CHAPTER 18

WHAT IS NEXT IN THE MEDIA AND METHODS DEBATE?

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The debate about the learning benefits of media has extended over eighty years. While the arguments have evolved, the debate is still very much alive. An increasing number of universities with instructional technology degree programs are using the debate as a teaching tool. A number of faculty ask students to familiarize themselves with debate positions to better understand the process of using research to make design and development decisions (see examples in the web site addresses described in the Preface to this book). In some cases, the debate has become a question on "end of program" university examinations. In addition, the recently renewed enthusiasm for distance education has led yet another group of technology advocates to seek media comparison evidence. Thus, the goal of this final chapter is to bring the argument up to date as this book goes to press.

THREE NEW DEVELOPMENTS

After discussing contemporary views with many of the key contributors to the debate, it is my view that a number of key positions have evolved significantly in the last few years. This chapter identifies at least three important trends: First, Bob Kozma, the most active debater, now agrees that there is no past evidence for a causal connection between media (or media attributes) and learning. Yet he holds out hope that new and less restrictive research methods will find evidence for the benefit of more complex inter-

actions between media and learners. The second change is a product of recent developments in cognitive instructional psychology. We now understand much more about the way that different modes of information are processed in "working memory." Some researchers believe that these new insights will help designers format a number of the display components of the visual and aural information in multimedia instruction. This chapter will briefly describe the research of John Sweller from Australia and Richard Mayer from U.C. Santa Barbara concerning these developments. Third, Tom Cobb at the Université du Québec à Montréal Canada has suggested an approach called "cognitive efficiencies" that might offer new insights about the benefits of instructional media and media attributes. Cobb's approach is very compatible with the new information about working memory and provides a new set of hypotheses for research.

KOZMA'S CURRENT POSITION

Kozma (1994b) in an article for the *School Library Media Quarterly*, suggests that "Perhaps it is time to go beyond our concern with 'proving' that media 'cause' learning so that we can begin to explore the question in more complex ways … we should ask … in what ways can we use the capabilities of media to influence learning for particular students, tasks and situations?". His view is that research designs drawn from behavioral psychology have forced the question into unnaturally simplified forms that strangle the complex, multifaceted processes that characterize instructional interactions with new electronic media. He argues that our current research designs do not permit any evidence for unique learning benefits from media. Yet he believes in the potential of new media to enhance learning if it is used correctly by instructional designers. Kozma (1994b) suggests four approaches to questions about media and learning: (1) ground all theories of learning in the cognitive and social processes that support knowledge construction; (2) Define media in ways that are "compatible" with knowledge construction processes; (3) conduct research on the ways that characteristics of media interact with and influence construction processes; and (4) design instruction in ways that embed the use of media in knowledge construction processes. He goes on to describe a number of "possible" or "suggestive" uses of various kinds of media. For example,

> …the processing capabilities of computers can influence the mental representations and cognitive processes of learners. Their transformation capabilities can connect symbolic expressions (such as graphs) to the actual world. Their proceduralizing capabilities can allow students to manipulate dynamic, symbolic representations of abstract, formal constructs that are frequently

missing from their mental models in order to construct more accurate and complete mental representations of complex phenomena.

CLARK'S CURRENT POSITION

Kozma's recent recommendations for research on media and learning are nearly identical to the view that Gabi Salomon and I made at the end of our Third Handbook of Research on Teaching article (see the last part of Chapter 3 in this book) fifteen years ago. Salomon and I agreed with Kozma that there is no evidence for a causal connection between media and learning.

