# The Relative Effectiveness of Audio, Video, and Static Visual Computer-Mediated Presentations

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Research on non-computerized media such as television, slides, animation, and film has developed an information-processing framework that can be adapted to research on computerized media. We examined the relative effectiveness of three different forms of computer presentation: digital video presentations with text, audio-only presentations with text, and static visual presentations with text. ANOVA results showed that although the achievement scores of participants in different treatment groups did not differ significantly, there was a significant difference in the time participants took to complete the presentations. From an information-processing perspective, these differences may be attributed to bisensory interference or bisensory facilitation. We concluded that when computer-mediated presentations are being designed, the comparative efficiency of the learning medium might often be more pertinent than the effectiveness of media implementation.

Les auteurs ont analysé l'efficacité relative de trois formes de présentation informatisée : la présentation vidéo numérique avec texte, la présentation exclusivement audio et la présentation visuelle statique avec texte. Les résultats de l'analyse de la variance révèlent une nette différence dans le temps pris par les participants pour effectuer les présentations. Du point de vue du traitement de l'information, ces différences peuvent s'expliquer par l'interférence bisensorielle ou la facilitation bisensorielle. Les auteurs concluent que, dans les présentations assistées par ordinateur, l'efficience relative du média d'apprentissage peut souvent être considérée plus importante que l'efficacité réelle de l'utilisation du média.

As integrated computer-mediated instruction enters the mainstream of instructional development at all levels of education and training, the implications of the use of multi-media techniques have become essential to program design and development. Exploration of the relative effectiveness of various multi-media techniques and their impact on design efficiency, as well as on learning efficiency, has the potential to provide programmers and instructional designers with a theoretical and practical basis from which to select the appropriate medium for individual learning objectives.

The *effectiveness* of different multimedia formats in facilitating learning is a major consideration within this framework. An additional concern, however, must be the *efficiency* of the pedagogical program. In other words, although a specific media application may not significantly change learning *effectiveness* (how well the medium can be used in instruction), it is equally important to consider that medium's effect on the *efficiency* (how practical and time-efficient the medium is when compared to other forms of instructional delivery) implicit in its use. This must be considered from the standpoint of the learner as well as from the standpoint of the instructional designer.

## BACKGROUND

As interest in the application of computerized multimedia to education grows, activities seem to have been driven more by increasing technological capacity than by research and educational theory (Park & Hannafin, 1993). Much multimedia design has been driven by the beliefs of programmers rather than by the empirical findings of researchers in content and current instructional theory. What many practitioners have taken as a "given"—that computer applications generally assist in the improvement of learning (Kulik & Kulik, 1987)—was disputed by Clark (1983). Clark argued 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). If Clark's supposition holds true, the routine presentation of multimedia-assisted programs would not necessarily enhance learning, as compared to more traditional methods of delivery. Debate surrounding Clark's statement posited the need to consider the capabilities and implementation of media in conjunction with lesson development, as well as with choice of overall instructional style (Kozma, 1991).

Similarly, Schramm (1977) claimed that learning is influenced by the content and instructional strategy in a medium rather than by the type of medium itself. Building on Clark's and Schramm's concepts, Kozma (1991) suggested that all learning depends on the learner's ability to interpret symbols presented within the media. Kozma also stated that instead of examining only what students learn *from* a variety of media, researchers should also examine how students learn *with* media. This subtle differentiation suggests that comparing effectiveness may be important during the development of instructional computer applications.

The general public's acceptance of the benefits of computerized multimedia applications is exemplified by the article "Surfing Back to School" (Dwyer, 1996), the cover story of the August 1996 issue of *Maclean's* magazine. This article contended that students retain 10% from what they read, 20% from words they hear, 30% from pictures they see, and 50% from watching something being done or viewing an exhibit. The responsibility for exploring the validity of these claims of differences in learning retention should fall not to private industry, which has a considerable financial stake in education's wholesale acceptance of the computer medium as status quo, but rather to the educational research community.

A considerable body of previous and current research dealing with these issues has not yielded the conclusive results about learning retention claimed as "fact" in the *Maclean's* article. Neither our findings reported here, nor those of Clark (1983), nor those of Mayer and Sims (1994) concur with the *Maclean's* presentation.

## AN INFORMATION-PROCESSING PERSPECTIVE ON COMPUTERIZED MEDIA

The analysis of media in this study asserts that learning is an active, cognitively complex process. The learner acquires new knowledge from the interaction of environmental information integrated with information already stored in memory (Jonassen, Campbell, & Davidson, 1994). Perception and attention mediate this learning. If media can engage and maximize the learner's perception and attention, learning may be enhanced. This information-processing framework represents a possible link between media and learning. Given this premise, an analysis of media's effectiveness should examine the relationship between the presentation of material and the learning achieved. From this perspective, it may be proposed that people do not learn *from* media but instead learn *through* media.

