

Anticipating the Impact of Multimedia in Education: Lessons from the Literature

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ABSTRACT

'Multimedia' applications are frequently mentioned as opening new horizons for education in the 1990s. Often this kind of prediction is based on an assessment of the new technical capabilities of a medium (or combination of media) rather than on a critical assessment of applicable research. In this study an analysis is made of key trends and messages from previous empirical research related to the application of media in education and nine key conclusions are discussed. The application of these trends, messages and suggestions to 'new multimedia' developments in education is discussed.

INTRODUCTION

Multimedia applications in education can be defined in many ways. One broad definition is any learning experience that involves more than one medium for the organization, information exchange, and interactive aspects of the learning experience. If 'medium' is also defined broadly, so that it includes, for example, the human voice, chalkboards, paper, and books as well as carriers of more mechanical or electronic nature, many if not most educational exchange could be described as happening in multimedia environments.

Currently, however, electronic developments are bringing the subset of multimedia applications that involve some sort of integration of computer technology with other visual and audio carriers into the forefront of multimedia discussions. Advances in storage and speed are allowing multimedia applications such as interactive video to move out of specialized research or training settings and at least show the potential to move into schools. Advances in telecommunications and other

carriers of media used for distance education and open learning also bring a new emphasis to computer-related subsets of multimedia applications seen now as having powerful potential in education.

Because of the rush of technological developments in multimedia applications involving computer technology, multimedia references in trade and professional journals as well as in new research studies almost always make the implicit assumption that 'multimedia' can be taken to mean some sort of environment, under computer control, which integrates input from other media. Because this integration can be done with such speed and in ways not before feasible for educational settings, there is also appearing a tendency to ask broad questions, such as 'What is the potential of multimedia applications in schools?' or 'Will multimedia applications lead to new, different, and better learning experiences?'

Such questions are highly reminiscent of similar questions asked in the early 1980s with respect to computers in education, and before

this, with respect to television in education, and before this to various other categories of audiovisual media in education. The purpose of this analysis therefore is to anchor discussions of new multimedia applications in education in contexts broader than the potential and characteristics of the new multimedia applications themselves. The analysis represents a perspective on the potential of computer-related multimedia applications in education in the 1990s based on relevant research literature from past experiences with other 'new media' and their possibilities in the classroom.

The theoretical framework for this perspective on multimedia in education, on which this analysis is grounded, is that policies and directions for multimedia applications in education in the 1990s must build upon the extensive experiences that have already been accumulated with regard to the impact of media on learning and the learner. New multimedia applications may indeed offer new possibilities to education, but much is already known about the more general experience that will continue to be pertinent even if and when new multimedia applications are regularly part of the educational environment. For example, in their extensive review of 105 research studies related to learning, cognitive processing, and instructional design (most of which are based upon empirical data), Hooper and Hannafin (1988) conclude that:

Learning from computer-based interactive video, or any other media, has little to do with the inherent capacities of the medium *per se*... From an instructional perspective, the capabilities of technology *and* learners are optimized when the potentials and limitations of both are weighed concurrently, cognitive requirements of the learning have been identified, and associated strategies prescribed accordingly, and instructional activities are developed to maximize those features of the medium that support most substantially the identified processing requirements. (p.4)

The analysis in this report reviews some key

research that supports this statement. The review focuses on results from reasonably well designed studies that base their conclusions on empirical data, in order to most effectively synthesize some of what we know about 'maximizing those features of a medium that support most substantially identified (cognitive) processing requirements'. The requirement of empirically based data is applied in order to separate studies based on practice from those based on prediction of potential. Hooper and Hannafin point out that it is common to read an endorsement of a medium in an article 'despite the relative paucity of empirically validated instructional effects. Instead... claims of effectiveness have been based largely on the presumed advantages engendered by technological superiority' (p.3).

The plan for this analysis therefore is to identify and interpret some key results from empirically based research relating to:

1. Audio-visual technologies in education;
2. Computer use in education;
3. Interactive video in education;
4. Other new media in education;

in that each of these areas of previous research offers a direct contribution to a subsequent analysis of the potential of new multimedia in education in the 1990s. Many of the key points made in Section 1 also apply to later sections. The analysis concludes with a summary of how the empirically established conclusions of earlier research can guide expectations for use of 'new multimedia' in education in the 1990s.

