the hard, tough, fibrous material that clogs arteries and leads to heart attacks — is being removed from an artery. This type of visual information can provide the reader with a conceptual link between the text and an understanding of what is presented in the text. Similarly, in other cases, meaning could be constructed through the use of sound, static images, or a combination of these media.

Studies should examine how students can gain meaning from text that is difficult for them to read. Particular emphasis should be placed on identifying ways in which various forms of media can enhance the reading process, such as providing background knowledge through video and sound and linking related knowledge for the learner to explore.

Anchoring Instruction in Meaningful Contexts

Another potential pedagogical benefit of integrated media learning environments involves situating or anchoring instruction in interesting and realistic video-based contexts that make learning more motivating, meaningful, and useful for subsequent problem solving (e.g., Brown, Collins, & Duiguid, 1989; Cognition and Technology Group at Vanderbilt, 1989). Work conducted in the technology center at Vanderbilt provides a wealth of data about the effectiveness of these "situated" or "anchored" learning environments, compared to more traditional approaches to instruction that are characteristic of most schools today (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, in press; Hasselbring, Goin, & Wissick, in press; Sherwood, Kinzer, Hasselbring, & Bransford, 1987; Van Haneghan et al., 1989).

Situating or anchoring instruction involves recreating some of the advantages of learning environments like those that occur during early childhood and in apprenticeships. Therefore, some researchers have begun to analyze some of the conditions that make children's early learning so successful (see especially Bransford & Heldmeyer, 1983). One major advantage seems to involve the opportunity to learn in the context of meaningful, ongoing activities. Thus, contextual cues and feedback provided by the environment allow children to make sense of their surroundings, including the words they hear and use. Contrast this with an imaginary decontextualized approach to language acquisition in which, for one hour a day, a young child is taken into a room where he/she is introduced randomly to new words and told to memorize their definitions. Under such circumstances, it is doubtful that language acquisition would occur (Chapman, 1978; MacNamara, 1972).

Research also suggests that children learn best when they and a parent, or some other mediator, share a context that can be mutually explored (Feuerstein, Rand, Hoffman, & Miller, 1980). For example, Sherwood, Kinzer, Bransford, and Franks (1987) noted that mediators (parents, peers, and other adults) can arrange the environment so that learners will encounter experiences that enable them to separate relevant from irrelevant information and connect present experiences with previous knowledge. Children and mediators can also share contexts by relying on memory.

Parents naturally help children relate the past to the present in order to help them understand new things. For example, imagine that a visiting neighbor begins to talk about hang gliders. A parent might help a child understand the conversation by reminding her of a hang glider that they saw while on vacation. Reminding strategies such as these can be effective because the parent has good information about the child's experiences.

Similarly, in the classroom, teachers try to help students relate new information to previously acquired knowledge. However, teachers often do not know which experiences are relevant for a particular child. In such situations, technology such as videotape and random-access videodisc becomes especially valuable. Specifically, with video, teachers can create contexts that can be shared with a child and can also serve as an anchor for new knowledge. Thus, one of the major goals of anchored instruction is to create theme-based environments or contexts that permit sustained exploration by students and teachers and enable them to see and understand how information and knowledge can be used as tools for solving problems in real-world settings. A second, and related goal of such anchored instruction, is to help students experience the value of exploring the same environment from multiple perspectives (e.g., scientist, historian).

Although textual anchors may be used, a video medium offers several advantages. First, video allows students to develop pattern-recognition skills, whereas text represents the output of the writer's pattern-recognition processes (see Bransford, Franks, Vye, & Sherwood, 1989). Second, video allows a more veridical representation of events than text; it is dynamic, visual, and spatial and, therefore, enables students more easily to form rich mental models of problem situations. The ease with which mental models can be formed from video is particularly important for low-achieving students and for students with low knowledge in the domain of interest (Bransford, Kinzer, Risko, Rowe, & Vye, in press; Johnson, 1987). Third, videodisc provides a major reason for using video technology due to its random-access capabilities. Random-access is advantageous from an instructional viewpoint because it allows teachers to instantaneously access information for discussion. Since one of our goals is to help students explore the same domain from multiple perspectives, the random-access capabilities are particularly useful for our work.

Most current research and development in anchored instruction has used videodisc technology as a Level I interactive system, generally by accessing the desired video sequence using a hand-held controller. Although this simple approach to anchored instruction has been shown to work well, it is our belief that by combining computer-controlled text, sound, and graphics with videodisc anchors, we can develop much more powerful systems that will help students experience the usefulness of information from multiple perspectives and treat it as a means to important ends.

We believe that integrated media information systems that incorporate anchored instruction techniques will have much more powerful effects on learning than systems where knowledge is not anchored. We recommend, therefore, that researchers begin to examine the effects of anchored instruction within integrated media information systems.

Fostering Generation of Knowledge

A third potential pedagogical opportunity provided by integrated media learning environments pertains to the goal of helping students become producers of knowledge rather than merely consumers. By combining text, graphics, video, and audio, students can create integrated media presentations that their parents, peers, and teachers want to see (e.g., Bransford et al., 1989). In so doing, students actively generate materials rather than merely reading about the information in a textbook or on a computer screen. Research has shown that even minor engagement of students in the learning process can facilitate memory (Slamecka & Graf, 1978). In addition, the feeling of pride in one's productions is powerful and can be especially important for learning handicapped students, who traditionally have experienced difficulty in school.

Curriculum specialists have long advocated specialized teaching procedures that require students to generate knowledge rather than only consume it. For example, science specialists have often recommended teaching by means of the discovery method; that is, teachers act as facilitators of students' own "scientific discoveries of basic principles." Such techniques, it is argued, lend an experimental basis to science and provide insight into scientific methods. Similarly, social studies specialists have typically advocated Socratic inquiry methods whereby students are prompted to use their own reasoning to arrive at relevant concepts, relationships, and ethical or moral principles.

Not surprisingly, our present system of formal education appears to be doing a poor job of attaining this goal, since much or our current instruction is focused on transferring information in the form of facts and procedures to the student. Consequently, facts remain inert and often are not spontaneously used to solve problems (Bransford et al., in press; Whitehead, 1929).

Recent research at Vanderbilt's Learning Technology Center has shown that when instruction encourages students to generate plans and questions, they make significant gains when compared to the use of a more passive form of instruction (Vye et al., 1989). Thus, these results suggest a need for classroom activities that engage students directly in generating knowledge.

In addition to the research on generative learning, a new body of research in cognition and instruction has shown that, unlike the conventional view of intelligence as being a fixed property of a single individual, intelligence and knowledge can be viewed as distributed across people and places, and may even be codified into books, notes, and computers (Pea, 1988). When viewed in this way, knowledge includes more than facts. Further, intelligence, in turn, encompasses how to access and retrieve knowledge as well as when and how to rely on these alternative sources of information. This new area of research on distributed intelligence highlights the need for instruction that encourages students to create systems of distributed knowledge and provides skills in how to utilize external sources of information intelligently.

Based on these experiences, we are proposing that research begin to explore the effects of generative learning within integrated media information systems. We predict that integrated media information systems that incorporate generative learning techniques will have much more powerful effects on learning than systems using passive learning. Yet, it is important that empirical evidence be gathered to support or reject this hypothesis.

Summary

We are proposing that research begin to examine integrated media design issues both in terms of the cognitive challenges posed by integrated media for handicapped learners and the specific pedagogical opportunities for enhancing learning. By embarking on this line of research, the field will gain a body of empirical knowledge that will add significantly to our understanding of how integrated media learning systems affect learning of mildly handicapped students as well as provide direction for future product development.

Author Notes

1 This paper represents a shorter version of a manuscript that has been submitted to the *Journal of Special Education Technology*. Please do not quote or reproduce without the permission of the authors.

2 We prefer the term *integrated media* instead of *multimedia*, as we believe that it is less ambiguous and that it more adequately describes the process of using diverse media.

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CAST and Its Mission

David H. Rose

CAST is a not-for-profit organization whose mission is to expand the educational opportunities for all children through innovative uses of computer technology. CAST provides direct services to individuals, offers consultation and training to organizations, conducts research, and develops software and implementation models for education.

Direct Services

CAST offers direct services to children with disabilities, as well as to parents and professionals who work with disabled and at-risk students. In addition, a variety of related services are available, including evaluations, consultations, workshops, individual training sessions, and adaptation or modification of existing technology to meet individual needs.

Consultation and Training

CAST also offers a major program of consultation and training to schools and other service agencies. For example, during the last few years. CAST has entered into cooperative arrangements with school districts to develop appropriate mainstream education. Programs have emphasized effective uses of technology within classrooms, as well as restructuring of learning environments, curricula, and school resources.

Research and Development

CAST researches and develops new technologies, including multimedia software and implementation methods, designed for use in schools and homes. A major focus of this development has been upon tools and materials that are accessible to all children, including those with significant disabilities.

Nature of Change

The *assimilation* of new technology into a cultu· nevitably brings changes in that culture — what Piaget called "accommodation." Thus, anthropologists have documented whole cultures that have been transformed or even destroyed by the assimilation of simple new technology. For example, a centuries-old hunter-gatherer society was dissolved by the introduction of relatively few steel axe blades from the West.

However, many new technologies, even very powerful ones, are not assimilated into a culture at all. For example, the earliest invention of movable type, in China, had essentially no effect on the culture. Only centuries later, and in a different culture, was the utility of movable type assimilated, this time with profound effects on the entire fabric of society.

New technology may be assimilated in ways that have more to do with a given culture than with the technology itself. Early in this century, missionaries working with the Tikopea noted their lack of oral hygiene. In an attempt to rectify this problem, they sent large quantities of toothbrushes to the island. These colorful pieces of technology were greeted with enthusiasm and were immediately assimilated — as earrings!

Similarly, the advent of computers in the classroom was hailed as a potential revolution by many progressives. In fact, however, computers were largely assimilated as replacements for printed workbooks — resulting in remarkably little change in the culture of schools. Worse yet, many computers have remained in closets or been used as door stops. In fact, the disequilibrating power of the computer imagined by advocates has actually been observed in very few classrooms.

Whether a culture will assimilate a new piece of technology, and what kind of accommodation will result, depends not only on the nature of the new technology, but on the match between the new technology and the nature of the existing culture.

The Key Issue

CAST's goal is to help transform our schools into places where all children, including those with disabilities, have full access to a high-quality education. It is our assumption that new technology can play a pivotal role in that transformation. To be effective, such a transformation will require (a) a technology that is powerful, yet easy to assimilate into the existing culture; and (b) a culture that is ready to assimilate the technology and to accommodate its practices. As a result, the key issue is to design an intervention plan that takes into consideration both the nature of the new technology and the nature of the school culture.

Nature of the New Technology

Despite its wide currency, the term "multimedia" may not be the most apt descriptor of what is new about the new technology. My sixth-grade teacher (circa 1957) used multimedia. She would put a filmstrip in the projector, place a record on the turntable, and advance the filmstrip every time the record "beeped." Throughout, she also made audible editorial comments for our amusement — often with very expressive body language. That's multimedia!

It could be argued that "multimedia" is very old, as old as the ancient storytellers, whose stories were narrated with voice, movement, gesture, and sound — multimedia of the body. These original multisensory stories have been lost because there was no external technology for recording them. Instead, they were recorded only in the nervous system of the observer. This was "sensorimotor" media, but multimedia in fact.

In later epochs, various technologies were introduced for permanently recording these stories. For example, the ancient Egyptians knew how to tell stories and record and illustrate them using many media — stone, sand, papyrus. Over time, these media were supplemented with others — paper, canvas, film, plastic. All of these media and their modern descendents share certain features — the capacity to "record" experience or communication such that it can be "read" back at a different time and place. The mean[illegible] recording is always some sort of physical or chemical operation (dyeing paper, chemically altering film, laying grooves in plastic) that changes the medium permanently. Media such as LP records, film, and printed books are "fixed" media. They are designed to store information (which may be multimedia) permanently, for retrieval at a later time.

The most recent revolution within the area of multimedia is the advent of electronic (including digital) recording and storage. Electronically stored information offers the advantage of permanence, similar to fixed media. Unlike fixed media, however, information stored electronically can be very malleable and flexible when brought from its place of permanent storage (such as a videodisc or CD) into the computer. Thus, on the computer screen, information can be represented in multiple formats, and can easily be transformed from one format to another. The ease of changing fonts and type sizes on a word-processed document is another simple example of this type of flexibility. Similarly, the same text can be represented as spoken output, either with synthetic speech or digitally recorded speech.

From our perspective, it is the malleability of the new media that holds the most prospects as well as challenges for the classroom. For example, this flexiblity allows information to be presented in the classroom in many formats, providing multiple access routes that reflect the diversity of the participants and providing multiple supports for children with special learning needs. At the same time, the inherent malleability of multimedia also offers multiple formats for students to *produce* information. Students can compose in multiple media without the intermediary of printing press, recording studio, or the like. Thus, they have broader alternatives for expression than presently available. This malleability is a potentially powerful feature. Is the existing culture of the classroom ready to assimilate this kind of technology?

Nature of the Existing Culture - Schools

Schools serve as the representatives of a culture to its children and, at the same time, often as its conservators. It is not surprising, therefore, that the culture of schooling has changed little over the last few centuries. Even the primary technology has remained the same — schools are still dominated by the technology of print. Most information is available only in print, most output from students is in print form, and most of the learning in school focuses on how to use print technology (how to decode or encode printed words, how to get the meaning from print, how to find information in books, etc.).

It is not surprising, therefore, that school literacy is synonymous with print literacy. As a consequence, the primary use of electronic technology to date has consisted of helping children use the old print technology. Thus, the technology companies that have succeeded have done so because they have understood this concept. By and large, they have built laboratories that are essentially remediation centers for learning traditional print-based skills.

Our present schools are dominated by the strengths (the capacity to store information for the culture, portability, low cost) and the weaknesses (e.g., the inflexibility, unequal difficulty of use, "one-size-fits-all") of print technology. As a result, the early years of regular education focus almost exclusively on mastering print-related skills. "Special education," in turn, has arisen primarily around issues related to print technology. Thus, children with print-related difficulties (dyslexia, dysgraphia, learning disabilities) represent by far the largest population in special education.

The learning of print techno' · and other "fixed" technologies for storing the knowledge of our culture, lends itself to certain kinds of structural and pedagogical solutions. And problems. These have been described in many forums and will not be reiterated here. One focus of our research, however, must be on discovering how the new technology can be assimilated into a culture that is so dominated by its existing technology and by its mission as conservator of the culture. Specific examples of CAST research efforts will be presented in the following section.

CAST Research

CAST's research is largely formative. That is, we design multimedia applications and classroom interventions that maximally exploit the flexibility of the new technology to integrate all children in successful mainstream educational experiences. By working in classrooms, we assess the success of these applications and interventions, revising and remodeling as necessary. As noted, we investigate not only those features that make technology powerful, but also those that allow the culture to assimilate it effectively. In order to do our research, we work closely with schools, identifying the needs of teachers, parents, administrators, and students. With the collaboration of all these groups, we develop and then evaluate applications that are designed to meet stated needs.

At present, we are working in one or more classrooms in each of five school districts — four in Massachusetts and one in Kentucky. In each classroom, children who would ordinarily be placed in an alternative placement are mainstreamed. To assist in this mainstreaming effort, classrooms are equipped with at least one Macintosh, a projection plate, scanner, and hard drive. In addition, software developed by CAST is provided along with standard commercial packages.

