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ABSTRACT

This paper reviews the literature on multimedia research focusing on what it says about the role of multimedia in instruction and whether extant research is sufficient and valid. The following topics are reviewed: definitions of multimedia; using multimedia research to evaluate multimedia programs; concerns over research; and suggestions for research. The conclusions drawn from this review are: neither developers nor researchers universally define the terms multimedia and interactivity; the most prevalent sources for the development of multimedia programs are assumption, intuition, and common sense; there is little useful research on multimedia; and with a few exceptions, there is no body of research on the design, use, and value of multimedia systems. (Contains 41 references.) (JLB)

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Multimedia: Promise, Reality & Future

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Multimedia: Promise, Reality and Future

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It is difficult to find educational technology periodicals that fail to address some facet of hypermedia or multimedia-based systems. Educators and researchers continue to question the effectiveness of these new systems in learning environments. Proponents say multimedia allows learners to create, annotate, and link information from a variety of media such as text, full-motion video, animation, and sound (Meyrowitz, 1988). Advantages are said to include the possibility of combining artificial intelligence, cognitive science, and advanced technologies to provide a quantum jump in learning (Molnar, 1988). Ambron (1988) states that multimedia frees teachers from the constraints of textbooks and allows students, to be active learners, controlling access to and manipulating vast quantities of information with a computer. Amthor (1991) states that multimedia arouses curiosity, promotes self-propulsion, and organizes knowledge by mirroring human activity.

Self-acknowledged visionaries proclaim the dawning of a new Renaissance, but perhaps ignore the basic processes of learning (Purcell & Myers, 1992). Reeves (cited in Sheehan, 1992) suggests that "interactive multimedia does not guarantee learning any more than the presence of a library on a campus or in a school guarantees learning" (p. 21). Reeves calls for a return to pedagogy and design which will support learners' interaction with multimedia.

Reservations abound. Some think it possible that learners will have such a trail-rich environment that it will be dysfunctional to the learning process, leaving the user disoriented (Conklin, 1987). Conklin suggests that it may be difficult to carry the mental load required to create, name, and keep track of links or trails. Heller (1990) adds that flagging commitment and unmotivated rambling may result. Bosco (1989) warns that multimedia can easily be used in trivial or ineffective ways, and it is too easy to get wrapped up in the technology as a thing unto itself. The penalty for this enthusiasm could involve a number of undesirable impacts. There may be a focus on the technology at the expense of instructional methodologies or a failure to design

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based on what we know about cognition and learning strategies.

This document's purpose is to review literature in multimedia research. We are interested both in what research says about the role of multimedia in instruction and whether extant research is sufficient and valid.

Multimedia Defined

The most commonly accepted definition of multimedia appears to support the concept of computer driven interactivity with the learner's ability to determine and control the sequence and content selection. Matchett and Elliott (1991) argue that "interactive multimedia" should include motion, voice plus data, text, graphic and still images. This definition permits multimedia to "absorb" the historically older and somewhat broader notion of hypermedia. As such, interactive video is a "high-bandwidth" source in the sense that a great deal of information, in many modes, or channels, are available at once (i.e., parallel fashion). DeBloois (1982) indicates that "it is important to realize that interactive video (multimedia) is not merely a merging of video and computer mediums; it is an entirely new media with characteristics quite unlike each of the composites" (p. 33).

The attraction of interactive multimedia is that it includes two of the more powerful educational technologies: the computer and video. Unlike some of the earlier linear technologies that allowed the user to remain passive, the new interactive programs not only allow viewers to become involved but demand it (Gleason, 1991). By doing so, these technologies, have closed the gap between some of the earlier theories of learner control and learning styles. Interactive multimedia allows the user to see, hear, and do. Through this mix of presentation techniques, interactive multimedia can appeal to learners who prefer to receive information by reading, those who learn best through hearing and those who prefer hands-on.