1. AUDIO-VISUAL TECHNOLOGIES IN EDUCATION: KEY RESULTS FROM AUDIO-VISUAL RESEARCH

Research results related to the impact of audio-visual technologies in education have been accumulating for over 50 years. Only a selection of the many studies in this area – those representing major trends – will be

mentioned here. Also, for this section, we will limit our discussion to audio-visual technologies with no computer component.

Studies at the micro level: the influence of particular design features in audio-visual learning materials on student learning and attitudes

The majority of earlier studies concerning the impact of audio-visual technologies on learning focused on what might be called the micro-level. A typical research design for such a study would be to: select one instructional design variable, for example, 'modality of visual representation'; develop an experiment in which some instructional event was presented with various representations of the chosen variable, in our example, perhaps photographs and hand-drawn sketches of the same object visualization; enlist a group of subjects (often university students taking a course in the researcher's department); somehow divide the group, so that one portion uses one type of instructional materials such as the photographs, another portion uses a different variety of instructional materials such as the sketches, and perhaps a third portion uses instructional materials without any visual component; and give everyone a pre- and post-test on the content of the instructional materials. Also, almost always, the subjects are asked to respond to a few self-report questions relating to their attitude with respect to learning with the audio-visual materials used in the experiments. Generally the period of use of the instructional materials is highly constrained and often the context in which the students use the materials is artificial rather than part of a full, meaningful instructional environment. Then, the data from the pre-test and post-test are analyzed and interpreted. Typical findings are that everyone's learning increased; learning with visualization is better than with no visualization; and since one of the types of visualization (let's say, photographs) was associated with higher scores on the post-test than the other, a conclusion is given endorsing the

more successful type of visualization. Subsequently this endorsement begins to be cited in other research, for example 'realistic visualizations are better than representation visualizations', in a way that suggests it is a well-established principle.

One major difficulty with this type of study is that once several of them, supposedly relating to the same variable, are compared, contradictory conclusions are often found. For example: 'Sketches are more effective than photographs'; 'Photographs are more effective than sketches'; 'Colour is preferable to monotonous'; 'Monotonous are preferable to colour'. Sometimes such inconsistencies are highly likely to be a function of variations in the designs of the studies but, more substantially, the gradual awareness and analysis of these sorts of inconsistencies has led to one of the major conclusions that can be made about media use in education:

Key point 1: "There is a growing body of evidence to indicate that no media variable, minute or gross as it may be, affects all groups of learners in one and the same way". (Salomon, cited by Schramm, 1977, p. 94).

The implications of this conclusion are far-reaching. One implication is that definitive conclusions about a design variable should not be made, even if a study is well designed and yielded a significant difference between two values of the variable. The second implication is that the learning situation in which a particular result occurred must be analyzed in order to get insight into what combination of circumstances may have influenced the result. This latter recognition has been increasingly developed and can be applied in a variety of ways, for example: that characteristics of the instructional content being communicated by a medium influence the effectiveness of the medium (Wells, Van Mondfrans, Postlethwait and Butler, 1973); that the characteristics

of the learner influence the effectiveness of a medium (Goldsmith, 1984); and that the way in which media use is integrated with other aspects of the instructional activity in which the use occurs influences the effectiveness of a medium (Hoban and Van Ormer, 1970). Hoban and Van Ormer in their review of early (1912–1950) research on instructional film as a medium, conclude that students taught within an environment where film and text are integrated do better than students taught only with text, but that this advantage depends on the media being ‘mutually reinforcing and supplementary’ to the text, with a cohesiveness of subject content that is overlapping but not repetitious.

Schramm (1977) also has synthesized a large collection of earlier audio-visual studies and reaches a similar conclusion: ‘Used in the right place, in the right way, for an appropriate purpose, (educational media) will improve a classroom experience’ (p. 56). This leads to an extension of the first key point:

Key point 2: We cannot make general conclusions about the effectiveness of particular design variables in media. Such effectiveness is dependent on the context in which the media are used. ‘Context’ includes characteristics of the learner, of the learning goals and context, and of the relationship of the media use to other aspects of the instructional setting.