Teachers in participating classrooms are trained in using the Macintosh and in working with commercially available software that meets their general needs. In addition, CAST develops multimedia applications, specifically designed to make curriculum accessible to all students, including those with identified disabilities. Furthermore, CAST provides frequent in-classroom consultation.

Program success is determined at several levels. First, we examine outcome variables related to the children themselves. Have mainstream classrooms been able to utilize technology to accommodate the needs of students, in particular students who have disabilities? Are these students succeeding — academically, socially, and emotionally — in the mainstream classroom? Second, we look at attitudinal and behavioral changes in caregivers. For example, how do regular education teachers, students, and parents experience the inclusion of special needs students in mainstream classes? How do they view the new technology? Third, we look at structural variables, such as: Has the role of special education changed? How are students assigned to classrooms and services?

This type of formative research continues along several paths -- in the design of better multimedia applications and in better models for cultural preparation and training, including teacher, student, parent, and administrator. Our research continues to suggest that, as this paper has briefly argued, these are not independent processes.

Hypermedia Computer-Assisted Instruction: Adapting a Basal Reading Series

Kyle Higgins
Randall Boone

Every day in elementary school classrooms across the country students sit in teacher-directed reading groups and read from their basal readers. Often this type of instruction follows the teaching strategies outlined in the teacher's guide for the basal, including work on vocabulary skills, semantic and syntactic reading skills, and comprehension skills.

While systematic reading instruction is at the core of the elementary school curriculum, as much as 70% of reading instruction time in these classrooms does not involve the teacher. Instead, the students work independently on noninteractive reading-related assignments such as worksheets (National Academy of Education, 1985). Given the current trend in public schools to educate students with mild handicaps in the general education classroom, and with the majority of elementary school teachers using the basal reader approach (National Academy of Education, 1985), adapting a basal reader to multimedia computer-assisted instruction for these students is an exciting approach to using technology in the elementary classroom.

The Research Project

A school-based, cooperative research project between the University of Washington and Hazelwood Elementary School is being conducted in Renton, Washington. This three-year longitudinal project involves developing and testing multimedia reading materials in a hypermedia format based on the elementary basal reading series used in the district. Specifically, the multimedia/hypermedia reading materials are designed to facilitate successful participation of students with mild disabilities in a general elementary classroom basal reading program (K-3). The project is evaluating the impact of these materials on children's development of reading skills, participation in reading-related classroom activities, and yearly achievement gains in language arts.

Eight classrooms (K-3) involving over 300 students in both experimental and control settings are participating in the study. The natural movement of students from one grade level to the next results in random assignment of students to control and experimental classrooms each year. Thus, the project is accumulating longitudinal information on five separate subgroups based on the sequence and number of years the students participate in either experimental or control classrooms:

- Students who use the multimedia/hypermedia reading materials every year for three years.
- Students who use the multimedia/hypermedia reading materials two years in a row.
- Students who use the multimedia/hypermedia reading materials for two years with a one-year hiatus between the two years.
- Students who use the multimedia/hypermedia reading materials for one year.
- Students who do not use the multimedia/hypermedia reading materials any year.

The Software

Technological Features

The multimedia software developed for and used in this project is accessed through a hypermedia interface written in HyperCard (Atkinson, 1987) for the Macintosh family of computers. The technology requirements are exclusively microcomputer based and do not include additional hardware such as a CD-ROM drive or videodisc player and monitor. Limiting the software to the microcomputer's audio and visual capabilities achieves two purposes:

1. The cost of a single student workstation is kept to a minimum. This provides research data based on a reasonably priced technology that schools can afford and, therefore, are more likely to implement.
2. The use of a single-screen format is consistent with the gestalt law of closure (i.e., we see things that are within a closed region as having correspondence to one another), which dictates that a single screen be used to present information (Nielsen, 1990) to assure that students are not confused about where they should look for information (A. P. Givens, personal communication, April 1, 1991). In addition, using this format, students are more likely to understand the connections between the layered hypermedia information and the original text (Nielsen, 1990).

Educational Strategies

Unlike much commercial multimedia and hypermedia software that is more a database of information to be explored by students, the software in this project employs educational strategies based on specific learning goals. That is, rather than computer-assisted instruction, the "look and feel" of the interface between the student and the software is kept constant from lesson to lesson through visual iconic representations of commands for controlling the lessons, as well as auditory cues, instructions, and reinforcements relayed to the student via headphones.

Format

Lessons consist of verbatim text from the basal readers presented on a computer screen in a large (18 or 24 point) typeface. The nonscrolling pages are linked linearly from first to last with the option of paging forward or backward. In addition the first and last pages are also linked to provide a metaphor of circularity. Multimedia enhancements are available on each page through the hypermedia interface of buttons linked to text windows, graphic windows, and digitized speech. There are no relational links from page to page as found in many hypertext and hypermedia documents. This limited or guided hypermedia format offers students the relational information inherent in good hypermedia while lessening the chances for confusion within a large network of information.

Instructional Strategies

The multimedia/hypermedia capabilities of the microcomputer hardware and software helped define the instructional strategies selected for adaptation to the lessons in this project. Thus, strategies that could be faithfully "reproduced" by the multimedia/hypermedia format were chosen (e.g., lead a student through the same sequence of prompts as a teacher would), and only those that were successfully implemented in a pilot test were included in the software (see Figure 1).

Instructional strategies incorporated into the software through its hypermedia links meet three criteria:

- The instruction must constitute an effective reading strategy or intervention for students with mild disabilities.
- The instruction must be similar to a strategy the teachers are likely to be using or with which they are familiar.
- The instruction must be transportable to the microcomputer format without sacrificing important elements of the strategy.

Year 1

Software developed for the first year of the project includes *vocabulary enhancements* to the basal reader text. Research indicates that pairing unknown words with additional information about those words is a highly effective vocabulary learning procedure (Graham & Johnson, 1989). Computerized pictures, animated graphic sequences, definitions, synonyms, and digitized speech, linked to words and pictures from the original basal text, provide the students with new experiences related to reading.

Year 2

The second-year software builds on the software from year one, adding instructional enhancements for *understanding syntactic and semantic structures* in the text. Since elementary school children are less likely to use pronoun clues for understanding text than are adult readers (Lesgold, 1972), Chai (1967) concluded that making logical connections between pronouns and their referent words may be necessary to prevent potential ambiguity of meaning. Based on these findings, the new software features for the second year graphically depict the relationship between pronouns and anaphora with their referent words.

Year 3

Software developed for the third year builds on the second-year software, adding enhancements for *comprehension strategies*. Two strategies — questions inserted in text as prompts (Wong, 1980) and questions presented as prereading goals (Wong, 1979) — have proven successful with students with mild disabilities. As a result, questions inserted in text, rereading to find specific information, and prereading goals are implemented in the third-year comprehension strategies.

Teacher Considerations

Recognizing that any instructional strategy, including computer-assisted instruction, can be successful only when used regularly by a teacher, the project took the following principles into consideration:

- Teachers prefer to use computer software that directly relates to what they are already doing instructionally (Howell, 1990; Mokros & Russell, 1986); therefore, the software should support the already established curriculum.
- Software for use in a mainstreamed classroom setting should provide increased interactive instructional time for students without increasing the demands on the teacher's time for either instruction or evaluation.
- Meaningful integration of a computer-assisted component into the instructional and management schemes of a classroom requires both a flexible instructional product and adequate teacher support.

Approximately 50% of the stories from the basal reader series, preprimer through fourth grade, were adapted as multimedia/hypermedia lessons. Students used the lessons independently either before or after a teacher-directed reading activity, rotating from independent seat work at their desks to the computer station in their classroom. Throughout the three years of the project, the teachers received training on the use of the computers and software, participated in scheduled group support meetings after school, and received frequent support within their individual classrooms during the school day.

Results

Achievement gains from the first and second years, based on pretest and posttest scores from the basal criterion referenced test, were examined by treatment grouping (experimental vs. control) and instructional sequence grouping (intervention either before or after teacher-directed reading group). When comparing entire classes, almost no difference was found between experimental and control groups at any of the four grade levels. However, classifying students within classes into ability groups (e.g., high, medium, low, resource room) provided evidence that the intervention was a significant educational help for some low-achieving students and for students with mild disabilities.

Results are inconclusive as to whether the lessons are best used before or after a teacher-directed reading activity. However, anecdotal information from the teachers in the experimental classrooms indicates that when used as advanced organizers, the lessons provide some students with increased confidence and additional skills for participating more actively in the teacher-directed reading group.

Year 1 data. Low ability group students in the kindergarten experimental classroom achieved higher improvement scores than their counterparts in the control class in letter identification, auditory discrimination, and total test scores. Whole group significance was found, with experimental kindergarten students outperforming the control group in letter identification and auditory discrimination. Further, the medium group in the kindergarten experimental class performed significantly better than the corresponding control class group in auditory discrimination and total test.

Students in the second grade experimental class defined as low obtained significantly higher improvement scores in comprehension and total test. While no significant differences between experimental and control students were found in the low groups, at the third grade level students defined as medium and high outperformed their counterparts in the control classroom in vocabulary and comprehension skills, respectively. No difference was found in improvement scores between the students defined as low in the two first grade classrooms.

Year 2 data. Whole group significance was found at the kindergarten level, with experimental students outperforming the control students in letter identification. Low group students in the experimental classroom performed significantly better than the control group in letter identification. However, no difference was found in the performance of the medium and high groups at this level.

In first grade, whole group significance was found, with the experimental group outperforming the control group in decoding, vocabulary, and total test scores. By ability level, the decoding test scores of students in the experimental low group were significantly higher than those of the control students. Similarly, compared to the control students, students in the experimental high group achieved significantly higher test scores in decoding, vocabulary, and total test scores.

In the second grade, students in the experimental classroom low group outperformed the control group in language skills, while the high group outperformed the control group in vocabulary skills. Finally, for third grade students, the high experimental group achieved significantly higher decoding and total test scores.

One of the most interesting results of the second year was the achievement gains of two resource room students in the third-grade experimental classroom. Over the course of the year, these students advanced out of a resource room for all their reading instruction, to full participation in the middle reading group in their home classroom setting. Protocol analysis with these two students revealed an understanding of the key instructional elements of the software as well as enthusiasm for reading the lesson on the computer. Anecdotal teacher information indicates that the students came to reading group prepared to participate with the other children, with knowledge of lesson vocabulary, and with enthusiasm.

Recommendations

The teachers who are using this multimedia/hypermedia software contribute perhaps the keenest insight into which aspects of the project are most important both instructionally and in terms of classroom integration. This commentary from the classroom provides a useful point of departure for discussion of further research. Informal formative evaluation conducted during after-school support meetings along with videotaped interviews near the end of the third year reveals several aspects of the project the teachers felt were salient to their success.

- The students were able to use the computer independently with no teacher involvement for either operating the hardware or successfully completing the lessons.
- The software directly supported what the teacher was currently doing instructionally, both in content and in instructional strategy.
- The software was instructional, not just drill and practice for information or concepts already presented by the teacher.

The teachers' acceptance of the computers and software as a regular component of their reading programs for a three-year period is perhaps as important a research finding as the project's effect on student reading achievement. Finally, it is imperative to retain the three features suggested by the participating teachers as components of educational multimedia and hypermedia research. Future research should examine not only development of more powerful technologies and instructional designs, but also alternate paradigms for the role of computer assisted instruction in the elementary classroom.

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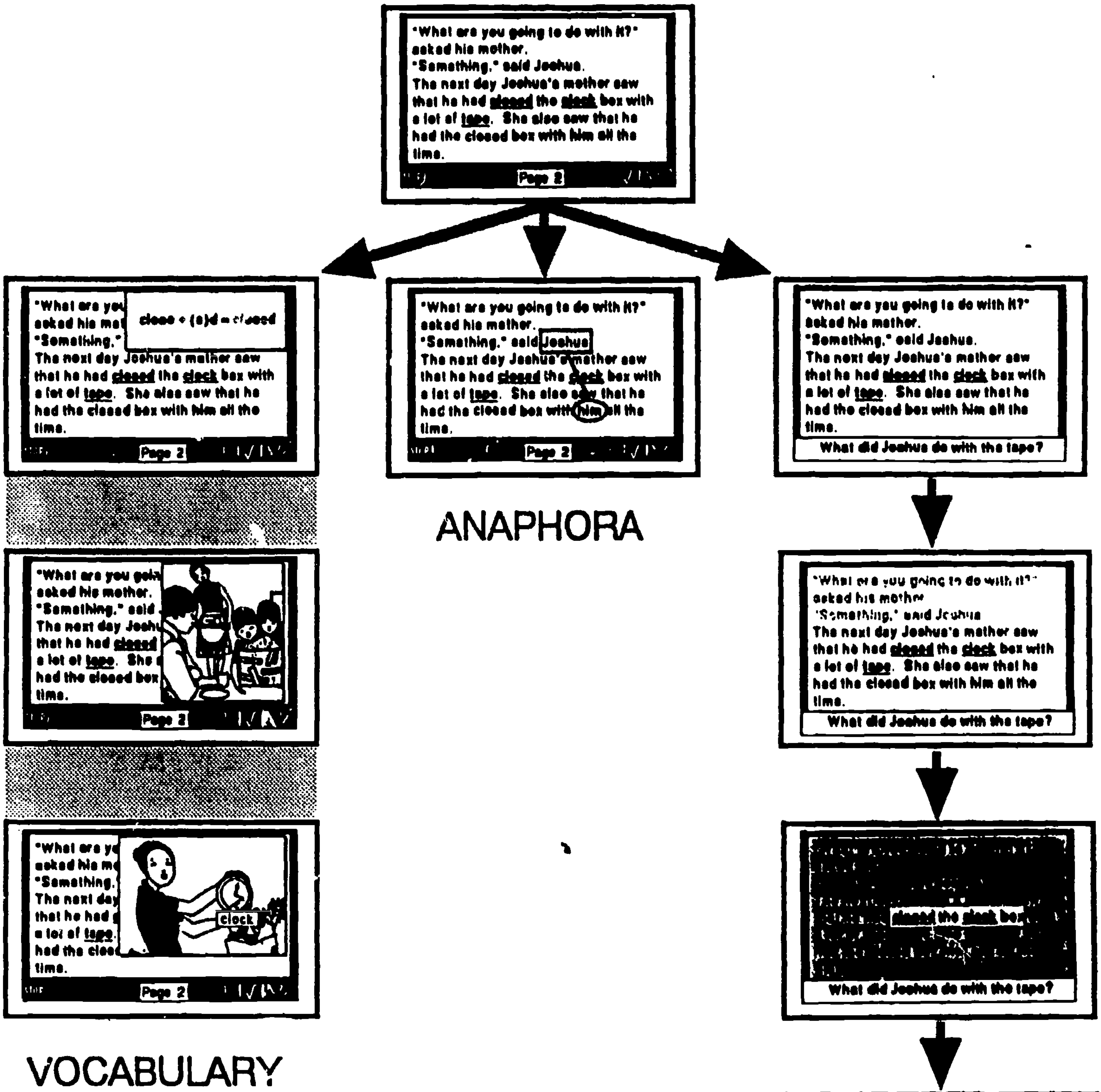
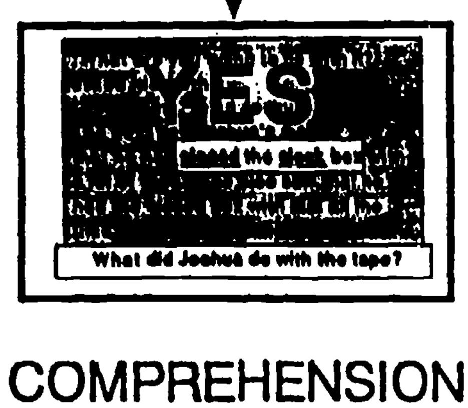
Figure 1. A hypermedia lesson flowchart.