Various researchers have considered the subject of media and learning. According to Hannafin and Rieber (1989), "The deliberate application of research on cognition to the design of courseware is at best unsystematic and all too frequently absent altogether" (p. 91). Park and Hannafin (1993) claimed that most computer research does not reflect the direct application of learning style theory — which emphasizes the learner rather than the medium used to present the material. Petkovich and Tennyson (1984) suggested that educational psychologists and those interested in the learning effectiveness of computerized instruction should find the necessary conditions for learning, and use this knowledge to generate instructional methods. Media attributes, they contended, should be examined using an information-processing approach. Approaches such as Salomon's (1979) symbol-processing theory and Paivio's (1986) dual-coding hypothesis, can, therefore, be used to examine attributes of multimedia, such as their ability to present material in different modes (e.g., audio, video) or from different perspectives.

Cognitive approaches emphasize the learner's activity in processing and structuring information (Kail & Bisanz, 1992), rather than emphasizing content or presentation. Therefore, the cognitive perspective of information and symbol processing can be used to assess the potential of computerized multimedia programs to enhance the delivery of educational programs.

Much current emphasis in the study of cognitive development takes an information-processing perspective, which has led to a diverse "family" of theories (Kail & Bisanz, 1992). Information-processing theorists seek to explain relations between observable stimuli (input) and observable responses (output) by describing mechanisms enabling intervening activities. Complete models incorporate specific mechanisms for all cognitive activities. Models that incorporate learning and development have the additional components of description of how information processing changes over time, and identification of characteristics of the system and its environment that could either enable or constrain change.

Theory about single-channel processing suggests that audio and visual perceptions enter working memory from the perceptual system in a linear, orderly fashion (Salomon, 1979). The perceptions are encoded separately and are possibly later associated in long-term memory. This proposed system differs from the common-code theory (Kail & Bisanz, 1992), which suggests that all memory is stored and entered in one format. Some controversy surrounds the question of which modality enters the channel first — verbal (Halpern & Lantz, 1974) or visual (Lang, 1995). Minimal capacity is necessary to process information in this model (Lang, 1995).

Alternatively, Paivio's (1986) dual-coding theory contended that verbal and non-verbal information are functionally *independent* but interconnected systems. He suggested that the non-verbal system specializes in encoding, organizing, transforming, and retrieving special spatial knowledge about concrete objects and events. The verbal system is described as being composed of discrete linguistic units that process sequential information. In other words, verbal information is interpreted in small packets that are processed as they are perceived. These two systems interact to intensify the information stored in "working memory."

The implication in Paivio's work (1986) that instruction with more than one modality — for example, providing both verbal (textual) and visual cues — will probably benefit the learner has clear applications to multimedia instruction. A body of research supports the contention that student learning is affected positively by presenting text and illustrations together (Mayer & Sims, 1994). Furthermore, other studies of the utilization of animation and text (Rieber, 1990, 1991) have contended that visually-based information significantly improves learning by children and adults and have suggested that the dual-coding hypothesis may explain these findings.

These considerations make it necessary to explore whether study participants, when presented with media different in form but with similar content, will differ in their post-presentation content knowledge. In the study we report on here, we attempted to discern whether learners interpret information in significantly different ways when identical content is presented to them using different input methodologies. We were also interested in finding out whether learners differ in the time it takes them to process identical information from different media presentations. More specifically, we examined whether adding video, audio, or static visual information altered the achievement or efficiency of learning in the context of computer-assisted instruction.

## METHOD

### *Content and Treatment Groups*

One of Clark's (1983) criticisms of past research on learning and media was that researchers lacked confound control. He suggested that further research maintain consistent content, amount of content per screen, and method of presentation. He also suggested that "novelty effect" might significantly influence learning with computers. We attempted to minimize the effects of these possible confounds.

To this end, we devised a series of programs in Visual Basic 4.0. We digitized segments of a *National Geographic* videotape entitled "Fusion: A Work in Progress" (1982), and from this movie footage created a digital video format, an audio format with static visual clips taken from the video clips, and a static visual format without moving pictures or audio. To ensure that the content presented using the different media types was equivalent, all presentations included an on-screen textual transcript of the content material provided.