Studies at the system level: Comparing the effectiveness of audio-visual media

Another large group of studies focus more on the question of the effectiveness of a category of audio-visual media (ie, instructional film, educational television, educational radio, educational video) relative to other categories than on specific design choices within a category of media. The reviews of Schramm and Hoban and Van Ormer, men-

tioned above in respect to design features, also include many studies asking these kinds of macro-level questions; Van der Voort and Beishuizen (1986) provide another extensive review. The same conclusions are pertinent to these system-effectiveness studies as were derived from the design-level studies. As before, the major conclusions are that there is no simple conclusion possible and that effectiveness depends on many factors; such as design and implementation choices within the specific media products, contextual variables in the setting where the media are used, and the interactions among the implementation choices and the contextual variables. Clark’s well known synthesis of audio-visual media concludes with a striking statement that expresses this interdependency: ‘Instructional 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’ (1983, p. 445). From this, another pertinent conclusion similar to key point 2 (which focused on design choices within a category of media) but with respect to comparing one category of media to another can be made:

Key point 3: It is not possible to make statements about ‘the’ effectiveness of a particular medium because effectiveness is a function of many variables, such as design choices within the medium’s implementation, contextual variables within the environment where the medium is used, and interactions among these implementation and contextual variables.

Hooper and Hannafin even suggest that the only meaningful rationale for one medium over another is the relative degree to which one rather than the other ‘provides the potential to deliver consistent, replicable instruction to large numbers of people’ (1988, p.3; see also Clark, 1985). This idea is pertinent to

considerations about the cost-effectiveness of a category of media

Even though definitive statements about the effectiveness of particular types of audio-visual media or of particular design features within applications of a medium cannot be made, the empirically based research, taken as a whole, does support at least two other important conclusions:

Key point 4: Students like audio-visual experiences; learner comments expressing positive reactions and attitudes to audio-visual experiences appear in study after study.

Key point 5: Media used as a supplement to classroom teaching are generally more effective than media used as a substitute for classroom teaching or media used outside a context of classroom teaching.

Key point 5 is a major conclusion of both Schramm's and Hoban and Van Ormer's reviews. However, it may also need to be reconsidered with respect to new work in the effectiveness of distance education. The success of the RADECO interaction radio project in the Dominican Republic, where radio compensates for highly limited traditional education, is valuable to consider (Agency for International Development, 1990). With respect to the importance of the affective conclusion (key point 4) – it is not clear from the empirical data how important positive attitude is to subsequent learning, but the value of positive attitude is generally taken without question in education.

Non-computer-related audio-visual media incorporating interactivity

The previous sections have summarized trends in sets of research studies. However, one category of audio-visual applications might be particularly relevant to multimedia in the 1990s: those that emphasise interactivity.

MacMahon (1977) reports on a large-scale

project in Ireland that involved 10–12 year-old students and their teachers in 149 Irish schools. The project could be called an early multimedia study, in that it involved the conceptual integration of radio and print media. The key feature in the instructional design of the radio and print materials was to build in student interaction opportunities. The children were to sing along as they listened to parts of the radio broadcast and were given tasks that involved the active exploration of their environments. The teachers felt that the way overt participation was structured into the use of the media was the key factor in their highly positive assessment of the multimedia activity. The interactive radio projects sponsored by the U.S. Agency for International Development also share this design approach (A.I.D., 1990). These are excellent examples of Clark's point cited earlier – it was not the media in themselves, but the way the media were used, that made the difference.

Interactivity is also a key element in the successful results reported in three studies evaluating the use of 'Level 1' video products. (Hasselbring, *et al.*, 1987–88; Mably, 1987; Straker, 1988). Level 1 video products use video playback units that allow the user to quickly move backward and forward to certain sequences of frames on a videotape. They are typically operated via a hand-held remote control unit and also allow freeze-frame viewing. In the three studies cited above involving Level 1 video products the teachers used such a resource in a whole-class setting, starting and stopping the videotape at appropriate places relative to what they and their classes were discussing and practicing.

All of these Level 1 video studies (Hasselbring, Mably, and Straker) report benefits to learning and high teacher and student acceptance. The teachers appreciated the easy availability of high-quality visualizations on the video disks and of integrated student materials and especially the way in which the visual instructional materials were organized so that the teacher could make the local decisions

about pacing and sequence. Because of the way the videodisk materials were deliberately designed to place high-quality visual display materials under teacher selection and control, these materials can be described as 'robust instructional packages transportable from classroom to classroom' (Hasselbring, *et al.*, 1987-88, p.167), offering strong implications for cost effectiveness. The interactive radio experiences mentioned earlier have also been evaluated in a highly positive way relative to their cost effectiveness (Jamison, Searle, Galda and Heyneman, 1981).