Three categories of hypermedia enhancements are shown in this flowchart: (a) VOCABULARY, text and graphic windows appear over the main text screen; (b) ANAPHORA, a graphic connects the pronoun to its antecedent; and (c) COMPREHENSION, students search for the line where the answer to a question is found. The software limits the text to be searched each time an incorrect choice is made.

Bank Street College of Education

Kathleen S. Wilson

Bank Street College was founded in 1916 in the Village in New York City by Lucy Sprague Mitchell, who called it the Bureau of Educational Experiments. At that time, Bank Street's teachers were thought of as teachers/researchers and the entire enterprise of teaching was considered a research effort. Teachers designed their own curricula and developed their own materials, revising or recreating them as needed. Mitchell had strong views about education, not unlike those of progressive educators such as John Dewey. For example, she felt that learning should be child-centered, discovery-based, reflective, interdisciplinary, and collaborative. To this day, work at Bank Street is influenced by this philosophy of learning and teaching. As complements to the school, new divisions were created, such as a master's level program for educators, a product development division that produces a variety of educational materials, and a research division. These divisions co-exist within the Bank Street College of Education today.

Multimedia Research and Development at Bank Street

At Bank Street's Center for Children and Technology, a variety of research projects have been conducted with teachers and students over the last 12 years. Projects range from considering what role technology might play in new forms of assessment and the effects on student learning of new technologies, to creating interactive multimedia prototypes for use in schools and other educational settings, such as museums. This paper is a brief summary of such exploratory observational research conducted over the last six years with teachers and students using and reflecting on various iterations of evolving interactive media technology.

There are many ways of defining *interactive media*, or *multimedia*. Our use of the term refers to computer-based learning environments that allow for electronically integrated display and user control of a variety of media formats and information types, including motion video and film, still photographs, text, graphics, animation, sound, numbers, and data. The resulting experience for the user is a multidimensional, multisensory interweave of self-directed reading, viewing, listening, and interacting through such activities as exploring, searching, manipulating, writing, linking, creating, juxtaposing, and editing. Examples of this form of interactive media include ABC Interactive's *In the Holy Land*, Apple Computer's *Visual Almanac*, Bank Street's *Palenque*, IBM's *Ulysses*, National Geographic's *GTV*, and WGBH-TV's *Interactive Nova*.

Our "poking around" at Bank Street as designers and researchers in this ever-changing area of interactive media is perhaps not unlike that of teachers and students trying to come to grips with this technology. Thus, we always seem to come back to the questions, What do we mean by *learning* and *teaching*? What do we hope children will learn? How can teachers foster this? How can we assess this? What role can educational materials and technology play effectively and uniquely?

We have chosen to address approaches that attempt to integrate interactive media directly into ongoing classroom activities. Since teachers are clearly central in this process, we will focus on their concerns.

Practical Teacher Concerns

When faced with the opportunity and challenge of integrating new technologies into their classroom activities, teachers have many practical concerns and questions. These include:

- What is it [interactive multimedia]?
- Of what value is it? How relevant is it to my current practices, materials, activities? What difference will it make? How will I evaluate its effectiveness?
- What do I have to learn to use it effectively? Where will I find the **time**? the support? the expertise when needed?
- What kinds of changes will I have to make to integrate it into my classroom? Where will I find the **time** to plan? the space? the equipment? the time in my already overloaded classroom schedule?

Many teachers are still not using computer-based materials in their classrooms. Yet, a large number of teachers are interested in new technologies and are motivated by the thought of introducing new kinds of computer-based tools and software for their students to use, as well as by the gratification of learning new computer-related skills themselves. However, most teachers need the time and support to learn how to use technology and to develop the confidence and strategies to select and use it effectively in their teaching. Many are unfamiliar not only with the technology of innovative multimedia applications, but also their content and pedagogical style. In a national survey conducted by Bank Street's Center for Technology in Education, responses of teachers accomplished in the use of computers suggest that to reach this proficiency level has typically taken them 5-6 years (Sheingold & Hadley, 1990). Even the most accomplished teachers, in terms of computer use and comfort, still express a number of concerns, including the need for more space, more equipment, more flexible scheduling, and more time to learn how to use and plan how to integrate new technology into their teaching.

Integrated Classroom Uses of Multimedia

One of the main questions teachers have about multimedia is how it can be used effectively in their classrooms. Developers of available interactive media applications (mostly multimedia databases with sophisticated indexing systems, learning activities and simulations, references, and editing tools) typically list four potential classroom uses:

- presentations
- exploration, inquiry, hypothesis testing, and research
- authoring or producing "multimedia reports"
- teacher-made materials

Each of these types of classroom applications will be briefly discussed.

Presentations

Our work with teachers suggests that interactive multimedia usage displays a trajectory-like evolution from the first uses as a presentation device to the more advanced uses for individual student and small-group research and production. Perhaps using interactive media for presentations comes closest to what many teachers are doing with their classes already.

Research

Another proposed use for interactive media in classrooms is student-directed research. Given computer control of a rich database of images, sounds, and text, students can, hypothetically, use various browsing and indexing tools to study new areas of interest in their own way, at their own pace. Ideally, they can use interactive media applications and tools to learn how to ask meaningful questions, to gain access to new information, to do things they have not done before, to go somewhere they have never been, to see things in new ways, and to provoke conversation and further investigation.

For teachers, this use of multimedia means incorporating student-directed work into classroom activities and schedules. It means taking the time to learn how to manage individualized or small-group work that may or may not fit precisely into a prepared instructional sequence or class period because it requires following a student's interests and learning needs, not a prescribed lesson plan. It means learning how to manage a more public display of students' work in progress. It means helping students learn how to formulate meaningful questions. In addition, teachers have to become familiar with the process of helping students think critically about, reflect on, and make sense of their personal inquiries, explorations, associations, observations, inferences, and discoveries, because in interactive media databases, information is often decontextualized and deconstructed to the point of being removed from any rational argument or meaningful whole.

Since most students have much less experience and information about the world than adults, teachers often have to help them understand the context and interconnectedness of various information "chunks" they encounter while browsing freely in large interactive databases. That is, teachers often have to interpret the associative links. Related to this kind of teacher support is a form of literacy that many teachers feel obliged to provide. This type of assistance helps students understand the existence of biases in databases, that databases are created by someone who has a certain point of view, and that the "raw" video, slide, text, and audio material in them has an original source. In this way, teachers also help students step back from the data themselves and recognize the inherent limitations, as well as strengths, of databases, simulations, and various forms of mediated information. These activities represent learning opportunities, as well as challenges.

Multimedia Authoring

Student creation of multimedia reports is a third proposed classroom use for interactive media. Using software editing, graphics, and word processing tools in conjunction with rich visual, textual, and auditory databases, students can create a new kind of "report" that incorporates a variety of media formats, including text, motion video clips, still images, graphics, music, and sounds.

Although teachers typically are not filmmakers, editors, publishers, or media designers, they feel a need to learn how to help students think through the research and authoring process of learning something new by investigating a multisensory and multidimensional database or simulation; selecting appropriate information to include in their reports; and organizing the information in new and meaningful ways. While this use of multimedia is exciting to many teachers, it is not always easy because there is not yet a commonly understood and agreed-upon sense of what production of a multimedia report is. Unlike film or text, it is too new to have an accepted language, set of conventions, or forms. Teachers and students alike, therefore, are not sure what they are creating with these tools or how to [illegible] the effectiveness of their productions once completed. However, they are excited by the process.

The tools available for interactive media authorship range from simple to complex. The simplest tools allow for recombining and resequencing images, sounds, and text stored in databases. The more sophisticated tools allow for the input of student-generated text, and sometimes narrative audio tracks, in addition to the ability to recombine images, sounds, and texts. Only the most advanced applications allow input of images, sounds, and video clips researched and produced entirely by students. Until this capability becomes more prevalent, many teachers will continue to feel the need to help students understand the nature of their reports and drawing upon and recombining others' research, ideas, images, and sounds. Thus, understanding issues related to original research and authorship is a part of the learning process, in addition to the insights learned from the research itself. At this point, many teachers are more interested in what students have learned in the course of their research, in the effectiveness of their collaborations, in their problem-solving processes, and in the communication of their thoughts than in the sophistication of the design of their multimedia reports.

Teacher-Created Materials

A variety of software packages are designed to allow teachers to create their own learning and teaching materials. Although the potential of these programs is exciting to many teachers, and although they have become relatively easy to learn to use, it still takes time and commitment to become proficient at using them. Moreover, in order to be successful, teachers not only need to be proficient with the hardware and software tools, they also need to possess a basic understanding of interactive design, graphic design, video and audio production, and a host of other elements, with which most of them are not familiar. We have found, for example, that many teachers have great ideas for new educational applications or for tailoring existing applications to their needs, but very few have the desire or time to actually implement their ideas. Instead, most prefer to have a designer or a development team take over.

Other Uses

Many other potential classroom uses of interactive media may be suggested. Most likely, accomplished teachers will ultimately use interactive media in a variety of ways to suit particular learning situations and particular student needs, given the availability of appropriate, well-designed software.

One example is teacher research using complex databases and simulations in rapidly changing content areas, such as science and math. Another is teacher research of appropriate and available teaching materials and methods, stored in large databases for use in new kinds of teaching and learning experiences. Yet another use of interactive media includes student assessments and diagnostics. For example, an audit trail can be made automatically of a student's path through a particular application and reviewed later to determine learning processes and potential problem areas. Or, video reports of work in progress at different stages of completion can be used to capture the drafting and revision process, and to allow students to reflect on that process. Such records can be passed on with students as they move from teacher to teacher through the school system.

What Does the Use of Multimedia Mean for Students?

Once interactive media is integrated effectively into classroom activities, the question of its impact on students immediately comes to mind. Does it make any difference in children's learning experience? Does it have any impact? If so, what? A number of university and corporate research laboratories around the country have started to address these questions as more of the relatively sophisticated computer-controlled videodisc systems and software become available to schools (Ambron & Hooper, 1988, 1990; Bransford, 1985; Bransford, Sherwood, Vye, & Rieser, 1986; Collins, Hawkins, & Carver, 1991; Wilson, 1985, 1988; Wilson & Tally, 1990, 1991).

Summary

Successful integration of advanced interactive media materials into classrooms is a challenge for teachers, students, and school administrators, alike. New interactive media tools and applications are slowly becoming available for classroom use, but little is known about the nature and value of using such materials or the conditions under which they are best introduced and integrated in these settings. In order to successfully integrate these materials into classrooms, teachers and administrators must confront a wider range of challenges than frequently acknowledged, including technical and social support from school system administrators; the structure imposed by individual teachers' classroom schedule, curriculum, and environment; teacher integration of the interactive media materials into ongoing classroom activities; and the design of the multimedia software itself.

Clearly, there is a need for continued research into how to teach effectively with interactive media and its impact on student learning. In addition, there is the need for continued research, design, and development of effective and innovative educational software. Basic to all this, the larger questions seem to remain: What types of changes must our educational system make to best serve students in the coming years? What role may new technologies play in this change? And, how can the process of change be designed and implemented so that new technologies are used most effectively by both teachers and students?

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Summary of Discussion Session
Learning Theory and Education Goals in Development and Application of Multimedia Technology

Based on the information presented in the keynote address by John Bransford and the panel on multimedia research in progress, the primary discussion centered on (a) the power and applications of multimedia to create authentic activities for learning; and (b) the concept of creating environments that are open-ended and exploratory, yet give attention to goals, transfer, and navigation.

Questions and comments included:

- how to assure generalizability and general goal structures
- how to assure that students do not get lost in open-ended discovery — navigational issues
- the importance of scaffolding to assure child is not operating in isolation
- the teacher's role as mediator or mentor
- the importance of tracking and structuring student's learning path and problem-solving methods
- effects of multimedia on definitions of special needs students (e.g., attention deficit disorders, LD)
- effects on teachers of multimedia
- situated learning: issues of transfer and measurement

In general, the use of situationally based integrated multimedia changes the role of the teacher as well as students. The teacher's role focuses more on acting as a mediator and facilitator, that is, helping students set goals, tracking student's approaches, and recommending alternative strategies. For special needs students, the implications of multimedia environments include:

- the greater concern for navigational issues, especially in some hypermedia formats
- appropriate scaffolds and plans of action
- situational learning has more real-world meaning and allows students to see linkage of information
- in cooperative learning environments, each learner can become an expert on some aspect of the group's problem solving
- transfer or generalization of information becomes more real. The student is better able to see what information is content specific vs. what is dynamic and used in other situations.

Demonstrations: Education-Based Applications

The three presenters focused on products that have been developed using multimedia as well as the potential for further research and development. Both Monica Bradsher of National Geographic and Tony Peacock of IBM stressed the need for cooperation between educational researchers and their respective company's product development efforts. Bradsher pointed out that National Geographic had begun development of multimedia in 1985-86, but due to the lack of research base proceeded mostly through trial and error, a process that is very costly because of numerous revisions. Peacock noted that although IBM has major efforts underway in development of the technology, they alone cannot meet the major challenges for implementing the technology. As a result, they need the educational researchers working with them.

National Geographic

The products and efforts presented from National Geographic included the well-known KIDS Net. Although a telecommunications not a multimedia product, it does promote collaborative/cooperative learning; *Mammals,* a CD-ROM based multimedia encyclopedia; and GTV, a videodisc-based presentation using anamatics, a process which gives a sense of motion to still pictures.

All of National Geographic's products are surrounded by print and other resource materials taking advantage of multiple media. For *Mammals*, for example, the disc includes color pictures, movie clips, sound and text. Though these are limited to one-quarter of the screen, by placing the display in the center it appears more like full screen. This design is a result of National Geographic's focus on screen display qualities. Findings have also indicated that LD students, in particular, react to sounds; therefore, the sounds offer additional motivators to exploration and learning.

GTV which uses still pictures in video format is designed as a teacher presentation tool and enables students to make their own presentation using images, interactivity, and instant access. GTV reflects the assumption that, "... kids watch so much TV that there's no reason why they should suffer sensory deprivation when they hit the classroom."

The GTV selection shown demonstrated the integrated curriculum nature of the product as applied to social studies content, "Effects of the industrial revolution on the quality of life in New York tenements," used in an 11th-grade inner city English class. It can be a student presentation tool, that reveals emotions and includes the affective side of life. The product serves also as a motivator and springboard to other learning tools and activities. In all three National Geographic products, the collaborative/cooperative learning environments tend to make special education students "disappear" in that their strengths come to the fore.

IBM

The presentation by IBM featured current products as well as the future developments and visions based upon advancements in technology. All K-12 products being developed by IBM's multimedia group center around LinkWay. Three current product descriptions, representing different types of multimedia, included *Hurricane Hugo* developed in cooperation with CNN, a videodisc program which can provide two-screen presentation or, with video overlay card, one-screen motion video; *Alphabets*, a talking book using voice, music, high-quality color graphics and animation; and *Columbus*, a multimedia LinkWay based product, designed and produced for the forth-coming Christopher Columbus anniversary. The 150 hour program, due for release in September, is designed to interface across the curriculum.