Where we continue to disagree is about the future benefit to be derived from asking about whether media or media attributes are "causal" in learning and about the future benefits of conducting what he terms "qualitative, cognitive and social case studies and other innovative methodologies … (rather than) traditional experimental studies" (personal communication, June 2, 2001). I share Kozma's enthusiasm about qualitative data and case study methods. Yet the data that result from these approaches are primarily useful for hypothesis construction or evaluation and do not permit conclusions about, or generalizations to, future instructional events. One distressing feature of current thinking about research design is that when a traditional design does not provide evidence for a set of variables we "know" to be powerful, we throw out the design and offer the speculative hope of results with a different set of designs. When scientific methods applied to instructional media questions does not provide the evidence we expect for the benefits of media, some reject scientific method. In general, there is a disturbing recent trend in media research to "kill the messenger" when we do not like the message. Yet it is possible that Kozma's future hopes for limited but important effects of media attributes might find support in future research.

Kozma (1994b) recommends embedding the study of media attributes in research and theory about cognitive knowledge construction processes. I agree totally and suggested a similar approach in my work with Gavriel Salomon (Chapter 3). In fact, it was not until the cognitive, multifaceted research recommended by Kozma was designed and conducted in the 1970s and 1980s that I made the clear statement that media and attributes of media do not have unique effects on learning. Gavriel Salomon agreed with me. Salomon was responsible for many of those early cognitive studies. While the research designs Kozma suggests for the future have been conducted for many years in the past, compelling results are not yet forthcoming. Kozma (1994b) acknowledges that no clear evidence exists for the

benefit of the methodology he recommends. Yet it is possible that we might find limited benefits in the future.

Kozma may be suggesting something very similar to the argument that Gary Morrison advances in Chapter 17. Morrison recommends media comparisons for the "equivalent" evaluation of different delivery platforms for instruction. I understand Morrison's suggestion to be something like the following: Different mixes of media provide different types or "affordances" for presenting similar instructional methods. Morrison discusses this strategy in reference to the evaluation of distance education courses and a comparison with the design and impact of "live" on-campus versions of the same course. He suggests the following example of how equivalent evaluation can identify beneficial instructional methods in different settings and media:

> Classroom discussions are synchronous and are typically limited to class time. A course offered online is not bound by the same classroom-meeting time frame of the more traditional class. A graduate level seminar course might only meet one evening a week and have a different topic of discussion each week. In contrast, the same seminar offered online would require different discussion strategies. A research study might ask how student discussions differ between a classroom and an online course. By using a media replication strategy, the method used in the classroom course might follow a more traditional format of the instructor asking a question to start the discussion and then facilitating the student interactions. Although it is possible to hold a synchronous online chat for three or four hours, there is a fatigue factor to consider as well as interest due to constraints of the technology (although, it is harder to create a verbose reply!). The method used in the online course might be an asynchronous discussion using either a mailing list or discussion forum for posting responses. An analysis of the two discussions might reveal that the online discussion lasts a full seven days as opposed to a single evening, the online posts are given more thought, and the online students are more likely to seek additional references to support their arguments (Weiss & Morrison, 1998). If students in both treatments achieve the objectives, then the two strategies are considered equivalent. If the online discussion was found to be significantly or qualitatively better, then future research might investigate its use in both an online and classroom course. Research questions might ask if it is the asynchronous time frame, having access to additional reading materials while posting comments, or the lack of face-to-face contact of the online discussion that influences the discussion. (Morrison, this volume, Chapter 17, pp. 323–324)

Yet Kozma's point seems to go beyond equivalency of results. I suspect that he believes evidence will be forthcoming that for some learners (perhaps only one or two people) a very specific and possibly complex set of media attributes, perhaps including features such as the immediacy of interac-

tion, *will be* important for the achievement of learning objectives on some learning tasks at some point. He wants to find methodologies that will identify these suspected benefits for individuals under specific task and prior knowledge conditions.

One of the conditions where cognitive benefits might be available is suggested by new research on processes that underlie working memory function during learning from instruction.