These last studies combine with others from the non-computer-related audio-visual work to suggest two more important directives:

Key point 6: The design and organization of instructional materials should facilitate teacher intervention in decision making over pacing and appropriate content, and should strive to make the intervention process as comfortable as possible for the teacher.

Key point 7: Interactivity appears to be an important component of a learning experience involving audio-visual media, but the interactivity can take place in a variety of ways, such as through the teacher; or through students' activities stimulated by the teacher. Thus it can be integrated conceptually within the audio-visual materials rather than being a specific component of the media materials themselves.

2. COMPUTER USE IN EDUCATION: KEY RESULTS FROM RESEARCH RELATED TO THE INSTRUCTIONAL EFFECT OF COMPUTERS

Instructional applications of computers have been the focus of research since the early 1960s, with a marked acceleration in quantity

of this research accompanying the start of microcomputer use in schools in the early 1980s. The amount of research available is now vast; in this section only a sample of representative studies can be mentioned. As before, comments are limited to studies whose conclusions are based on empirical data. Also as before, comments are organized first around the effect of 'micro-level' design choices in educational software and, second, on the overall effect of computer use compared to other technologies. This section is shorter than the previous one relating to non-computer-related audio-visual applications in education because as will be seen, the same basic conclusions apply.

Studies focused at the micro-level: the effect of specific design choices in educational software on student learning.

Perhaps what is most remarkable about the hundreds of studies that investigate 'micro-level' design features in educational software - for example, the use of screen display variables relating to colour, and to text presentation, and variables related to the use and implementation of graphics - is that these studies exist at all, given the history of work that had gone before in the audio-visual domain. Salomon's observation, in 1977, that no design variable affects all learners in the same way, and the awareness that the effectiveness of a medium is a function of the contextual variables in which its use occurs, would seem to suggest that research studies investigating the effect of specific instructional design variables should be set at a more sophisticated level of focus than that of comparing two levels of a single design variable - for example, colour or no colour - in an artificial laboratory setting. Yet many studies involving educational software characteristics have proceeded as if unaware of the extensive background of work that has already occurred with relation to other media in education. The naive question, 'Are computers better than...?' also seems to underlie many studies.

Perhaps some of the micro-level educational software research was built upon the idea that the computer medium is somehow substantially different from other media and therefore needs to be studied afresh, only with reference to other computer-as-medium studies. It is fair to say that a sizeable portion of the research was motivated by a genuine belief that computers offered revolutionary opportunities to education. Such an orientation does not reflect an understanding of the implications of Clark's landmark syntheses of older media research and early computer-related research (1983, 1985) in which the 'media as a delivery truck' conclusion was drawn. But apparently many researchers came to the study of computers in education, not from an audio-visual background, but from a psychological or technical background from which they were perhaps unaware of, or failed to see, the generic similarities in issues related to the effect of any media on learning and learners. There are, of course, some differences between computers and other media, notably perhaps the capacities to build in structured interaction and to automatically vary the learning experience. But the overall conclusions of the earlier audio-visual work – the overriding importance of context, the teacher, and instructional embeddedness – have now been re-established with respect to computers as educational media (Clark, 1985; Hooper and Hannafin, 1988; Roblyer, Castine and King, 1988). Roblyer and her colleagues, for example, conclude their meta-analysis of computers-in-education research by saying, 'The effect of all instructional media is highly dependent on careful design and implementation techniques' (p.92). It is important to emphasize this, so as to avoid allowing current enthusiasms for new multimedia developments in education to follow the same patterns of naive exploration of the impact of a particular feature of multimedia or of disinclination to learn from the educational media research, that have happened before.

Studies at the system level: the effect of computers in education

Despite the awareness that we should not make simplified generalizations about a medium, it is useful to report the overall results from various meta-analyses of the effects of computer use in education, in order to comment on general trends. A number of meta-analyses have been done, mostly yielding similar results. The earlier meta-analyses (Kulik, Kulik and Cohen, 1980 (59 studies); Kulik, Bangert and Williams, 1983 (51 studies); Niemiec and Walberg, 1987 (16 reviews of meta-analyses)) all reported small but significant gains in achievement and attitudes for students using computer resources compared to students not using computer resources, and often in the same or less time. Although much criticism has been levelled at the technique of meta-analysis and the applications of the technique in these studies (see Clark, 1985), the studies do show an overall positive effect of computer use on learning. In a more recent meta-analysis Roblyer, Castine, and King (1988) found interpretations consistent with the key points developed earlier in this chapter. Among their conclusions are the following:

1. The effect of all instructional media is highly dependent on careful design and implementation techniques (p.92). (For example: word processing use has generally a positive effect, but this is highly dependent on the instructional decisions of the teacher).
2. Although there is evidence of educational effectiveness from the use of Logo, CAI, and problem solving software, unstructured use is generally ineffective.
3. There is no overall conclusion that can be made about computer use being better for one ability level of student than another.
4. There is consistent evidence that attitudes toward the computer experience are positive, but no real transfer of these attitudes to school or to subject matter generally.

occurs ('The overall impact in improving motivation toward learning seems to be very limited' (p.35)).

From all of this, is there a key point to be made about computer use in education that is not already expressed in the other key points? Perhaps the following, although to a certain extent it is an extension of key points 1 to 7:

Key point 8: When an instructional need exists, and some characteristic of computer use is an appropriate way to address this need, then the potential of the computer application having a valuable effect increases.

Generally, features of computer use must be relevant to instructional needs in order for their impact to be positive or, at least, not counter-productive. Teacher decisions about instructional integration of computer use are critical variables determining the effect of that use.

3. INTERACTIVE VIDEO IN EDUCATION: KEY RESULTS FROM RESEARCH RELATED TO THE INSTRUCTIONAL EFFECTS OF INTERACTIVE VIDEO

Much work and research has occurred in the area of interactive video, as the medium forms an interesting blend of both audio-visual and computer-based experiences. Many writers endorse the effectiveness of interactive video, however often without reference to empirical data (Reeves, 1986). 'The rationale for acceptance appears to be largely intuitive: If the computer and video are capable of delivering efficient, effective, and motivating instruction, then incorporating both must be at least as effective as either individually' (Boen, 1983 p.43). However, the ability to combine modes of presentation – pictures, video, computer graphics, text, audio – suggests benefits in terms of meeting the needs of individual references in learners

and responding to the needs associated with various learning situations. What messages are there from the empirical research on the effects of interactive video in education? How effectively is this multimedia potential being translated into educational achievement?

Research results

Research involving empirical, or at least observational data related to the educational effectiveness of interactive video, seem to separate into three categories: users' experiences in handling navigation within the interactive video; users' attitudes toward using interactive video; and impact on some aspect of learning or performance. In general, however, most articles about interactive video are little more than descriptive. In a report on the 'Palenque' project, for example, after an extensive discussion of the new technology, DVI (Digital Video Interactive) used in the interactive videodisk, the only comment made about user reactions or achievement was, 'As confirmed by extensive user testing, the computer novice using Palenque transcends the complex interface now associated with many applications through the liberal use of audio and visual' (Ripley, 1989, p.818). The majority of articles about interactive video discuss educational potential, and involve no user data (beyond data from a few individuals – usually not representative of the eventual target group – who interact with a prototype version in a laboratory setting), but describe instead the planning and initial development of a particular interactive video product. MacKay and Davenport (1989), for example, describe various cycles of development of an interactive media application on coastal navigation. User experiences with each cycle are only described generally, not with data and not in terms of learning effects.

There are some exceptions. The article by Binsted (1988) is a particularly good example of a study describing a development and validation process for an interactive video

system. Binsted's analysis of the system appears to yield a positive conclusion, both educationally and economically. Even in the Binsted article, however, the only 'empirical data' are comments from some end-user representatives relative to the realism of the video sequences, based on seeing them in 'videosketch' or prototype form.

There are of course some studies that present data-based results relative to specific IV-systems. Pals and Verhagen (1988) compared the performance of eight vocational education students who were taught a fault-finding procedure using an interactive video system with that of other students taught with traditional methods. There was no difference in the performance of both of these groups on a subsequent hands-on transfer test. Verhagen also reports (1989) on an evaluation of a different interactive video system intended to be validated in a variety of actual school settings. Although some insights were gained, little empirical data were collected, as implementation of the system proved continually difficult. The major result reported that students liked it. Hermans (1988) reports a similar reaction ('students like it') with respect to an IV-system involving simulations of interviewing and counselling approaches, but noted that the medium was better for the training of observation skills than of counselling skills. 'The simulations were judged better than a study of the literature and worse than a workshop' (p. 442) where real practice in dialogues could occur. Copeland (1988) summarizes six empirical studies on the application of IV on training and found that IV 'is well-liked by users and achieves high levels of learner success' (p. 62). Laurillard (1987) describes an evaluation of technical students' use of an IV on the structure of materials. Students enjoyed it, and thought 'the continual interrogation and the varied presentation was a good way to learn' (p. 84). Phillips, Hannafin, and Tripp (1988) studied 'orienting activities' within an interactive system designed to individualize student conceptual skill development. They found, on the basis