Current development efforts stress DVI because digital information can be networked, analog cannot. With networked information, whole libraries of information can be accessed by every student. This empowerment occurs when we combine the power of the network and the power of multimedia. The power curve of technology is so great that we are seeing tenfold improvements every three years. With such development, the electronics are getting faster and smaller, as the power becomes greater, the cost becomes smaller. Access to the technology is changing the role of teachers, and students, particularly those at risk. IBM currently produces products or a combination of products for practically every type of special needs student. But, to assure the paradigm shift necessary to assure widespread access, use, and application of an electronic learning system researchers and businesses must work together.

NTID

The products developed at the National Technical Institute for the Deaf (NTID) also represent the collaboration of researchers and content specialists. NTID's Communications Research department, working together with theoretical researchers and specialists in sign, English, and speech reading, has developed three videodiscs products. One is a pronunciation stack for hypercard that is used in courses, for small group instruction, and by speech therapists. It has seven levels of presentation including diacritical markings, dictionary pronunciations guides, and shows how words are produced. The program offers a test file for later analysis of student's progress by the student and others. The product has promise for accent reduction and ESL students as well as speech and hearing problems. The second product, is a videodisc sign language dictionary. It provides expressive drill, receptive drill, and vocabulary. The disc has one video and two audio tracks per side. On the second audio track are examples of deaf speech that clinicians may use to listen to classifications of deaf speech. A browsing feature allows access word-by-word, in modules, or categories. The third disc has environmental sounds. It only uses audio track and is used for auditory training. It contains 55 sounds of 15 seconds duration each. It includes several musical instruments playing the same selection. The sounds may be grouped by category, e.g., nature, ments playing the same selection. The sounds may be grouped by category, e.g., nature, house, machines, music, people, telephone, transportation, warning sounds. It has been found to have great motivational value for students who otherwise are not very interested in auditory training.

NTID produces 100 copies of each disc and retains only 25 for their use. The others are available at cost. As with many developers, they have found that the process is very time intensive if you are to assure quality; and, the dissemination and marketing is problematic. Future development plans include the use of a signal processing editor and the use of CD-ROM for auditory training.

Discussion: Curriculum-Based Applications

Participants were divided into three discussion groups to address issues of multimedia applications for special education across the curriculum. The focus groups represented:

1. Reading/Language Arts
2. Social Studies, Humanities, and Foreign Language
3. Math and Science

Following a 15-minute discussion, a representative from each group provided a synopsis of questions, issues, and concerns dealt with in the respective group.

Reading/Language Arts

- What can multimedia do now to facilitate communication skills and provide experiences that will facilitate mental models within the context of reading and language arts?
- The need for a seamless curriculum that brings all content together.
- Trends toward focusing the direction away from print and toward the development of effective communication.
- The use of multimedia to support cooperative and group learning that will promote teaching from students' strengths and learning from others.
- Need for teacher support and training to ensure effective classroom use of multimedia.

Social Studies, Humanities, and Foreign Language

- What dependent measures are needed that are sensitive for multimedia research?
- How do we assess and evaluate achievement to meet the needs of districts and developers?
- Need for established instructional goals as a prerequisite for measurement.
- Where should research be conducted (e.g., in the lab, or in a dynamic classroom)?
- Influence on the teacher of the pedagogy of multimedia.

Math and Science

- Lack of a research base in multimedia.
- Effects of teacher training lagging behind technology.
- Need for establishment of goals for effective assessment of effects of multimedia.
- Examples of readily available technology not being used (e.g., why not more voice output in use?).

Although participants self-selected content area groups for discussion, the overall concerns were generic issues such as teacher training, research, and assessment with less attention to specific curriculum content.

Interactive Multimedia Research Questions: Results from the Delphi Study

Ralph P. Ferretti

Introduction

A growing interest in the pedagogical possibilities afforded by interactive multimedia technology spans such dimensions as content area and students' developmental level and abilities. At the same time, teachers and researchers are concerned about how best to use this promising technology. The Center for Special Education Technology responded to these circumstances by conducting a Delphi study about research questions that should guide the analysis of interactive multimedia use in special education.

The Delphi study was comprised of two questionnaires. In the first, experts in the special education technology community were asked to identify the five most important research needs in interactive multimedia. Their responses were compiled and returned to participants as part of a second questionnaire in which they performed two tasks. First, they judged the importance of each response; second, they selected as well as justified responses that described the five most important multimedia research needs.

Descriptive analyses showed that respondents were most frequently concerned about design issues affecting the efficacy of educational interactive multimedia. These issues included instructional strategies and methods, the multimedia environment, navigational tools, and strategies for promoting transfer of skill. Two other themes emerged. First, experts were interested in how the characteristics of persons with varying disabilities affected the efficacy of educational interactive multimedia. Second, they were concerned about the technical and training resources needed to use multimedia effectively in practice. The pedagogical possibilities afforded by multimedia technology have spawned a burgeoning interest. Specifically, educational interactive multimedia has been developed to foster knowledge and skills about topics such as entomology (Gay & Raffensperger, 1989), English literature (Yankelovich, 1987), reading (Blanchard & Rothenberg, 1990), and teacher education (Lampert & Ball, 1990). This and other work has been largely motivated by intuitions about the characteristics of learners and the intrinsic properties of multimedia that may improve instructional outcomes. For example, interactive multimedia allows integration of graphics, sound, video, and text in instruction (Layman & Hall, 1991). In some instantiations, these media are linked on a computer with hypertext software to establish elaborate, interconnected instructional systems. An intuitively attractive characteristic of hypermedia applications is that they enable teachers and students to make nonlinear connections among various informational sources. People are thought to connect ideas in flexible networks (Bush, 1945; Lampert & Ball, 1990). Presumably, hypermedia systems encourage elaboration of the knowledge network, the development of multiple paths to knowledge, and the active exploration of information (Hassselbring, Goin, & Wissick, 1989).

These intuitively compelling ideas have not yet received the sustained research attention that would establish the efficacy of multimedia. In part, this is due to the atheoretical and technology-based nature of most work in the field (Duffy & Knuth, in press). To make predictions about the effects of multimedia, we need to analyze how the technology is used to attain specific goals from the perspective of theories of cognition, learning, and instruction. By doing so, we can ask important questions about the educational consequences of interactive multimedia (cf. The Cognition and Technology Group at Vanderbilt, 1990).

The field is clearly in a formative state with respect to research about the efficacy of interactive multimedia. The Center for Special Education Technology responded to this situation by conducting a Delphi study, asking special education technology experts to identify the key issues that should guide research about the use of multimedia in special education. The Delphi process is a method of eliciting opinion about a topic by administering successive questionnaires to respondents who are selected on the basis of their perceived expertise (Lauffer, 1978; Turoff, 1970). At each stage in the process, respondents receive feedback about the results of prior questionnaires to clarify points of agreement and disagreement in the community. The method is considered to be relatively fast, inexpensive, and easy to administer. It is especially useful when the informed opinion of experts may be more valuable than hard data, adequate information about some topic is unavailable or would be too difficult to get, time is scarce, or the disagreements among experts is so severe that face-to-face discussions would be unproductive (Lauffer, 1978).

Method

Participants

Participants in the Delphi study were selected by the Planning Committee for the Center for Special Education Technology's Seminar on Educational Interactive Multimedia. A list of prospective participants was drawn from persons holding technology research grants from the Office of Special Education Programs, as well as individuals with known expertise in technology use in special education. The 48 persons who were identified in this manner comprise the pool of experts from whom opinion about multimedia research questions was sought.

Eighteen of these 48 persons (38%) responded to the first questionnaire. The results of this questionnaire were summarized and used to construct a second questionnaire that was mailed to the 18 original respondents. Twelve of these 18 persons responded to the second questionnaire. Thus, the results for the second questionnaire are based on responses from 25% (12/48) of the original pool of experts.

Materials and Procedures

Two questionnaires comprised this Delphi study.

Questionnaire 1. The following question was posed in the first questionnaire:

"Think about the conditions in special education which currently exist and those that may develop by the year 2000. Considering the following definition of educational interactive multimedia, what are the five most important research needs in educational interactive multimedia which must receive attention for the technology to be successfully used in special education?"

Educational interactive multimedia was defined as:

Nonsequential and nonlinear presentation of text, graphics, animation, voice, music, movies, or motion video in a unified information-delivery system centered on a personal computer, that involves the student as an active participant and is applied in an educational setting for any number of instructional purposes."

The goal was to sample a wide range of research questions about multimedia from experts in the special education technology community. Consequently, responses to the first questionnaire were intended to be open-ended.

In total, the 15 respondents generated 97 responses to the first questionnaire. These responses were compiled, and the frequency with which certain themes appeared across all respondents was counted. This was accomplished by reading, sorting, and re-sorting each of the responses until common themes emerged in the mind of the investigator.

Questionnaire 2. Consistent with the nature of a Delphi study, the second questionnaire was comprised of the 97 responses generated by the first questionnaire. Thus, it began with a summary of the seven most frequent themes from Questionnaire 1. Respondents were then asked to perform two tasks with the responses to the first questionnaire: a rating task and a selection task. For the former, respondents were asked to:

"... consider all responses to the Round One Questionnaire in light of the above-mentioned themes. The goal of the Round Two Questionnaire is to establish **consensus about the five most important research questions** that must receive attention for the use of multimedia in special education. With this goal in mind, please read each response to the previous questionnaire. For each response, we have tallied the frequency with which it (or a similar response) occurred in Round One. Please rate the importance of the research need described in that response on a scale of 1 to 5..."

For this scale, 1 = Unimportant, 3 = Moderately important, 5 = Very Important.

In the selection task, respondents were asked to:

"... select the responses that describe the **five most important research needs** and provide a brief (1-2 sentences) explanation for choosing each... Restrict your selection of these five research needs to those responses that you deemed "Very Important" ("5" on the rating scale)..."

The rating task sought data about the average level of importance attached to each of the 97 responses. The selection task, in turn, helped constrain the number of possible responses by identifying a subset that was deemed to be "Very Important." In total, 38% (37/97) of the original responses were selected among the five most important multimedia research needs in special education. Both tasks provided converging information about the research questions that are deemed important by members of the special education technology community.

Results

Questionnaire 1

The investigator counted the frequency of responses with similar themes across respondents. The following seven themes appeared most often in response to the first questionnaire:

- The characteristics of **effective multimedia** that impact academic, social, and functional outcomes in special education (10/97 = 10%).
- The characteristics of the **target population** that influence the effectiveness or design of multimedia in special education (7/97 = 7%).
- The factors that enable special education students to **navigate** the multimedia hyperspace (6/97 = 6%).
- **Logistical considerations** that may affect the use of multimedia in special education (e.g., dispersement of equipment, required technical resources)(5/97 = 5%).
- The factors that affect **integration** of multimedia into the special education curriculum (5/97 = 5%).
- The characteristics of **preservice and inservice training** that ensure special education teachers' proficiency with multimedia (4/97 = 4%).
- The kinds of experience that promote **transfer or generalization** of skills acquired through multimedia to real-life settings (4/97 = 4%).

In total, 41% of the responses (41/97) to the first questionnaire were captured by these seven themes.

Questionnaire 2

Rating and selection tasks. Respondents were asked to perform two tasks for the second questionnaire. In the rating task, they judged the importance of each of the original 97 responses on a scale of 1-5. In the subsequent selection task, they chose five responses that described the most important multimedia research questions and then wrote a brief explanation for having chosen each response. The explanations were used by the investigator to clarify the respondents' interpretations of their choices.

First, the mean rated importance was computed for each of the original 97 responses. The overall mean rating was 3.34 (range = 5.00 - 1.67), suggesting that the sample believed that these responses described research issues that were at least "Moderately Important." This conclusion is bolstered by the percentage of responses that fell within unit intervals on the rating scale. That is, 25% (24/97) of the responses were rated between 5.00 - 4.00, 39% (38/97) were rated between 3.90 - 3.00, 34% (33 /97) were rated between 2.90 - 2.00, and only 2% (2/97) were rated between 1.90 - 1.00. Of the 24 responses that were rated between 5.00 - 4.00, 83% (20/24) were among the respondents' five most important research questions in the selection task.

Next, the responses that described the respondents' five most important research questions were compiled from the selection task. Across respondents, 59 selections were made (one respondent made only four choices). Many of these responses were selected by more than one respondent. Consequently, 37 of the original 97 responses (38%) were selected as the five most important research issues. These responses were also rated to be among the most important research issues in the rating task. The mean rating of these 37 responses was 4.02 (range = 5.00 - 2.75). Further, 60% (22/37) of these responses received a mean rating of at least 4.00 on the rating task. Therefore, converging information from both tasks points to the importance of those responses that were selected and also attained a rating of at least 4.00. Attention will be directed to these responses in subsequent analyses.

Classification of research themes. The investigator sorted the responses to the second questionnaire according to common research themes. This sorting was backed by the respondents' explanations for their choices, which increased the fidelity of the resulting response classification. Three overarching themes emerged from the rating and selection data: design issues, population characteristics, and logistical considerations.

Design issues. The first research theme focuses on design issues affecting the efficacy of educational interactive multimedia. This includes the creation, modification, and organization of multimedia information and related instruction for the purpose of enhancing educational outcomes. This category accounted for 78% (29/37) of the responses selected as important research topics in multimedia.

The design theme was divided into four interrelated subcategories. The first of these had to do with **instructional design** in multimedia environments. Overall, 30% (11/37) of the responses addressed instructional design issues. Moreover, 38% (11/29) of the responses in the design category focused on instructional design issues. Table 1 contains illustrative responses related to instructional design selected by our sample of experts. Two pieces of information are associated with each response: the frequency with which the response was selected as an important research question and the mean () rated importance of the response.

Table 1

Illustrative Responses to Research Questions about Instructional Design

1. What specific instructional strategies are most enhanced through the use of multimedia?	Frequency = 2; m = 4.83.
2. What defines good instructional practice that can be created or enhanced by the use of multimedia technologies, based on instructional theory, the experience of practice to date, and the experience of using analogous presentation or learning technologies?	Frequency = 2; m = 4.75.
3. How to effectively integrate multimedia learning experiences into the special education curriculum — effective practices to supplant other forms of instruction, to support ongoing instruction, or to extend the experiences in new and unique ways.	m = 4.42.
4. The ability of the learner to make decisions regarding instructional sequence is critical to the use of a nonsequential, nonlinear presentation. What design features provide students in special education programs with the information they need to guide instructional decisions?	Frequency = 1; m = 4.33.

The following are some of the research questions that are prompted by the experts' responses about instructional design:

- What instructional practices are enhanced by multimedia?
- What are good instructional practices and how are they enhanced by multimedia?
- What kinds of knowledge and skills are taught best with multimedia (including academic, metacognitive, social, community, and independent living) and how does such knowledge/skills affect performance in multimedia environments?

The second subcategory concerned the design of **effective multimedia environments.** Whereas overall, 24% (9/37) of the responses were concerned with multimedia design, 31% (9/29) of the responses in the design category were about multimedia design issues. Table 2 lists illustrative responses about design issues in multimedia.

Table 2

Illustrative Responses to Research Questions about Multimedia Design

1. What are the characteristics of educational interactive multimedia (EIM) that contribute to effective and efficient learning for students with special needs?	Frequency = 3; m = 5.
2. What principles should be followed in the design of EIM for special education students of different ages with different characteristics?	Frequency = 3; m = 4.67.
3. What effects does the use of educational interactive multimedia have on the learning of students with varying exceptionalities? What changes occur? Under what conditions?	Frequency = 3; m = 4.67.
4. What are the characteristics of effective multimedia? Effectiveness may be/should be defined in terms of academic andmotivational variables.	Frequency = 3; m = 4.58.
5. How much "choice" in interactive multimedia is optimal? (Does this differ for each type of impairment?).	Frequency = 2; m = 4.08.