### *Sample*

Forty-five volunteer undergraduate education students were randomly assigned to one of three treatment groups of 15 participants. To reduce novelty effects and confounds surrounding computer unfamiliarity, participants were recruited from classes of students who had had at least one year's experience with computers and who were accustomed to basic computer use. Each participant was screened to ensure he or she was unfamiliar with basic concepts of nuclear physics, the content of the presentation.

## PROCEDURE

In our study, each of the three treatment groups took part in three major activities — a familiarization activity, a learning activity, and an evaluation activity. The familiarization activity introduced participants to the computer controls and learning environment. Each participant was shown an example of the three treatment activities as described below before being assigned to one of the three treatment groups for the learning activity.

In each treatment group, participants were given a series of 14 pages of content extracted from a digitized movie on nuclear physics — specifically, on the constructs of fusion and fission reactions. As previously mentioned, the content in each presentation was intended to be equivalent, but the medium used to present the information differed in each treatment group.

The first group was given digital video clips, including an audio component, from the movie that corresponded with the prescribed text. The second group was presented with video still photographs from the movie as well as the audio clip corresponding to the text. The third group was presented with only the still photographs from the video (no audio component was provided). All groups were given identical transcripts of the text.

Participants were then asked to complete an achievement test consisting of 20 multiple-choice questions. The program automatically recorded the test results, the amount of time taken to view the presentation, and the amount of time taken to complete the evaluation. Only the time taken to view the presentation was used in subsequent analyses. Cronbach's Alpha was estimated at 0.70, indicating acceptable reliability of the measurement instrument.

After they had completed the achievement test, participants were asked to comment on how the effectiveness and aesthetic qualities of the media presentation they had seen compared to other forms of content presentation they had viewed in the familiarization activity.

## RESULTS

A one-way analysis of variance was completed to test for group differences. Although participants did not differ significantly in the time they took to complete the evaluation (video mean = 8.62 minutes; audio mean, 8.67 minutes; static visual mean, 8.77 minutes; $F_{(2,42)} = 0.71$, $p < .05$), they did differ significantly in the time they took to view the presentation (video mean, 17.52 minutes; audio mean, 20.01 minutes; static visual mean, 16.55 minutes; $F_{(2,42)} = 3.60$, $p < .04$). Post-hoc Scheffé analysis revealed that the audio group's mean was significantly different from that of the static group at $p < .05$ and that the audio group took significantly longer to view the presentation than did the video group. This may suggest that the audio group replayed some of the clips, or read or reread the text after the audio clip had finished playing; we confirmed this by observing participants as they viewed the audio presentation. Correlational analysis and subsequent $t$ tests, however, indicated no significant relationship between the time spent viewing the presentation and the achievement scores ($p < .05$). That the achievement test results for participants in all groups were similar suggests that the three methods of presentation were equally effective for learning. However, the significant differences the three groups' time to complete the program indicated differences in the efficiency of learning.

## DISCUSSION

Mean time differences reported between the audio and video groups may be attributed to bisensory "redundancy" and "conflict." In other words, in the video presentation, the visual cues facilitated the auditory cues, with video motion intended to complement the narrator's speech. The presentations were designed to show participants the natural link between the rate of speed of the audio presentation and the video clips. In our interviews with participants after the presentations, the audio treatment group reported that the sound was presented at a rate different from members' personal reading rate, which perhaps interfered with their reading. The audio group also reported that these conflicting inputs (reading and audio clips at different speeds) forced them to read the text over after the audio presentation to understand the content. This interference likely explains the longer presentation times for the audio group as compared to the other groups. It may be considered evidence of what Halpern and Lantz (1974) defined as bisensory interference.

The video group and the static visual group completed the task in similar amounts of time. Because the static visual group was not constrained by the time limits specified by the audio or movie clips, we had expected that members of this group would complete the presentation more quickly than members of the other two groups. The presentation time of the static visual treatment was limited only by the participant's reading speed and the amount of time needed to become familiar with the content. It was expected that the time for this group would be significantly lower than that for either the video group or the audio group, but only the difference between the audio and static groups was significant. No significant differences were found between the video group and either of the other two groups.

We expected that the video group would view the video clip and then spend some time reading the associated text. Although we did not systematically observe group members, our analysis of time differences suggests that this did not occur and that participants in the video group may have chosen not to review the material after seeing the media clips. Perhaps they did not feel a need to read the actual text, after being presented with both audio and visual representations of the content. This would support Paivio's (1986) and Halpern and Lantz's (1974) definitions of bisensory facilitation, which proposes that information presented simultaneously through two independent sensory channels will facilitate memory retention and learning.