of data from 72 students interacting with their system, that the carefully designed orienting effects built into the system appeared to have little effect. They also found that 'high-level' embedded questions were not more associated with high-level responses on a subsequent transfer test than were 'low-level' (factually oriented) embedded questions. Their conclusion is interesting, in that it reflects the conclusions noted earlier from the audio-visual research and summarized as key points in this chapter. It is:

The absence of effects associated with orienting activities provides further evidence of the limited power of such techniques when used in combination with other instructional variables. In this study, practice, item familiarity, and type of learning collectively accounted for nearly 60 per cent of the total score variance, while orienting activities, including both main effects and associated interactions, accounted for less than 3 per cent of the score variance. (p. 100).

Finally, Smith (1987) provides a synthesis of studies involving the use and effectiveness of interactive video. He concludes that active participation of the learner with the learning material should not be uncritically accepted as better than no participation and that we should 'beware of empty interactions' (p. 8) because they can interfere with achievement; that various studies support the positive impact of interactive video on learning (pp. 4-5); that students can learn faster with IV; and that students accept and like it (p. 7).

So, can we conclude with another key point pertinent to new multimedia applications in education, based on empirical data from interactive video studies? It seems not, except perhaps as an extension of the previous key points. It is not the particular medium itself, but the intersection of capabilities of the medium, user needs and characteristics, and implementation of design strategies to connect these other characteristics that can make an instructional impact. This leads to a final conclusion:

Key point 9: The extent to which a technology is sufficiently flexible to meet a range of user needs and characteristics might be a predictor of its overall educational value.

4. OTHER NEW MEDIA IN EDUCATION: KEY RESULTS RELATED TO NEW MULTIMEDIA APPLICATIONS IN EDUCATION

In this section 'new multimedia' will be defined as a collection of two or more media, including a computer or microprocessor, functioning as an instructional unit. The unit may be physically connected or conceptually connected, or both. There are relatively few studies available. What trends can be found in those that involve empirical data?

Multimedia application: conceptual linkage

Two studies are examples of those that report empirical data relating to the effectiveness of a multimedia unit which is conceptually, rather than physically connected. Reynolds and Meierdiercks (1989) describe the multimedia approach to instruction being followed in some courses at the University of Singapore. One particular course was offered in both traditional and self-paced multimedia form. For each section of the course, the multimedia form consisted of printed material, a videotape, practice exercises and questions on a computer, and a visit with a tutor to discuss the result of the tests administered via the computer. One hundred and twenty students were randomly assigned to one or the other of the two formats; at the end of the course there was no difference in achievement between the two groups, leading the researchers to argue that the self-paced material was more cost-effective than traditional instruction, once the initial costs of production of materials have been recovered. Also, the students liked the self-paced materials better than the traditional approach.

Gibbon and Hooper (1988) describe 'The Voyage of the Mimi', one of the best known examples of conceptually connected multimedia educational material. In this unit about whale migration, students have 26 video segments, print materials, and four software packages. Extensive teacher training preceded the initial observation of the materials in use in classrooms in the United States. An evaluation study was done, but with no direct data about student learning. Instead, teachers reported that they and their students found the materials 'exciting' and that the 'students also indicated an appreciation of science and human values after experiencing the program materials' (p. 184). Teachers admitted, despite the extensive support provided to them by the project staff, that they found it difficult to fit the materials into the traditional classroom context.

Hypertext

Much is being written about hypertext and hypermedia. Hypertext is defined as 'non-sequential writing; a directed graph where each node contains some amount of text or other information. A node may have several out-going links, each of which is then associated with some smaller part of the node, called an anchor (or button). When users activate an anchor, they follow the associated link to its destination node, thus navigating the hypertext network' (Nielsen, 1990, p. 298).