Some of the research questions that are raised by these responses include:

- What are the characteristics of multimedia that contribute important academic and motivational outcomes?
- What design principles should be followed when developing multimedia applications?
- How much and what kinds of media contribute to effective learning?

The third subcategory included questions about the kinds of **navigational aids** needed by persons with disabilities to traverse the hyperspace. Overall, 14% (5/37) of the responses were concerned with navigational issues, while 17% (5/29) of the responses in the design category dealt with navigation. Table 3 shows illustrative responses about navigational aids:

Table 3

Illustrative Responses to Research Questions about Navigational Issues

1. How to design multimedia programs that enable students with diverse abilities to utilize the nonlinear environment of most multimedia applications. (Concern for levels of readability, extensive use of text, locator systems built into the program, and self-determination of what/how to explore the nonlinear environment.)	Frequency = 2; m = 4.75.
2. To counteract the disorientation that is frequently observed among users of multimedia there is a need to identify the factors that effectively aid students in navigating the hyperspace (e.g., structural overviews such as cognitive maps, concept webs, and indices) and their optimal characteristics.	Frequency = 5; m = 4.42.
3. For students of various cognitive ability levels, how many "levels of hyperspace" can they effectively use without becoming "lost" in the hypermedia?	Frequency = 1; m = 4.08.
4. To counteract the cognitive overload that is frequently observed, there is a need to identify factors that effectively aid students in determining what information is relevant or essential and what information is not essential to the problem solution (e.g., advance organizers such as clearly stated educational objectives).	Frequency = 1; m = 4.00.
5. What support features such as notetaking, search and find, cognitive maps, are most beneficial to students requiring special education and most important in EIM?	Frequency = 1; m = 4.00.

Some of the research questions about navigational issues include:

- What features enable children with diverse abilities to navigate hyperspace? (including cognitive maps, concept webs, indices, notetaking)
- How many levels of hyperspace can be searched before children with differing cognitive abilities become lost?
- What factors enable students to distinguish relevant and irrelevant information? (such as advanced organizers)

The final subcategory included questions about the aspects of multimedia technology that promote **transfer or generalization** of knowledge and skills. Overall, 11% (4/37) of the responses were concerned with the transfer of skill, and 14% (4/29) of the design responses were concerned with the problem of transfer. Table 4 shows responses that were concerned about transfer.

Table 4

Illustrative Responses to Research Questions about Transfer Issues

1. What are the most effective instructional aspects of interactive multimedia technologies that appear to have the most positive effects on learning and generalization for individuals with mild to moderate handicaps?	Frequency = 2; m = 4.83.
2. To ensure that the knowledge and skills learned in the hyperspace or the multimedia environment are applied to real world problems inside and outside the classroom, there is a need to identify attributes and techniques of effective multimedia environments that optimize transfer to other settings and contexts.	Frequency = 3; m = 4.42.
3. The development of multimedia learning packages that simulate real world experiences for handicapped students to provide training in functional skills and generalization of these skills into daily living. (Should also address social problem solving and social skills, not just the traditional functional skills, and training for transition.)	Frequency = 2; m = 4.42.
4. Will the skills learned by students using interactive multimedia technologies generalize to other classroom and/or community-based activities?	Frequency = 2; m = 4.25.

Research questions about transfer include:

- What are the instructional and technical aspects of multimedia that promote positive transfer of various skills?
- What skills acquired by students while using multimedia will generalize to other settings?
- How can multimedia be used to simulate the use of various skills in real-world environments?

In sum, design questions having to do with instructional strategies, multimedia environments, navigation, and transfer were at the forefront of experts' thinking. This finding is not surprising, given these factors' contribution to the effectiveness of interactive multimedia in special education.

Population characteristics. Experts in the special education technology community understand that the efficacy of any instructional technology depends upon the cognitive abilities, learning styles, and developmental level of the student. Research questions about **population characteristics and individual differences**, and the degree to which they influence the effectiveness of multimedia, appeared in 16% (6/37) of the respondents' selections. Table 5 shows illustrative responses that pose questions about the effects of population characteristics or individual differences on multimedia outcomes.

Table 5

Illustrative Responses to Research Questions about Population Characteristics and Individual Differences

1. How to design multimedia programs that enable students with diverse abilities to utilize the nonlinear environment of most multimedia applications. (Concern for levels of readability, extensive use of text, locator systems built into the program, and self-determination of what/how to explore the nonlinear environment.)	Frequency = 2; m = 4.75.
2. What effects does the use of educational interactive multimedia (EIM) have on the learning of students with varying exceptionalities? What changes occur? Under what conditions?	Frequency = 3; m = 4.67.
3. What principles should be followed in the design of EIM for special education students of different ages with different characteristics?	Frequency = 3; m = 4.67.
4. To what degree do individual differences in cognitive skills (e.g., learning styles, memory skills, perceptual processing abilities) influence the reception, perception, responding to and retrieval of information associated with IM.	Frequency = 1; m = 4.08.

Two major questions about the affect of population characteristics are:

- How should multimedia learning environments be designed to accommodate students with wide-ranging abilities?
- How do individual differences in cognitive skills affect the reception, transformation, and retrieval of information obtained in multimedia environments?

Special education professionals believe that multimedia learning environments must be designed to accommodate the widest range of abilities, skills, and learning styles. Consequently, they wish to better understand how population characteristics and individual differences among students affect the efficacy of multimedia learning environments.

Logistical considerations. The efficacy of a new instructional technology depends not only on the intrinsic strengths of the technology, but also on the teacher's proficiency at using the technology, availability of the technology in the schools, and institutional support for using the technology. For these reasons, questions about logistical considerations in the use of multimedia appeared in 14% (5/37) of respondents' selections. Table 6 shows the responses that deal with questions about logistical considerations in the use of interactive multimedia.

Table 6

Illustrative Responses to Research Questions about Logistical Considerations

1. How to create adequate access to multimedia learning experiences, focusing on dispersement of equipment, student scheduling, teacher readiness to utilize the technology, support mechanisms for the teacher, and a database of available products across the scope and sequence of curriculum.	Frequency = 1; = 3.08.
2. The critical factors that will assist special education teachers in using multimedia programs effectively in their classrooms (i.e., training or tutoring students, modifying multimedia programs to meet students needs, and creating their own multimedia programs) need to be investigated: (a) to see if they are the same factors that influence the use of computer-assisted instruction; and (b) to discover ways to promote or encourage those factors.	Frequency = 1; = 3.33.
3. How do teachers acquire the required skills to (a) operate interactive multimedia; (b) design instruction to utilize IM; and (c) establish reasonable/valid measurement of IM in generalized settings.	Frequency = 1; = 3.50.
4. What training is necessary for teachers to effectively integrate educational interactive multimedia into the existing classroom/curriculum? This would also include follow-up technical support.	Frequency = 1; = 3.75.
5. What technical resources are required for schools to effectively implement multimedia for good instructional practice, at low-high levels of implementation, and in the near term, by 1995, by 2000?	Frequency = 1; = 2.75.

The following research questions are posed by these responses:

- What skills and technical competencies do teachers need to possess to capitalize on multimedia technology and how can they acquire these skills?
- What resources are required for schools to be able to implement effective multimedia learning environments and what arrangements are conducive to their use?

As reflected in their responses, special education technology experts wish to identify the resources, skills, and institutional conditions that contribute to effective use of interactive multimedia in the classroom.

Discussion

The purpose of the Delphi study was to assess expert opinion about research questions that should guide the analysis of interactive multimedia use in special education. The study detected consensus about important multimedia research issues. Specifically, three overarching research themes emerged: (a) questions about instructional and multimedia design, (b) population and individual differences among students, and (c) training and resources that affect the availability and efficacy of this emerging technology.

First, and most importantly, the special education technology community is concerned about design issues that affect the efficacy of educational interactive multimedia. The experts recognize the interdependence of instructional factors and the design of the multimedia learning environments in promoting important educational outcomes. This interdependence is shown in different ways. One possibility is that specific instructional strategies may be bolstered by the use of multimedia technology. For example, one respondent expressed an interest in investigating the benefits of linking collaborative learning with multimedia technology. Other researchers have expressed an interest in this question (cf. The Cognition and Technology Group at Vanderbilt, 1990; Van Hanegan, Barron, Young, Williams, Vye, & Bransford, in press).

Another possibility is that well-designed multimedia environments may be especially effective in promoting particular instructional objectives. For example, hypermedia databases seem to be especially well suited for making linkages among disparate sources of information and establishing salient interrelationships among disciplinary perspectives (cf. The Cognition and Technology Group at Vanderbilt, 1990; Duffy & Knuth, in press). Instructional objectives and activities that emphasize these linkages may benefit from multimedia learning environments. The results of the Delphi study clearly establish the value of pursuing research about instructional and multimedia design issues that affect important educational outcomes.

The ease of establishing nonlinear, multidimensional linkages in a complicated semantic space holds real instructional promise. However, it places great demands on the cognitive resources of students, who must monitor their place in the problem space. The possibility of student disorientation has been mentioned in the educational technology literature (Conklin, 1987; Tripp & Roby, 1990). Evidence from the general experimental literature suggests that students with disabilities may be especially susceptible to disorientation because of constraints on their cognitive resources (cf. Ferretti & Cavalier, in press; Torgesen, Kistner, & Morgan, 1987).

Consequently, the special education technology community is interested in studying how navigational aids facilitate student performance in multimedia learning environments. A widely sought instructional outcome is flexible use of knowledge and skills. Some have argued that educational institutions have been structured on the assumption of learning transfer (cf. Lave, 1988). In any case, teachers and researchers alike recognize that transfer is an elusive phenomenon that is bounded by situational factors (cf. The Cognition and Technology Group at Vanderbilt, 1990; Perkins & Saloman, 1989; Singley & Anderson, 1990). This problem is exacerbated by teaching and learning situations that lead to the acquisition of "inert knowledge" (The Cognition and Technology Group at Vanderbilt, 1990; Hasselbring et al., 1989). For example, students may not learn to use skills as tools in problem solving, the learning contexts may be devoid of meaning to them, the relations between the conditions of learning and use may be obscure, or students' representations of learning and transfer tasks may differ. Any of these factors (and others) can result in poor transfer. However, multimedia learning environments hold considerable promise for overcoming these obstacles to transfer. For example, learning activities can be designed to capitalize on videodisc-based information. This technology can present dynamic visual information that encourages the construction of veridical representations of learning and transfer environments (The Cognition and Technology Group at Vanderbilt, 1990). In theory, this should lead to positive transfer. Due to the importance of this pedagogical issue, the special education technology community is clearly interested in the possibility that multimedia technology can be used to promote transfer among children with learning handicaps.

Two other research issues were of considerable interest to experts in the special education technology community. In particular, the experts were concerned about how population and individual differences in cognitive skills, physical characteristics, and learning styles affect the efficacy of multimedia learning environments. For example, as mentioned, children with learning handicaps may be especially burdened by the cognitive load imposed when having to search the semantic space. This issue led to questions about the kinds of navigational aids that may be especially helpful to students with learning handicaps. Questions such as these could be asked about a host of cognitive, physical, and learning characteristics and their answers would enable the development of multimedia learning environments that were sensitive to the learning needs of all students.

Finally, many respondents were interested in studying how the teacher's skills and the technology's availability affect the use of multimedia in practice. These factors have been of considerable historical interest within the special education technology community (cf.

Blackhurst, 1977; Blackhurst, MacArthur, & Byrom, 1988; Gerber, 1988; Goldman, Semmel, Cosden, Gerber, & Semmel, 1987) for two major reasons. First, teacher training programs based upon clearly articulated competencies may affect the education of children in practice. Surprisingly, the effects of teacher preparation courses based on these competencies have not been extensively investigated (cf. Okolo, 1990). Clearly, the task of validating a comprehensive list of special education technology-related competencies is daunting. To do so, one would have to consider the following questions: What are the teachers' instructional goals in practice? Under what conditions would I expect to see these competencies used? What tasks are teachers performing in practice? How does the availability of instructional technology affect teachers' performance? How do institutional goals affect teachers' behavior in the classroom?

Second, and related, a range of administrative and institutional considerations (apart from knowledge and skill) limit teachers' performance in the classroom (Gerber, 1988). According to Gerber (1990), a wide range of questions about systemic factors (e.g., Who should use technology? When? For how long?) have very complicated answers that depend upon the conflicting goals and aspirations of the institution. For example, to determine whether it is more effective to place multimedia technology in special education classrooms or in the regular classroom, one need to consider the relative benefits of decreasing the variance in educational outcomes as compared to increasing average gains in performance across all students. This example suggests that the study of logistical considerations, as well as design and population differences, must be guided by thoughtful analysis of the goals that motivate the technology's use. Perhaps this is the most important implication of this Delphi study conducted by the Center for Special Education Technology.

Author Notes

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Initiating a Multimedia Research Agenda: Perspectives of a Faculty Member's Search for Support

James Emmett Gardner

In many respects my portrayal as an "isolated researcher with limited support" imperfectly labels the context of my research environment. To begin with, the terms "isolation" and "support" are relative. I am isolated in the sense that I appear to be the only faculty member on my campus who is pursuing research in instructional applications of technology and media with individuals with developmental disabilities. Yet, I have colleagues in educational psychology and technology who are interested in working on collaborative projects. Although financial support for equipment to conduct multimedia research and development is nonexistent at my college, I have the spirit of support from both my dean and my department chairperson. Regrettably, vendors are unable to accept "in spirit" payment for multimedia equipment. Therefore, I address the issues from the context of a junior faculty (i.e., third year in academics) member searching to acquire equipment and otherwise coordinate opportunities to initiate research in multimedia applications with exceptional learners.

University Research and Development Environment

The University of Oklahoma (OU) is a comprehensive research institution, which maintains an active enrollment of approximately 20,000 students. Over the past decade, higher education resources in Oklahoma have been scarce. Having never adequately recovered from the oil bust of the 1980s, the University of Oklahoma currently wavers between holding the rank of 7th or 8th of Big Eight institutions in terms of state appropriations. Recently, our President asked for a 55 million dollar increase in funding to elevate OU closer to the median level of Big Eight Institutions – the state legislature proposed 21 million (a final figure has yet to be determined). The next few years hold no foreseeable changes in legislative appropriations. Moreover, the University of Oklahoma's current funding dilemma appears identical to funding environments at other national research institutions of higher education.

Like other comprehensive research institutions, the University of Oklahoma is highly supportive of those who acquire or seek to acquire externally sponsored research. For example, the University operates an Office of Proposal Services to assist faculty in grant writing. In addition, there are sources at OU, albeit limited and highly competitive, which support faculty research and creative activities. Unfortunately, in an environment where faculty must compete for scarce resources (and an environment where the University is thirsty for external funding), the pragmatics of internal funding decisions often implicitly become prioritized based on a quasi-benefit/cost analysis. To see the implications of this situation, one need only compare the relative merits of subsidizing exploratory research and start-up costs for projects proposing to seek external funding in the range of $500,000+ from the National Science Foundation with that of a lone researcher seeking approximately $75,000 for a multimedia project.