To gain insight into participants' preferences of media styles, and their reactions to the program presented to them, we asked participants to assess the media presented to them from a personal pedagogical perspective. Most participants reported that the video and audio presentations were or would have been more aesthetically pleasing than the static presentation.

Many participants reported that they were "audio learners" or "visual learners." Many self-professed "audio learners" in the static group said that they would have scored higher on the achievement test if they had been given the audio clips. In addition, the self-identified "audio learners" in the video group suggested that the video was distracting and that they liked having the option of not using the media clips. On the other hand, some participants reported that the visual cues helped them to retain information. These conflicting statements suggest that media clips are useful for some learners but disruptive for others.

Also, although the students may *believe* that these specific inputs help them to retain information, this may not actually be the case, given an objective measure of achievement. What participants report as assisting in learning may only reveal their relative enjoyment of the presentation itself. However, students' enjoyment of a presentation style may lead them to pursue the learning of more information—ultimately affecting their ability to pay attention and the amount they learn.

One common criticism by participants pertained to the linear nature of digital video and digital audio. Students tended to rely on the text portions of all presentations because: (1) participants believed that the content presented in the text of the display was more reliable and more straightforward; (2) the text could be quickly re-read; (3) text could be viewed at a flexible pace. It was simple to skip over unimportant sections in a text-based system, but not during the sequential viewing of a digital clip.

When asked what media type they preferred when studying for a test, many participants reported that they preferred to view the text and the media clips separately. They relied on the text for information, but wanted the media clips to supplement and reinforce what they had learned. Some preferred to see the media clips first, as an overview or advance organizer, before confronting the "serious" content provided by the text.

Several participants expressed a preference for being able to pace their learning themselves, indicating that computer presentations may be appropriate for this purpose. Many participants reported a dislike for having a computer as the sole learning device, however. Of these, some found it difficult to retain information from a computer screen. Still others said they needed to write things down before they could process the information. Taking written notes was not permitted during testing, as we were studying memory retention through the achievement test. We acknowledge that proprioceptive feedback may have aided learning for some participants. Nonetheless, the study design excluded this variable as it would have introduced additional complexity.

## CONCLUSION

Our study examined the relative effectiveness of three different forms of computer presentations. From the recommendations of Clark (1983) and others, content, invigilator, and instructional method were held constant—the only independent variable was intended to be the style of media presentation. Although we found no significant difference in the achievement scores of participants in different treatment groups, we did find a significant difference in the time it took participants to complete the presentations. This suggests that the media presentations did not significantly differ in their content but did differ in their efficiency of presentation.

From a practical perspective, instructors should be cautious when using computerized media. Although Kulik and Kulik's (1987) meta-analysis suggested that computer applications benefit instruction, instructors should be aware that media designs may not all be equally efficient. Our study supports what Clark (1983) and others have argued, that without rigorous empirical justification computer-mediated instruction should not be considered a pedagogical panacea.

Teachers and computer instructional designers must focus on matching educational strategies with the content to be delivered, as well as with characteristics of the learner and objectives of the lesson. Our study suggests that relative effectiveness of comparable media should also contribute to the choice of instructional design. The "unspoken assumption that technology is an unmitigated good — that its many benefits simply must outweigh any possible negative effects" (Dwyer, 1996, p. 40) should be approached with caution. Consideration should be given not only to *whether* to use multimedia in a given lesson, but also to the *specific type* of multimedia that should be used. Although our study found no significant differences in achievement for the different types of presentations, the differences in the time presentation required may be crucial in today's tightly controlled lesson-planning environment.

Further research should examine how we can develop computerized media that maximize learner benefits while minimizing distraction or interference effects caused by an over-abundance of multimedia. The "glitz" of a presentation that uses a variety of visually impressive multimedia stimuli will be worthwhile only this presentation provides the most efficient and effective way for the student to achieve the learning objective. This should serve as a caution against the kind of technological one-upmanship that may result from several program designers' attempting to create the "best" multimedia presentation without due consideration for the needs of the learner or for the particular content at hand.

Many educational situations will nonetheless arise in which complex multimedia presentations will offer the optimum learning climate. Emerging educational fields such as distance education provide new opportunities for the application of multimedia education. As educators search for ways to deliver traditional content in non-traditional locations, and to non-traditional students, as well as attempt to do "more with less" in conventional areas of education, multimedia presentations delivered by computer offer flexibility necessary in the changing world of pedagogy. Serious consideration should always be given, however, to the individualized nature of education, and decisions about implementing multimedia should be based on research, not just intuition.

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