Using the Evidence to Evaluate Multimedia Programs

Does multimedia really work? It may be useful to differentiate between evaluation studies and research. Evaluation is practical and is concerned with how to improve a product or whether to buy/use a product. Studies that compare one program/media against another are primarily evaluations. Evaluation seeks to find programs that "work" more cheaply, efficiently, quickly, effectively, etc. Research, on the other hand, tends to be more concerned with testing theoretical concepts and constructs or, attempting to isolate variables to observe their contributions to a process or outcome. Having said this, we should point out that the terms evaluation and research are often used interchangeably in the fields of education and media.

Multimedia is a combination of many technologies, most notably the computer, which allows for true interaction. What information from previous research, relates to new multimedia programs? Strommen and Revelle (1990) stress the importance of existing research literature on computer usage for understanding the pragmatic requirements of developing interactive tasks in the multimedia

programs that were developed at the Children's Television Workshop. This literature helped "take children's special needs into account and...(delineate) what the content of our interactive tasks should be and how those tasks should be structured" (p. 77-78).

Computer instructional software should be consistent with basic learning theories as should the instructional setting. Lillie, Hannum, and Stuck (1989) state that often, when computer instructional software is compared to specific learning theories, the research results are not consistent nor positive. However, using evidence based upon an extensive review of more than 600 studies concerning effective instruction, Lillie, Hannum, and Stuck (1989) identified a number of instructional principles that could be critical to the design, development, and effectiveness of computer programs for the classroom (and therefore, useful to multimedia design). The principles noted include the following:

1) Students will learn more when activities begin with a review of relevant information and skills as well as objectives and purpose of the lesson (Fortune, 1967; Kozma, 1982).

2) Students will learn more when they are able to handle tasks with high rates of success (Emmer, 1981; Kozma, 1982).

3) Students will learn more when provided with clear and concise directions and tasks (Emmer, 1981; Lillie, Hannum, & Stuck, 1989).

4) Students will learn more from computers when assignments and activities are monitored (Emmer, 1981, McConnell, 1977).

5) Students will learn more when computer based instruction provides timely and specific feedback of both correct and incorrect responses (Gersten, Carine, & Williams, 1982; Webb, 1982).

"While there may be no agreed-upon definition of interactivity, there is nonetheless wide agreement among researchers that user-computer interactions are cognitive in nature and that an effective interactive design must take into account the user's cognitive ability" (Strommen & Revelle, 1990). These lessons from research on computer assisted instruction (CAI) and the cognition aspects should be kept in mind when looking at the design of newer interactive multimedia technologies.

Smith (1987) indicated that there are three major sectors in our society that use, and conduct research on the effects of, interactive multimedia: the military, industry, and education. Educational use of multimedia programs is still limited and in most cases still experimental. Two multimedia formats (video-disc and videotape) are predominate in education. As you would expect, multimedia researchers are still debating their relative values and virtues (Smith, 1987). However, the marketplace may decide the winner and DVI technologies such as CD-ROM (McCarthy, 1993) and Quicktime™ may well settle the debate in a practical sense. Despite the short duration of multimedia's

availability, Smith (1987) reported evidence for both the effectiveness and efficiency of the interactive media on learning.

Other researchers like Hannafin (1985) and Slee (1989) argue that there is little to support the contentions of the effectiveness of interactive media. They contend that little progress has been made since Clark (1983) argued that media in general have little substantial impact on learning. Hannafin (1985) asserts that while interactive technology, as noted earlier, offers interesting potential, interactive video differs little from the allied technology from either "learning or cognitive perspectives."

McNeil and Nelson (1991) in an extensive analysis of 10 years of interactive video research, indicated that interactive video can be an effective form of instruction and that their findings were similar to the earlier research results of computer-assisted instruction. However, many of their analyses were based upon studies that compared interactive methods versus more "traditional teaching approaches." These comparison studies often match a new medium such as interactive video with a rather poorly defined and operationalized "statement" called "traditional instruction." Researchers such as Clark (1983), argue that these types of studies have produced little useful outcomes. Kozma (1991) and Hannafin (1985) stress that research should instead concentrate on interactive features that maximize learning effectiveness. Studies, therefore, should not be directed at a specific medium, (i.e., interactive video), but on instructional methods and settings, the cognitive processes involved, the use of learning strategies, and how the content is structured (Jost, 1990).