As an environment conducive to multimedia research, there is little centralization of technology resources at the University level. The College of Education's Department of Educational Psychology, for example, offers two primary sources of technology access: (a) a microcomputer classroom with 12 Apple //e and 12 Apple Macintosh SE computers used exclusively for instruction; and (b) a Special Education Technology Demonstration Center providing students with access to examples of instructional and assistive technology and media applications in special education. The Center's hardware resources include an Apple IIgs, Apple //e, Macintosh SE, a CD-ROM player, and a Pioneer LD-V4200 Laserdisc player with TV/monitor. A library of technology-related articles and resource materials, software, and videotapes is also housed at the Center. Although its primary objectives are training and demonstration, the Center recently completed its final year of operation under a Department of Education, OSERS, Handicapped Personnel Preparation Training Grant. Current plans call for continued operation at a departmental level, with greater emphasis on research and development. Funding for the Center was awarded prior to my arrival at the University of Oklahoma.

Multimedia Research Interests and the Initiation of Research

My learning-theory orientation is best categorized as representing a cognitive/developmental perspective. My research interests in multimedia include examining the affective/motivational factors related to learning via multimedia, including other issues related to practical applications of multimedia (e.g., efficacy, generalization, contextualization of information). I am also interested in exploring whether there are differences based on the varieties of learning (i.e., intellectual skills, verbal information, cognitive strategies, motor skills, and attitudes) taught via multimedia; and to what degree individual differences in cognitive skills (e.g., learning styles, memory skills, perceptual processing abilities) influence the reception, perception, responding to, and retrieval of information associated with interactive multimedia. I plan to examine many of these factors within the context of multimedia applications that present functional academics and life skills instruction to individuals with mild to moderate disabilities.

Actively conducting research within specific methodological parameters, compared to merely stating research interests, represents different stages in the research process. Given my isolation and relative support, the principal issue within my research environment relates to obtaining suitable access to equipment and employing efficient strategies to begin a productive multimedia research agenda.

Multimedia Productivity and Collaborative Strategies: Advantages, Related Issues, and Concerns

The backbone of a multimedia project is the equipment that comprises its delivery platform. Roughly, a multimedia delivery platform costs between $4,000 - 10,000. Depending on how ambitious a given project is, development and production costs can quickly double or triple a project's budget. When university researchers are faced with limited equipment resources and development support within their university setting, their only other recourse is to direct their effort and creativity towards acquiring equipment and becoming productive. Examples of potential strategies that may facilitate productivity and collaboration with colleagues are presented in Tables 1 and 2. Multimedia researchers should evaluate the advantages and disadvantages of each strategy within the context of their own research environment to determine which strategy is the most effective. Probably, a combination of strategies will yield the greatest potential for productivity.

Table 1

Multimedia Productivity Strategies Within a University Setting when Local Resources and External Funds are Limited*

Strategy to Obtain Multimedia Equipment	Advantages	Related Issues/Concerns
Acquire multimedia (MM) equipment on a piecemeal basis	o Systematic, steady effort o Costs spaced over time	o Initially, the multimedia perspective will be less comprehensive (e.g., graphics & sound only)
Acquire equipment via loans or by negotiating access time from those who have equipment	o No up-front costs o If a prototype can be developed and piloted, results may help justify additional support	o Fragmented control over MM platform o Fragmented access impedes development
Acquire equipment under alternative emphasis and priorities (e.g., using MM to improve personal teaching	o Funding sources more likely to fund their priorities o Control of information/equipment that can support researcher's priorities in the future	o Tied to funding source's agenda & goals o Obligation to conduct less appealing research o May force collaboration if the "fundable" project is outside researcher's primary expertise
Assume a teaching overlead and use funds to purchase equipment	o Noncompetitive source of funds o Control over funds and equipment	o Increased teaching impedes research time o University policies may prohibit the practice
Strategy to Obtain Multimedia R&D Time*	**Advantages**	**Related Issues/Concerns**
Coordinate a low-enrollment MM R&D course as an overload, or advise/consult/mentor students in related programs (e.g., instructional design) interested in designing multimedia projects	o Teaching and research are combined o Course objectives can be tailored to MM R&D activities o Student apprenticeship	o Increased teaching may impede research time o Students' investment will affect development
Acquire a work-study student to help develop multimedia projects by providing matching funds	o Low cost (matching federal funds)	o Paltry compensation, given the degree of technical competence sought; limited pool
Direct personal time towards developing a prototype to take to local and state private funding agencies	o "Sweat equity" o Agencies able to visually observe MM may be more interested in providing support	o Prototype may not be congruent with agencies' priorities; funding agency may seek to match R&D to their agenda vs. researcher's

Table 2

Multimedia Collaboration Strategies Within a University Setting when Local Resources and External Funds Are Limited*

Collaboration Strategy	Advantages	Related Issues/Concerns
Collaboration with colleagues within one's department (e.g., special education)	o Partnership & division of labor (e.g., shared interests, methodology, access to subjects) o Equipment is shared and remains within departmental jurisdiction o Control over R&D topics and scheduling	o Compatibility of colleagues' multimedia (MM) research interests
Collaboration with colleagues within one's university setting	o Partnership & division of labor o Interdepartmental collaboration often respected & rewarded o Expanded resources o University wide Multimedia R&D Ctr o Strength in comprehensiveness	o Compatibility of colleagues' MM research interests o Management & ownership of R&D resources o Fragmented control over R&D scheduling o When Ctr demand outweighs availability?
Collaboration with colleagues using resources at other institutions	o Partnership & division of labor o Enlarged access to funds & resources o Enlarged access to sites & subjects	o Compatibility of colleagues' MM research interests o No control over R&D management, ownership, and related resources

Other Issues and Strategies

Adapting One's Interests to the Environment

Oklahoma is a state of contrast. Although a significant percentage of the population is centered around the urban cities of Tulsa and Oklahoma City, most Oklahoma school districts are located in small rural communities. As multimedia projects are developed within my environment, those that address the unique curricular needs of urban versus rural special education programs and students will probably be better received and supported. Therefore, it is to my advantage to address this issue in my research.

Oklahoma also has one of the largest Native American populations in the country. Recently, I was contacted about developing a project associated with capturing a multimedia record of tribal elders' use of their native language. Although this is not directly related to the needs of exceptional individuals, it represents an avenue of collaboration and development that shows funding promise locally.

Investigating Local Private Funding Sources

Beginning educational researchers often consider state and federal agencies the principal funding sources for their research. However, local private funding sources should also be investigated. Two methods of accessing information about local, state, and national private funding sources include the SUNY SPIN network and the *Handicapped Funding Directory* (Eckstein, 1988).

The SUNY SPIN network, operated by The Research Foundation of the State of New York (SUNY), offers an electronic database entitled Sponsored Program Information Network (SPIN). Using methods similar to those of DIALOG, this database allows researchers to acquire information about potential funding sources based on key word descriptors that include topical areas of research (e.g., multimedia) and subject populations (e.g., exceptional learners). The SPIN network tries to stay current with federal sources of funding; in addition, it provides access to information about state and national private foundations.

For researchers trying to acquire initial funding in the range of $10,000-20,000, private foundations appear to be less competitive and stringent in their proposal evaluation criteria. For example, several national industries/companies entertain proposals when the proposed project provides direct educational interventions for school districts based in communities where they have a factory or plant.

The *Handicapped Funding Directory: A Guide to Sources of Funding in the United States for Programs and Services for the Disabled* lists sources of private funding by state (Eckstein, 1988).

Beginning Multimedia Research Using Practical Strategies

Develop multimedia prototypes to present to local education agencies and local private foundations. Try to determine ahead of time these agencies'/organizations' priorities, implicit or explicit, and tailor a project accordingly. No matter how well it is described, verbally or in writing, multimedia has a greater impact when it is observed visually. Thus, an effective multimedia presentation may tip the scale in favor of an LEA, SEA, or local foundation committing support in "funds" versus in "spirit."

Finally, do not begin multimedia research with overly ambitious projects. Instead, initiate a multimedia research agenda using a task analytic approach. That is, begin with small, discrete projects that correspond to existing equipment resources and support networks. Seek external funding in areas of competition that look to fund a breadth of small (i.e., $5,000 - $15,000) awards.

Summary and Conclusions

State and national funding sources for multimedia research are scarce and, therefore, highly competitive. As a result, isolated researchers with limited support must be prepared to try a variety of creative strategies if they hope to become productive. Major hurdles include acquiring controllable access to equipment and organizing one's research time to maximize productivity. Once this stage is accomplished, developing small multimedia projects within the context of state and local needs and priorities may accelerate access to alternative sources of funding and support.

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Establishing a Collaborative Context for Multimedia Research

Cheryl A. Wissick

One current definition of *multimedia* emphasizes the integration of media in a unified delivery system such that students can participate actively in learning and can access the program in a nonlinear manner. The use of the prefix "multi-" with the root word "media" implies that several types of media will be used. Another possible interpretation is suggestive of professionals working together to provide different perspectives on teaching, learning, scripting, and design using the media. Perhaps only within such a collaborative context can one fully develop ideas and incorporate design principles to establish a research agenda based on learning theory and involving multimedia.

For a beginning assistant professor, the development of a research agenda involves the quest for funding and school participation as well as the cultivation of a collaborative community. In reflection, the collaborative communities in which I have been involved as a teacher and later as a doctoral student have inspired my continuing interest in and ideas about interactive multimedia.

Research Interests

I had my first glimpse of the possibilities of multimedia for exceptional learners during the UVA/IBM Institute in the summer of 1986. The participants — special educators, researchers, and speech clinicians

— formed a collaborative group for exploring the potential of interactive videodisc technology and learner-based tools. One of my colleagues immediately saw the potential for creating simulations for students with moderate or severe disabilities. She envisioned those simulations not as a replacement for but as a supplement to community training, especially for skills involving potentially dangerous situations (e.g., street crossing, safety rules). That vision of creating community-skill and vocational simulations with interactive videodisc sparked in me a desire to pursue research in the area of special education multimedia.

Although still motivated by my colleague's enthusiasm and by a commitment to teaching students with moderate disabilities, I continually question my involvement in multimedia — whether I want to be on the cutting edge with the technology or whether I have the tacit knowledge that there is something of value for exceptional learners. Some of the projects in which I have been involved have benefitted my own skill development or pursuit of technical expertise — learning about the potentials of hardware and software. However, more important than the acquisition of skills with the technology, I have been stimulated by the collaboration with others solving similar problems or pursuing educational outcomes. Thus, working in a collaborative context with teachers and students on the programs has provided me with descriptive information about the use of multimedia in the classroom. This continual process of developing multimedia lessons and assessing their impact on students reinforced my beliefs about the potential of multimedia in special education settings.

In addition to formative evaluation of programs in progress, I began to search the literature on the theoretical basis for designing simulations for students with moderate disabilities and the educational implications of using such simulations. One goal of a simulation is to enhance instruction in conjunction with training within the natural environment. Therefore, the medium chosen for developing a simulation should approximate the intended natural environment and provide the teacher with a tool for increasing the opportunities to interact.

A computer-interfaced video-based simulation would provide this type of interactivity by presenting a segment of the skill or task, requiring a response from the learner and, depending on that response, present appropriate feedback, remediation, or the subsequent task (Hofmeister & Friedman, 1986). Furthermore, computer- and videodisc-based instruction could be programmed to allow ready access to the important features of simulation (i.e., variation of performance conditions, sequence of training trials, and presentation of repeated trials). This would provide the teacher with a richer instructional program than either the technology or the teacher could provide alone.

As part of a class on interactive technologies, I was involved in designing and producing a videodisc of which I could develop a 5-minute portion for community skills training. The final product, a videodisc-based shopping simulation and teaching manual, followed guidelines recommended by Horner, McDonnell, and Bellamy (1986) and Nietupski, Hamre-Nietupski, Clancy, and Veerhusen (1986). Initial research on the use of this shopping skills training program and simulation demonstrated that interactive video does have potential for training students with moderate disabilities. Nevertheless, additional research was indicated on its effectiveness and necessary modifications for students with more severe disabilities as well as its practicality with students in other locations in the country. Further research should also focus on the design issues that would help increase transfer and generalization of the targeted community and vocational skills.

Research Environment

After completing the videodisc project and initial research, I changed research environments from that of a doctoral student to that of an Assistant Professor in the Program for Exceptional Children and Director of an Educational Technology Center (ETC) in the College of Education at the University of South Carolina. As Director of the ETC, I am surrounded by the technology, ranging from audiovisual equipment to a networked lab of PCJrs as well as Apple IIe's without color monitors.

New technologies also exist in the ETC; faculty have access to a Mac II and Model 70 with laser printers, CD-Rom drives, and a scanner.

For special education uses, the South Carolina Commission for Higher Education recently established the Center for Excellence in Technology for Learning Disabilities and Visual Handicaps. This center, codirected by two special education professors, shares the space in the ETC. With equipment ranging from obsolete to modern, we have been able to progress into the era of emerging technologies by purchasing four Mac Classics, two videodisc players, and IBM Model 30 and Model 55 with an M-motion board for multimedia teaching and development. Supporting a "dual-hardware" faculty and lab poses interesting challenges as one learns how to exchange files and write programs in various authoring systems for both presentation and instructional purposes. Currently, we are supporting and developing programs in Hypercard, Toolbook, Linkway, Storyboard Live!, and Hollywood.

Our access to the technology reflects the degree of administrative support I have, as long as the budget allows for funding. In addition, I receive support from both the College of Education and university research offices to introduce me to grant and contract proposals. Furthermore, our College of Education is affiliated with the Holmes Group, and faculty members are actively involved in the Professional Development Schools movement. As a result, teachers and students are accessible for projects or videotaping. Unfortunately, specialized equipment is not always available at local schools; however, our state supports grant funding to teachers. In fact, several school districts and individual teachers have been awarded grants, ranging from $2,000 to $90,000, to purchase and develop multimedia projects.

Research Strategies

The resources for the technology, possible funding sources, and cooperating schools are available within my research environment. Nevertheless, the challenge remains to seek out and build a collaborative context in which to develop multimedia applications. I have to expose and excite others in my program about the possibilities for instruction and the theoretical basis for research with multimedia. As I work to establish a collaborative community, I continue to pursue the development of video-based simulations for community skills and to establish communications with special educators at other universities who share similar research interests. Within my university environment, I am broadening my research goals to encompass such disciplines as foreign languages, criminal justice, or engineering. In addition, the recent formation of a multimedia group in our state, Association for Applied Interactive Multimedia (AAIM), has created a network of professionals who are concerned with the hardware dilemmas and educational issues in a rapidly changing field.

Based on my own experiences this year and the suggestions of other professionals, several tactics or strategies for research emerge. Some of these tactics may sound superficial, but they have value for creating a collaborative context for conducting multimedia research.