Although this definition makes hypertext seem rather formidable, the packaging of HyperCard with Macintosh computers has led to widespread public familiarity. Researchers and theorists are debating strategies for navigation in hypertext, at the same time as school children are using HyperCard to create text and multimedia databases with nonsequential links. HyperCard allows digitized graphics and sound to be stored as linked data, thus creating a multimedia

environment. It also can serve as a front end or driver to video stored on a videodisk or compact disk interactive.

With respect to the single machine (non-videodisk) versions of hypertext and hypermedia, much has been written about the problems users and organizers have in efficiently assessing the databases (Hardman, 1989; Nielsen, 1990). Nielsen (1990) summarizes issues related to navigation and problems related to the 'context-in-the-large', through backtrack facilities and 'footprints', and tested implementations of these with groups of university students. It appears that his data, like those of many other studies of this type, relate mainly to users' difficulties in moving around in the database. No attention appears to be given to collecting empirical data of effects on learning. (Incidentally, Nielsen sees 'context-in-the-small' problems as less solvable than navigation problems, in that context-in-the-small problems relate to the inherent limitation of only being able to see a limited amount of text at a time on the computer screen.)

Hypermedia-driven interactive video

An exciting 'new multimedia' application appearing in some schools is HyperCard-driven access of video stored on videodisk (or compact disc). One study was found that reported student reactions to such a product, 'The Shakespeare Project'. The only indication in the report of an actual learning effect was that 'students were able to notice details they had never noticed before' (Friedlander, 1988 p. 122). The rest of the evaluation comment relates to how much students liked the resource.

CONCLUSION

In some ways, it seems we cannot say much about the effects of media, old and new, in education. Certainly no easy recipes are possible nor are there simple answers to 'What is

effective?' But on the other hand, previous research has given us important results, not the easy prescriptive ones we might like, but fair and applicable results that should be carefully noted in formulating policies and directions for new multimedia applications in education. These key points can be summarized by the observation: *it is not the technology but the instructional implementation of the technology that determines its effects on learning.*

This general observation was amplified in this review through the nine key points:

1. Any implementation of media will affect different learners in different ways.
2. Overall effectiveness is dependent upon the context in which the media are implemented.
3. Effectiveness of 'micro-level' design choices in media is dependent upon the context in which the media are implemented.
4. Students like media in a learning context.
5. Media are generally more effective as a supplement to an overall, integrated instructional setting, rather than as the sole or major components of the setting.
6. Easy teacher manipulation of materials is important.
7. Interactivity is desirable but can be organized in many ways.
8. The basis for media use in education should be first, the identification of an instructional need, and second, an assessment of the characteristics of various media to see which can be best used to address the need.
9. The extent to which a medium is sufficiently flexible to meet a range of user needs and characteristics might be an effective way to describe its overall educational potential.

How do these conclusions relate to our expectations of new multimedia applications in education? Points 1, 2 and 3 warn us against the anticipation of 'easy answers' and Points 2

and 3 particularly give warnings to the research and development community to include real-world implementation loops and benchmarks in design activities. Point 6, coupled with sensitivity to implementation, suggests that a similar level of care should be given to the development of teacher or trainer support materials as is given to the technical realization of materials. In particular, an anticipation of teacher or trainer use of multimedia learning materials should be an ongoing aspect of design and development work, with continual reflection on how the materials are likely to interact with learner, teacher, and instructional setting variables in their actual usage. Point 8 relates to this type of parallel analysis and shows it should begin prior to any design and development work. Point 4 gives encouragement, unless of course, learners reach some kind of media saturation level or the novelty wears off.

Most importantly perhaps, Point 9, and the other variables taken as a set, suggest a criterion for predicting the potential effectiveness of any medium, including new multimedia, in educational settings: the extent to which the medium supports the generation of a large variety of learning experiences that can be tailored to the needs of particular educational contexts.

Considering these guidelines as a whole, we might summarize by saying a medium, new or old, will increase its likelihood of effectiveness to the extent that it has the capacity to be adapted to different educational needs and contexts and to be integrated into these contexts by the teacher in a time-and-effort efficient manner. Given an appropriate implementation, media (old or new) have the capacity to enrich and increase learning and to do so in a way that students enjoy. The potential of new multimedia applications in education is therefore strong, because of the increased potential adaptability associated with being able to combine and manipulate various media in fast and assessable ways for educational purposes. However, 'new multimedia applications' in education must be

seen in the context of what we have already learned about media and learning. This analysis offers one perspective for this type of anchoring.

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NOTES

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