Nevertheless, McNeil and Nelson (1991) in their analysis of 63 interactive video related studies related some potentially useful findings. These include:

1) Employing interactive video as a *supplement* to instruction was more effective than using interactive video as a *replacement* of traditional forms of instruction.

2) Using interactive video for group instruction was no different from using interactive video for individual instruction. Hofmeister et al. (1986) indicate that "the technologically-based, individual learning station must not be viewed as the ultimate delivery system for the public school" (p. 37).

3) Achievements of students using only videodisc were not different from students using videotape interactive based units. This conclusion should not be surprising considering Clark (1983) and Hannafin's (1985) warnings about using media comparison studies.

4) Learners who had *little or no control* over the instructional sequence of an instructional program *performed better* than students using interactive programs who had control over their instructional path. These findings may be further evidenc "that interactive video is best accomplished when it is guided and structured as opposed to being entirely under the control of the

learner (McNeil & Nelson, 1991, p. 5).

Surprisingly, perhaps, learner controlled interactive programs produced the lowest achievement. These findings may raise questions concerning the practical value of the concept of interactivity. Existing developmental research can also play an important role in guiding the design of interactive (multimedia) programs for children. For example, the knowledge that children have less capacity in working memory than adults (Case, 1985) and are less able to chunk information, should alert multimedia designers that tasks and activities should not be complex nor have a large number of options (Strommen & Revelle, 1990).

Ragan, Boyce, Redwine, Savenye, and McMichael (1993) summarized the findings of seven major reviews of research on multimedia. The 139 reviews were from a variety of settings, but the majority concerned adults. Among their findings were:

1) Multimedia is at least as effective as conventional forms and has substantial cost benefits and efficiency.

2) Frequently, multimedia instruction is more effective than conventional instruction.

3) Multimedia is more efficient in terms of learning time than conventional instruction (30% savings).

Ragan et al. (1993) stated that they were unable to determine why multimedia was appreciably more effective than conventional instruction, but cautioned that it would be inappropriate to say that multimedia is always the most effective delivery system. They suggested that certain instructional design features appear to enhance the quality of multimedia instruction. Among them are higher levels of interactivity, program or advised learner control, integration of multimedia with other delivery forms, and structured rather than totally exploratory learning.

Smith, Hsu, Azzarello, and McMichael (1993) reviewed 28 group-based multimedia studies. They indicated that group-based multimedia can be as effective as individualized multimedia, and it can be as effective or more so than traditional forms of instruction. They also found that learners prefer group-based multimedia to individualized multimedia and traditional instruction. Smith et al. stated they were unable to predict which situations are appropriate for group-based multimedia and that it would be erroneous to state group-based multimedia is always superior to traditional instruction or individualized multimedia.

In a separate review of the research on learning from interactive videodisc, Cushall (1987) reported knowledge gains and time savings when compared to "traditional" lecture methods. Positive attitudes were reported towards learning from interactive video programs relative to other, "traditional" methods of instruction by both students and teachers. Younger children had the most positive attitude gains, (Cushall, 1987). At the same time, however, Cushall (1987) cautioned that few studies investigated the learning

principles used in connection with interactive video. As do many others, Cushall (1987) indicated that, as a whole, most research so far on interactive video has *limited* generalizability and would be difficult to replicate.

Concerns Over Research

Many researchers such as Hannafin (1985), Smith (1987), and Clark (1983), and Reeves (1993) have also expressed concern over the existing research on the interactive multimedia platforms. Smith (1987) indicated that there are many existing procedures and guidelines for the development of interactive video available. However, as in the case of CAI, these guidelines are "experiential." They all appear to be commonsense development strategies depending upon "the designer's intuitions" about the instructional situation rather than upon any research based information or models. Bosco (1984) questions the value of "active learning" in many interactive programs. He asks: "Is the activity from the multimedia package actually involving the learner with the instruction, or is it merely automatic page turning, requiring no deep processing?" In addition, there appears to be an absence of analytical information on the effective use and *evaluation* of interactive programs. Nevertheless, Hannafin (1985) reports that while little research has been conducted, *some* appears to be favorable. However, "both instructional time and learning efficiency were found to be negatively correlated with increased interactivity, suggesting that additional learning under interactive video may be costly in required instructional time. Whether or not the gains associated with increased instructional time are worthwhile is unresolved" (p. 242).