- *Begin with small grants or projects.* Several small grants can provide resources and data to build into a more substantial grant. In addition, several small grants lend credibility when pursuing significant grant funding.
- *Cultivate more than one project at a time.* All of us work on several projects at once, never sure what project might take the lead. However, we must be aware of the fine line between being involved in several projects that will lead to a broader line of research and becoming overextended.
- *Work with computer sales managers, dealers, and vendors.* Local sales managers, for example, are involved with many different professionals every day. Thus, they can help making contacts with other professionals who share similar interests. In addition, they can assist with loans of equipment to support project development or to provide technology access to the schools.
- *Establish contacts with multimedia users around the university.* Special education may be a distinct field, but it shares similarities with many other fields. For example, foreign language instructors are concerned about making words meaningful in a concrete manner. Professionals training in criminal justice are concerned about adult literacy. Liaisons can be formed with other departments outside education creating broader instructional goals and additional sources for funding.
- *Collaborate with other university faculty.* Through Bitnet, for example, we can conduct preliminary discussions and work jointly on research proposals electronically. Connecting with another university faculty offers several possibilities: sharing resources in terms of ideas and talents, dividing funding and responsibility for grant accounting, conducting studies in different environments, and using different hardware configurations for similar tasks.
- *Network outside the university.* In addition to collaborating with other departments within the university or with colleagues at other universities, local professional groups might open new horizons. Groups with concern for education and with interest in the possibilities of multimedia include literacy groups, historical societies, fine arts commissions, museums, parks and recreation departments, and state development boards. If the organizations are state funded, they might not have available funds to finance a multimedia project, but they might represent sources for raw materials. In addition, they might have an already established relationship with the schools through a history of presenting slide shows or demonstrations.
- *Realize that group projects may take longer than individual research.* Without the bottom line for completed projects or end of fiscal year, group projects requiring group input and consensus typically take longer. Nevertheless, the end product

involving different disciplines might carry more influence in the educational community than an individual project from either a university or a private business.

Summary

I realize that although I am independent in my research, I am not isolated. Instead, I am building a base to establish a collaborative context for several multimedia projects. I am open to new collaborations, brainstorming with colleagues about the directions of multimedia, as well as considering the concerns over the multimedia blitz. My original interest in researching the potential of multimedia for exceptional learners has intensified as I have adapted to my changing environment.

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Multimedia Research in Special Education: Topics, Environments, and Adaptations

Al Cavalier

Multimedia offers researchers a complement of tools that are unprecedented in their power and versatility for exploring cognitive, metacognitive, and motivational issues related to the learning and performance of students with special needs. Multimedia technology represents the most sophisticated point on the evolutionary scale of educational media reached to date. In our work, we have adopted the definition of *multimedia* used by the Center for Special Education Technology: "Nonsequential and nonlinear presentation of text, graphics, animation, voice, music, movies, or motion video in a unified information-delivery system, centered on a personal computer, that involves the student as an active participant and is applied in an education setting for any number of instructional purposes." Further, we consider *hypermedia* to be a subordinate concept (i.e., a specific instantiation that gives emphasis to the nonlinear links among many of the textual, visual, or auditory objects).

In pursuit of our individual and collective research programs at the University of Delaware, I and my colleagues, Ralph Ferretti and Cindy Okolo, have come to realize that many of the specific questions of interest can best be answered using these exceptional tools. These issues-related inquiries, in turn, have raised additional questions about implementation factors in the use of multimedia.

Topics of Interest

A summary of the primary substantive issues and methodological questions that are of interest in our individual and collective research programs follows.

Research Area 1

The formulation of information-processing theoretical frameworks in mental retardation (Belmont & Butterfield, 1969; Brown, 1974; Ellis, 1970) has been responsible for a tremendous wealth of scholarly research. These conceptual models have served to shift the focus from the outcomes of a person's problem solving to the cognitive processes or strategies by which the person arrives at those outcomes. The net effect of this change in focus has been a dramatic increase in our understanding of the cognitive processes that differentiate students who are intellectually average from those who are mentally retarded. In brief, the critical dimensions that have emerged from this research are the dynamics by which cognitive strategies are produced in particular situations and the necessary and sufficient conditions for their transfer to other situations.

This body of research provides knowledge about the conditions that are conducive to remediating cognitive processing deficits. Examples of these materials or components include (a) students should have a rich and interconnected knowledge base related to the specific task or problem at hand (Bransford, Sherwood, Vye, & Rieser, 1986); (b) much of that knowledge should be automated to permit quick recognition of patterns that are relevant to task performance (Schneider & Detweiler, 1988); (c) the greater the extent to which knowledge is automated, the fewer the constraints on functional working memory and, as a consequence, the more likely the student is able to analyze similarities and differences between the training and transfer conditions (Ferretti & Cavalier, in press); (d) the training conditions should be similar to the real-world conditions in which the knowledge is to be used; (e) sufficient breadth across training exemplars must be ensured (Ferretti & Cavalier, in press); (f) training should make salient the eventual utility of the cognitive strategies for solving real problems (i.e., learning the strategies should not be taught as an end in and of itself) (Ferretti, 1989); and (g) the problem context should be rich enough to serve as a conceptual anchor for teaching the interconnectedness of the concepts and skills (Bransford, Hasselbring, Barron, Kulwicz, Littlefield, & Goin, 1988).

Hypermedia environments with these properties can be designed for the purpose of cognitive remediation. Our research interests focus on a componential analysis of these building blocks, as they relate to the learning and transfer of problem-solving skills.

Research Area 2

When observing a person interacting with one of the technological advances that pervade our living, work, and recreational environments — be it a microwave oven, a fax machine, or a simple thermostat on a wall —it is apparent that efficient and effective use is mediated by the interface between the human and the operation of the device (Norman, 1988). This is especially clear when the user is a student with cognitive impairments and the "device" is a computer-based instructional program (Tighe & Groeneweg, 1986; Vanderheiden, 1984). Initially viewed as the gateway to the control of information, the human-computer interface is being reconceptualized as a multidimensional surface that spans the range of human perception, cognition, and motor control (Norman & Draper, 1986; Schwartz & Norman, 1986). Careful consideration of human factors principles when designing these sensory-cognitive-physical interfaces for persons with disabilities can mean the difference between complete inaccessibility and effortless augmentation, between halting confusion and errorless performance, and between the learning of seemingly disparate facts and the learning of interconnected knowledge (Cavalier, 1989).

To optimize the instructional power of multimedia applications, important questions need to be answered about the instantiation of human factors principles within the operational and presentational components of multimedia. Some of these questions concern the nature of the conceptual aids used to counteract disorientation, the means of preventing information overload, the utility of bi-directional versus unidirectional links, and the trade-offs in comprehension between adjacent and overlapping displays of information. Our research interests are directed toward many of these questions.

Research Area 3

For an educational activity to be intrinsically motivating to a student, the presence of challenge, the stimulation of curiosity, the desire for self-efficacy, and the perception of control are important (Lepper, 1985; Malone, 1981; Okolo, Hinsey, & Yousefian, 1990). Personal control is evidenced when students bring about certain outcomes as a result of their specific choices. The consequence is that students feel more competent and self-determining, the educational activity is seen as more intrinsically interesting, and the student's motivation to achieve increases (Lepper, 1985).

Student control over learning is a particularly prominent feature of hypermedia-based applications. When this control is combined with pathways that are well-constructed and multimedia objects (i.e., graphics, sounds, text) that are designed to stimulate and satisfy students' curiosity, hypermedia can provide a learning environment that has an especially powerful impact on students' motivation to achieve. Hypermedia permits us to easily and systematically vary the learning control options and curiosity features in an effort to study the nature and magnitude of these effects.

Research Area 4

Some of the attributes of hypermedia should prove particularly useful for bringing undergraduates in special education training programs to an analytic and synthesized understanding of content in various topical areas. A well-constructed hypermedia application would provide a broad collection of documents and audiovisual objects that the instructor could link together. This, in turn, would create multiple paths through which students could either be guided or be allowed to browse freely. The resulting application would consist of a rich web of conceptually related material that permits extensive control over the selection of the information to match preferred learning strategies.

Empirically derived information that informs designers and instructors about optimal ways to construct such applications and about the nature and magnitude of their benefits are scarce. A notable exception is *The Intermedia System* developed over eight years at Brown University for the Macintosh AUX platform (Yankelovich, Haan, Meyrowitz, & Drucker, 1988). *Intermedia* is an exceptionally powerful and versatile research and development platform. It includes MacWrite- and MacDraw-like tools that permit students to record notes or compose papers while traversing the system, provides directional links across a near unlimited number of documents/objects, employs sophisticated navigational aids, and stores the links separately from the documents/objects. The latter feature allows instructors, when desired, to hide their links from students to permit students to impose their own conceptual structure on the material. By creating their own links, students reveal how they develop an argument or support a thesis (Walter, 1989).

We are nearing completion of a large *Intermedia*-based application to be used in an applied-behavior analysis course for undergraduates in our elementary teacher education program. This application will allow us to investigate a variety of system configurations and their effects on both the facility with which students operate the system and the level of understanding that they achieve.

The Research Environment

The multimedia research environment at the University of Delaware is characterized by a variety of administrative and operational supports.

Administratively, the University's new president has placed technology-based instruction and research among his top priorities. Further, the Dean of the College of Education views advanced technology as a valuable tool for his faculty's productivity and, consequently, has helped provide such tools both for general productivity and for individuals' laboratories. He has also supported the creation of The Center for Assistive and Instructional Technology within the College. The Center is driven by the special education faculty and has as a major focus the area of interactive multimedia. We consider the value our Dean places on our scholarly productivity and his support of special education technology initiatives as two of the most attractive features of our research environment.

During major university-wide planning three years ago, the faculty of the Department of Educational Studies, of which we are a part, announced the department's commitment to developing and fostering major programmatic efforts in the area of educational technology. Thus far, this long-term vision has been exemplified in the approval of a new master's-degree specialization and six new graduate courses in special education technology. On a more subjective note, there is a general feeling in our environment that advanced technology, when creatively harnessed in the service of educational objectives, can be a force for exciting advances.

Operatio ally, five primary components of our environment lend support to our multimedia research and instruction. First, the College of Education has a close working relationship with The Instructional Technology Center (ITC), a university-wide research- and instructional-support center. The ITC is directed by Fred Hofstetter, an international authority and IBM Consulting Scholar in multimedia. In addition, the ITC includes a consortium of talented instructional designers, programmers, and technical support persons to assist in our multimedia initiatives.

Second, The Center for Assistive and Instructional Technology, which I direct within the College of Education, is devoted in large part to advancing the multimedia-based research of the special education faculty. The Center includes a collection of commercial videodiscs in a wide variety of content areas, Macintosh, Apple, and IBM research-and-development platforms, a number of software development tools, and an extensive reference library. It also includes a computer laboratory comprised of 22 Apple IIGS, Macintosh, and IBM computers for student instruction.

Third, we have access to the university's state-of-the-art instructional television studio classrooms for on-site teaching, distance education, and research. The ITV studio classrooms can be used to deliver and broadcast courses nationwide via cable and satellite and can support interactive video and audio instruction in real time. All ITV classes are videotaped. Therefore, if students miss a lecture or wish to prepare for an exam, they can study the videotapes, which are on reserve at the university's Morris Library.

Three of the studio classrooms are linked to a control room with broadcast-quality production equipment and remote computer-controlled cameras to capture the instructor, the instructional materials, and the students from a variety of angles. Overhead cameras provide close-ups of desktop illustrations and demonstrations shown at the instructor consoles.

Three of the studio classrooms provide a TV monitor for every set of two students in a fully carpeted and acoustically programmed environment. The fourth is a fully equipped television recording studio used to develop videotapes and videodiscs. We have used the studio classrooms to teach undergraduate education courses and to model the use of instructional television. We are using the recording studio to develop a series of instructional videotapes on exemplary practices in special education.

In addition to the studio classrooms, the University of Delaware has constructed a building specifically designed for multimedia. The Kirkbridge Lecture Hall contains six classrooms and one auditorium arranged in a semicircle around a central media core. Three classrooms are on the ground floor, the auditorium is located on the second floor, while the remaining three classrooms are on the third floor. Projection equipment located in the central media core projects images onto large rear-projection screens that face the classrooms. The advantage of such a facility is that one technician working inside the core can oversee the multimedia setups for all seven rooms.

Fourth, faculty members in the educational technology program have access to *PODIUM*, an educational software application that offers a powerful, yet uncomplicated multimedia lecture tool. *PODIUM* serves as a common user interface with IBM's multimedia hardware. On any word processor, faculty can prepare an outline of the audiovisual material they want to use in a lecture, and *PODIUM* automatically creates a lecture display that lets the user navigate and quickly access any of thousands of slides, computer graphics, video motion sequences, or audio clips. The goal of *PODIUM*'s designer, Fred Hofstetter of the ITC, was to make it easier for instructors to have split-second access to all their multimedia materials all the time than to use traditional teaching tools, such as chalk, slides, overhead projectors, and video cassettes.

With *PODIUM*, images can be retrieved at natural speeds (30 frames per second) or in either slow or fast motion. Still or freeze-frame images can be viewed as long as desired. Further, visuals can be preprogrammed to conform to the flow of a lecture or to be accessed randomly in response to student questions. *PODIUM* employs IBM's new M-Motion Video Adapter and the IBM Audio Visual Connection that allow it to digitize and store multimedia video objects with photographic quality and multimedia audio objects with FM-radio quality. To create special effects, digital images can be overlaid on videodisc frames that can be resized and repositioned on the screen by using any word processor. Full-motion video from videodiscs can also be played back in any-size window on the screen.

Fifth, the College of Education has established a close collaborative relationship with the Delaware State Department of Public Instruction that provides a context for productive partnerships with public schools on classroom-based research. As a whole, the public school system in Delaware has been slow to implement educational technology and least-restrictive-environment (LRE) initiatives. By conducting technology-based research in the public schools, special education faculty members have helped raise the level of technology consciousness about classroom instruction in these settings.

Our individual and collective research programs have clearly been facilitated by the administrative and operational environment at the University of Delaware.

Adaptations

The administrative and operational supports notwithstanding, there are also characteristics and conditions at the University of Delaware that necessitate adaptations for proactive research programs.

The University has undergone severe budget cuts and is facing severe deficits. This has resulted in a reduction in the number of available graduate research assistantships and technology support personnel, and there is a clear indication that even more of the technology support functions will need to come from external support. Operating budgets for university-supported research are being significantly pared down. Given the nature of our research requirements in multimedia, we can best adapt to these circumstances by diligently seeking alternative support.

In addition to responding to federal Requests-for-Proposals, we are cultivating relationships with industry and private sources having an interest in special education technology and applications. We will also need to become creative in piecing together support for complete research projects from various small grants programs.

The public schools in the state are unusually deficient in their technology resources, which impedes timely execution of technology-based research. This situation occurs both because the appropriate technology must always be sought from other sources, and because we sometimes must act in the role of technology consultants/advocates, providing extensive explanations and education. However, we view this role as consistent with our inservice education mission.

As the state has only recently begun to comprehensively implement LRE practices for its special education students, we sometimes fall short in identifying an adequate number of integrated classrooms with students demonstrating the desired characteristics. This results in longer search-and-negotiation times, and sometimes forces us to travel to surrounding states to obtain suitable research sites for a project.

Probably the most significant concern in our research environment is the relative lack of technology-experienced teachers and technology-curious education graduate students. These conditions have widespread effects on the way we conduct research. Teachers in the schools have minimal access to technology of any kind and, therefore, cannot appreciate the value of technology-based instruction. We predicted that our federally supported master's specialization in special education technology would attract approximately 10 participants each year. We are pleased that near the end of the first year, almost 30 students are enrolled in the program. Typically, these graduate students are practitioners (i.e., teachers and therapists), who plan to return to the classroom with master's degrees. The fact that they will be major force for change in education in our state and the surrounding area is a source of great satisfaction for us in our teaching mission. However, these students do not typically bring with them the same thirst for "scholarship" or advancing the knowledge base that doctoral students do. They are more often concerned with discovering knowledge that is new to them. As a consequence, although they frequently require the same amount of our time to advance toward their degrees as doctoral students do, these demands are met without the "rewards" of our being able to advance research initiatives.