In a 1993 critique of learner control research, Reeves, suggested that much CBI (a term he defines as a wide range of systems from tutorials to complex environments) research is pseudoscience. This is "because it fails to live up to theoretical, definitional, methodological, and/or analytic demands (p. 39) of the positivist research paradigm. Here are some of the flaws he discusses:

1) Williams' review indicates most research on learner control has been conducted using drill and practice or tutorial programs with little done on simulations or hypermedia (cited in Reeves, 1993).

2) Definitional problems: an ability to define exactly what "learner-control" means.

3) Theoretical problems: few studies have linked learner control issues with theoretical issues found in learning theory.

4) Methodological problems: treatments are too short and/or infrequent.

5) Studies often place students in contexts unrelated to their education, sacrificing relevance and increasing threats to validity and reliability.

Reeves opines that perhaps a moratorium should be called on the types of quantitative studies he reviewed until qualitative studies conduct "...extensive, in-depth efforts to observe human behavior in our field and relate the observations to meaningful learning theory that may

later be susceptible to quantitative inquiry" (p. 44).

Suggestions For Research

Many practitioners developing and using interactive programs (and some researchers) have questioned the value of the existing research on interactive technologies. For one thing, little actual research has been conducted and what has been conducted has limited value. Practitioners and researchers alike are calling for a systematic research program that goes beyond the traditional comparison studies. McNeil and Nelson's (1991) summary findings of some 60 studies are an exception. Others like Grabowski and Pearson (1988), Slee (1989), Reeves (1986) and Kozma (1991) have made calls for conducting research on instructional strategies related to the specific attributes of the interactive medium. As early as 1985, Hannafin had made concrete proposals for future research into interactive technologies. He offered 12 propositions for further research that focus on the methods, the assumptions and the instructional strategies of the interactive technology rather than the technology itself. His research propositions included:

1) The more interactive the instruction, the greater the learning.

2) The type of interactivity affects the amount of learning.

3) Interactive video is appropriate for the full range of learners, content and types of learning tasks.

Hannafin (1985) contended that while some of his 12 propositions may be supported or refuted, the use of interactive video would thus be considered from an empirical base and not from the current intuition and assumptions as many are now considered.

An additional problem of research dealing with multimedia programs, according to Strommen and Revelle (1990), suggests that it is adult-oriented and non-developmental in nature. This is in no small part because it is expensive to develop and more likely to be designed for industry and military applications. Few, if any researchers, have considered "the ways in which adults and children may differ in their abilities to use computers" (p. 67). This concern also needs to be built into a program of research on multimedia.

The Bottom Line

What does the research say about multimedia and its interactive technologies? Unfortunately, not enough. The terms *multimedia* and *interactivity* are defined universally by neither the developers nor the researchers. Many of the current guidelines for the development of multimedia programs can be traced to just a few sources. One source is the behaviorist learning theory tradition of Thorndike and Skinner, the second is existing research investigating computer assisted instruction. The most prevalent sources however, are assumption, intuition, and (apparently) commonsense. In an extensive review of the literature, there appears to be too little useful research on multimedia. Quite frankly, with few exceptions there is *NOT* a body of research on the design,

use, and value of multimedia systems. The few exceptions are the meta-analysis of some 60 studies of McNeil and Nelson (1991) and the work at the Children's Television Workshop (Strommen & Revelle, 1990). The lack of research concentrating on interactive features which maximize learning effectiveness has been noted by both practitioners and researchers alike. Specific programs of research have been suggested to fill these gaps, for example: Hannafin (1985), Kozma (1991) and others. Until these calls are taken seriously, multimedia development will have a less than adequate research base.

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