Adaptations to this situation consist primarily of attempting to change it. For example, we look for every opportunity to increase teachers' and administrators' awareness of the instructional power and challenges of educational technology. This includes guest presentations to the special education district supervisors, workshops, local conference presentations, a summer institute of 10 courses on educational technology, and grant proposals on personnel preparation in technology. We also are making a concerted faculty-wide effort to promote the degree offerings of the University and the College of Education and to attract talented doctoral students.

The University historically has been technologized on IBM platforms. However, some of the faculty prefer to address certain research issues with Macintosh platforms. Unfortunately, because it often takes an excessive length of time to access the fewer Macintosh technical support and maintenance persons, faculty sometimes get sidetracked into their own attempts at problem resolution and, failing that, suffer extended delays.

In conclusion, the research environment at the University of Delaware has provided adequate support for establishing the foundation of stable research programs for faculty in special education technology. The University is undergoing a transition in which, at a general level, the technological sophistication is increasing while the number of technical support persons is decreasing. The research environment is changing from one characterized by significant institutional supports to one in which external support is paramount. We are committed to research areas that we believe address some exciting challenges in education — areas in which multimedia is both a powerful tool and a topic of inquiry in itself. At the same time, we recognize that to ensure that our research programs remain viable in the changing days ahead, we need to be more creative and flexible in our adaptations.

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The Private Research Firm

Carolyn DeMeyer Harris

While preparing my contribution to this seminar as someone representing a private research firm, I felt it would be helpful to provide a brief overview of my path to this position. I started working at a consulting company as a research assistant when I moved to the Washington, D.C., area after having been a public school teacher in special education for 12 years. My projects focused primarily on military training using traditional and technology-based delivery formats. Through my work with interactive videodisc training, however, I could see exciting possibilities for special education instruction. Thus, I felt fortunate when the opportunity arose to work at Macro on product development targeted for special education populations. During my first project at Macro, which was based on social learning theory, I became more concerned about theory-based applications.

Research Environment

At Macro, a private, for-profit consulting company, I work in the applied research division — education group. Other areas of focus in the company include health policy, training programs, and research — particularly AIDS and substance abuse — quality assurance and targeted software programs, management consulting, large-scale survey work, unemployment insurance, international demographic and support services, and market research. Most of Macro's funding comes through federal contracts from a variety of governmental departments and agencies. By nature, these contracts are prompted by a specific need or priority that has already been identified, whereupon someone is sought to propose an appropriate, sound, and specific approach to meeting the need.

Consequently, the research interests of a private consulting firm such as Macro are influenced by the research needs expressed by those agencies with which it works most closely. In the case of the group in which I work, Instructional Product Development, our research interests are frequently the needs identified by the Department of Education. Grants offer a good avenue for matching research interest with effort, because they tend to be more open-ended and provide opportunities to stipulate the focus of the work to be done. However, because the grant structure has no provision for funding profit (or fee), most private research firms are cautious about the number of such projects they allow, if any.

Within the structure of the private research firm, efforts are made to mesh my individual and Macro's corporate research interests with Department of Education priorities. Therefore, I seek initiatives that offer as much concentration as possible in my areas of interest. This means being aware of Department of Education concerns and recommendations, congressional actions and mandates, as well as related academic research, related field initiatives, and related industry directions.

The most common mechanism for pursuing projects is the competitive bidding process. Here the first level of support from Macro usually comes in the form of approval to pursue an announced initiative by submitting a proposal to conduct the desired work. Many considerations go into this decision, including research interests, reputation in the field, and ability to conduct the work.

When a project is awarded to Macro, several types of support are provided, such as necessary personnel and development hardware and software. Further, project staff are encouraged to make submissions for conference presentations, and financial support is available for those who are successful. Opportunities to pursue grants also must be considered a form of support provided by Macro. Although there is no funding for our fee, Macro allows staff to seek a limited number of grants when these represent a clear area of interest and expertise on the part of the grant seeker.

Specific Research Interests in Multimedia Technology

My primary research focus is on the use of the media — the selection of the most appropriate delivery medium or media and the application of instructional design principles to developing an instructional program that incorporates appropriate theoretical considerations. In terms of specific content, I believe there is a need for instructional programs in many areas of work-related behaviors and skills. Specifically, I continue to conduct and seek projects that deal with social and basic skills. Since my teaching experience primarily has been with students who have cognitive disabilities, I am most confident of my work when it focuses on the needs of this type of learner. However, my previous involvement with military training has prepared me to work with subject-matter experts, so I also am willing to undertake broader based projects. For example, new interests have emerged from a project involving preschoolers. Thus, as I work with the project director, whose expertise is in early childhood education, I am beginning to identify new areas of interest related to early childhood populations.

Relationship Between Research Interests and Research Environment

My research interests have been altered somewhat by the private consulting-firm environment in which I work, because we have to rely on projects initially defined by somebody else. However, I do not regret this situation. In the current setting, my career has been redirected in much the same way as in my previous jobs. For example, when I applied for my first teaching position I had undergraduate and graduate degrees in secondary education English and social sciences with a special fellowship program in receiving special education students into the regular classroom. The only job I was offered in a school district was that of special education teacher — by obtaining an emergency certificate based on my 12 hours in special education and completing a full certification program. This happened because there was a need for special education teachers. Later when I moved to contract research, my formal preparation had focused on research and evaluation. However, the company needed someone to develop training materials, and I could do that. As years have passed, I have become more identified with training and product development than with program evaluation. In an ideal situation, therefore, my work would be comprised of both development and evaluation — a situation that does not often occur in contract work!

Recommendations for Researchers

We all know that a single special education category does not represent a homogeneous group. The same is true of research environments. The labels used to describe the university environments represented on this panel also attest to differences. We could have included the following types of panelists — a private-firm researcher operating in an academically oriented environment and a private-firm researcher operating in a business-oriented environment. In addition, we could have delineated research environments further based on the diversity of the company's efforts or its level of commitment to a particular arena of work.

My suggestions to researchers who want to work in a private research environment are as follows:

- Understand the nature of contracting work. Whether profit or nonprofit, companies must charge time against contracts. To stay fully employed, you may have to work on projects that do not fall within your primary area of interest.
- Seek a firm that has an established reputation with the government agencies with which you want to work. A firm has to be viewed as a viable competitor in order to win contracts. It is similar to Catch-22: If you have not done work for them, you cannot do work for them!
- Seek a firm that most closely represents your approach to research. Some companies that operate on an academically based model have established internal mechanisms for supporting work that is not covered by outside contracts. Within this type of company, you are most likely to be able to pursue your own learning theory-based applications.
- Understand a firm's position on applying for grants, which may afford you the means to pursue your learning theory-based applications.

Discussion: Moving Multimedia Forward

Issues such as the cost of multimedia and the time it takes to reach full implementation of the procedures and technology involved make it necessary to provide strong evidence of the effectiveness of multimedia before educators dare ask that it should be adopted into the schools. To secure the support necessary to move multimedia forward, we must maximize our efforts. For example, researchers and developers must work together to identify joint goals, identify gaps in research and products, and encourage development based upon research and products, and encourage development based upon research. To accomplish such goals it is necessary to look beyond personal agendas and identify strategies, timelines, and communication vehicles that promote collaborative multimedia technology.

The group discussion provided a number of comments related to these issues as well as suggestions for future progress.

Evaluation and Assessment Issues

- Schools are beginning to ask for different types of data; they are not as interested in achievement, but more in looking at issues like student motivation and engagement.
- Research efforts that can add new types of data may hold more interest for schools because the projects can provide new data in addition to those already required.
- Engagement must be viewed carefully because even if the student is engaged it does not guarantee that learning is occurring.
- Assessment should be based upon defined goals so that we can probe and direct learning toward those goals.
- Assessment need not be comparative (i.e., "either this or that").
- We need to pay more attention to different forms of assessment such as portfolio assessment.
- New paradigms call for new types of data (e.g., ethnographic), which may provide both qualitative and quantitative information.
- These newer types of data may be more meaningful and of more interest to parents, faculty, and students than achievement data.
- These newer data often describe the process and important learning skills rather than discrete content knowledge.

Teacher Training Issues

- New paradigms require a shift in teacher training – training new teachers to do new things.
- Changes and development of new technology require continued teacher training and support.

- Colleges and universities, as well as training faculty, must keep pace with technology trends.

Research Agenda Issues

- We need well-defined goals for research, not just isolated efforts.
- Hardware and software companies are willing to support research and training issues, but want group not individual goals.
- Professional associations can set standards for multimedia technology (e.g., NCTM), but what group will set the standards for special education?
- An identifiable group is needed to address the issues of special education multimedia. The group should be expansive to assure representation of varied cultures and needs.
- A set of common goals (i.e., a research agenda) must be generated.
- Researchers need to develop a system for sharing research that assures expansion not duplication of efforts. Sharing will allow researchers to gain from one another, to build pieces that will add up to whole products.
- The group needs to look at models that have been used by other groups (e.g., NCTM).
- The group needs to work with companies, organizations, andassociations, as well as the Office of Special Education Programs.

Conclusion: Summary, Synthesis, and Next Steps

Dr. John Bransford characterized the presentations and contents of the conference as representing the Hopes, Fears, Frustrations, and Promises for the Next Steps in Multimedia Technology.

Hopes

The technology is providing new opportunities for fuller participation in life. Multimedia, especially integrated multimedia technology, gives us all hope as it humanizes experiences because of what it presents and what it allows people to do. The conference gives us hope in that we saw people using multimedia technology to present and share their work with others. We heard about exciting new developments such as the vector cursor that have resulted from research and identified needs of learners. We saw where multimedia technology is, and where it can go with the cooperation between research and development (e.g., products like those being developed by National Geographic, IBM, and the National Technical Institute for the Deaf). Hope was also provided by the projects that described alternate ways to learn; the use of the video environment, the fact that future grants for video must include closed caption; and technology that fills in for blind access to video. Ultimately, integrated media gives us hope in that it addresses the need to "break the mold" and develop new approaches that facilitate learning.

Fears and Frustrations

We also saw and heard some of the problems and issues that have led to fears and frustrations for multimedia technology and research.

One such issue is research and development. In most disciplines, basic research leads development, but in education development often leads the researchers who study it. Researchers and developers must work together; otherwise, we end up with products that are created without a sound research base; products for which we cannot gain the rights for use; and static rather than dynamic research and development.

We heard too of the difficulty some of the new developments may cause for special education students such as the navigational issues of hypermedia. Another area of concern is that multimedia can be glitzy; therefore, we must guard against creating technology for technologies sake. Too much emphasis is placed on television mentality in videos; they are not designed to give teacher or students an opportunity for integration into the curriculum.

Further concerns causing fear and frustration include the threats to multimedia presented by the costs of research and development as well as issues related to control of the curriculum.

Promises for Next Steps

The work that was described throughout this conference, like the work being done by the Vanderbilt Group, offers much promise for "breaking the mold" and assuring major advances in education for all students.

The Jasper Woodbury Problem-Solving Series, which uses videobased anchors to teach complex, generative problem posing and problem solving, was used as an example of the promise for the future. It is designed to allow teaching and learning principles including:

- video presentation format
- narrative format
- generative learning format
- embedded data design
- real-world complexity
- pairs of related adventures/related knowledge
- links across curriculum

As an alternative to text-based curriculum, this series breaks the mold and puts students in charge by being active generators of knowledge rather than passive recipients. It allows teachers, other students, and parents more control over curriculum than the traditional text-based, or adoptions-based approaches.

Beginning with a strong research base, the development costs are less extreme and the product viability is increased. These features can also lead to stronger cooperation and collaboration between the education and publishing communities.

Programs that take this integrated curriculum approach also support natural assessment of students — evaluation based upon progress toward and achievement of realistic goals, rather than an either or type of achievement.

Just as the technology holds promise, so do the efforts of the researchers and developers currently engaged in work with multimedia technology. If we are to "break the mold" and realize these promises, it is imperative that this group work together to form the basis for long-term collaboration and frequent, ongoing communication.

Technology Seminar

MULTIMEDIA

ANA Hotel, Washington, DC
May 20-21, 1991

Agenda

This multimedia seminar has been planned to update researchers on emerging technologies; to examine potential applications; and to identify research issues, as well as design and use implications, fcr special education instruction and training.

Monday, May 20, 1991

12:00 - 1:30 p.m. Lunch - Ballroom 1

Welcome

Susan Elting, Center for Special Education Technology

Keynote Address: *Learning Theory as the Basis for Developing Multimedia Applications*

This opening session will highlight the seminar's focus on learning theory as the basis for incorporating interactive multimedia into the instructional process.

John Bransford, Vanderbilt University, Peabody College

1:30 - 3:15 p.m. **Panel: *Multimedia Research In Progress***

The role of learning theory and educational goals in the development and application of multimedia technologies in special education will be addressed. Research projects that have successfully based development on theory will be demonstrated. The panel will discuss the influence of key issues and questions on their projects.

Ted Hasselbring, Vanderbilt University, Peabody College

David Rose, CAST

Kyle Higgins, University of Washington

3:15 - 3:30 p.m. Break

3:30 - 4:30 p.m. **Panel and Large Group Discussions: *Research Issues***

John Bransford, Vanderbilt University, Peabody College

5:30 - 7:30 p.m. **Reception and Demonstrations:** ***Emerging Multimedia Technologies***

A reception sponsored by IBM will be held at Tech 2000, 800 K Street, NW, Suite 100, Washington, DC. Participants are invited to tour the gallery and work with the applications on display.

7:30 p.m. Dinner on your own

Tuesday, May 21, 1991

8:00 - 8:30 a.m. Continental Breakfast - Ballroom 1

8:30 - 10:30 a.m. **Demonstrations:** ***Education-based Applications***

Several educational applications of multimedia will be presented as examples of good uses of the technology that are currently available or show the potential of technologies to come.

Monica Bradsher, National Geographic

Bill Clymer, NTID

Tony Peacock, IBM

10:30 - 10:45 a.m. Break

10:45 - 11:45 a.m. **Discussion:** ***Curriculum-based Applications***

This discussion will explore maximizing the use of multimedia technologies and the difference they may make for the special needs learner.

Kathy Hurley, IBM

11:45 - 12:15 p.m. **Presentation:** ***Interactive Multimedia Research Questions— Results from the Delphi Study***

The results of the Center's Delphi study to identify multimedia research questions will be presented.

Ralph Ferretti, University of Delaware

12:15 - 1:15 p.m. Lunch - Latrobe Room

1:15 - 2:45 p.m. **Panel: *Research Issues within Research Environments***

This panel will present issues related to conducting multimedia research in various settings and with varying levels of administrative or financial support, as well as ways to work toward building a broader-based environment for research in multimedia.

* *Isolated Researcher with Limited Support*
Jim Gardner, University of Oklahoma

* *Isolated Researcher with Outside Support*
Cheryl Wissick, University of South Carolina

* *Special Education Dept. Interest with Administrative Support*
Al Cavalier, University of Delaware

* *Private Research Firm*
Carolyn Harris, Macro Systems, Inc.

2:45 - 3:15 p.m. **Discussion: *Moving Multimedia Research Forward***

This discussion will focus on ways to move research and the multimedia knowledge base forward.

Liz Lahm, COSMOS Corporation

3:15 - 3:45 p.m. **Conclusion: *Summary, Synthesis, and Next Steps***

This presentation will provide a wrap up of information presented and seminar discussions, as well as direction for what should come next.

John Bransford, Vanderbilt University, Peabody College

Technology Seminar

MULTIMEDIA

May 20-21, 1991

LIST OF PARTICIPANTS

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