RECENT EVIDENCE ABOUT VISUAL AND AUDITORY BUFFERS IN WORKING MEMORY

Recently, Mousavi, Lowe, and Sweller (1995) and Mayer (1997) have claimed that presenting novel and difficult science concepts to learners in both auditory and visual symbolic modes results in more learning than information presented in either mode alone—provided that the two modes of information are integrated with each other in time and space. This is the current incarnation of the dated "dual processing theory" (Paivio, 1986). Mousavi et al. (1995) and Mayer's (1997) explanation for their findings is that working memory is connected to both auditory and visual "buffers" that specialize in storing different symbolic representations of information to be learned in each of the two modes. Conscious consideration of information to be learned or used in problem solving is very brief (approximately 3–9 seconds) unless the learner is able to repeat or elaborate. Failure to hold information in short term memory requires that the learner use perceptual and motivational resources to again review information that has been forgotten. Presumably, working memory can independently access identical information content in two different modalities (visual and auditory) from each of the two buffers and therefore increase the duration and quality of information available to learners during cognitive processing (see a discussion of these sensory memory buffers in Bruning et al., 1999, Chapter 2). Thus, providing information to be learned in two integrated modes (pictorial depiction accompanied by auditory narrative) might extend the representational duration of key science concepts during learning for some learners for a vital few seconds.

It is critical to note that Mayer (1997) limits this "learning efficiency" impact of both visual and aural modes of instruction to a very small group of learners. The increased efficiency was primarily useful for students who had a very low prior knowledge and very high visual ability and it primarily influenced recall of information. One might wonder what percentage of students received a significantly enhanced efficiency from both visual and aural forms of instruction? Yet, this area deserves more attention from media researchers since it fits nicely with the current interest in "multime-

dia instruction." It may also be an example of a unique sensory mode effect on retention during learning described by Kozma (1998).

Split Attention and Redundancy Problems

A related line of research conducted by Sweller (1999) and his colleagues offers cautionary information on the misuse of the sensory mode evidence in multimedia format and design strategies (see Chapter 15). Sweller (1999) describes two types of instructional conditions that often cause students to exceed the limitations on their working memory and so cause learning problems. The split-attention effect "occurs when learners are faced with multiple sources of information (about the same topic) that must be integrated before they can be understood" (p. 22). This effect often occurs when graphic displays and their verbal or aural "explanation" are separated from each other in space and/or time and when neither source of information can "stand alone" and so both sources must be considered together in order for effective learning to occur. The mental effort required to integrate graphic and text components of a display often overload working memory and cause learning difficulties for many learners.

A related phenomenon called the "redundancy effect" occurs when both textual and graphic material on some topic are redundant. Sweller (1999) presents evidence that when students attempt to master the redundant graphic and text information the effort results in an unnecessary and sometimes negative effect on the cognitive load in working memory. Presumably, students invest unnecessary mental effort to integrate redundant messages. It may also be the case that when integration of the redundant messages fails (as it must because no integration is possible) students' perception of failure enhances the violation of the efficacy threshold. The split-attention effect can be eliminated if graphic and verbal information on a topic are fully integrated. The redundancy effect can be eliminated if instructional displays provide only one form of information about a topic (or two fully integrated forms). It would be interesting to investigate the nature of the working memory failures caused by overloading working memory with the split-attention or redundancy effect. Cognitive motivation theory would suggest that overloaded learners in these two conditions would default to focusing on different or novel learning goals (or non learning goals).

Another promising area to examine for evidence of media and media attribute effects on learning is to ask about their capacity to speed learning or make it less effortful or expensive. A recent development in this area which may have solid promise for future research is a recent suggestion to conduct studies on "cognitive efficiencies"

RESEARCH ON COGNITIVE EFFICIENCIES FROM MEDIA

Tom Cobb, a second language learning researcher in Canada has published a criticism of the "media does not cause learning" argument (Cobb, 1997). Cobb makes a very interesting proposal to study the "efficiencies" in learning due to different mixes of media, symbolic modes and media attributes. He suggests that some media and symbolic modes lead to quicker and/or less demanding learning and performance outcomes than other media or symbolic modes for some people and some learning tasks. This prediction sounds very much like Kozma's expectations.

One way to think about Cobb's idea is to generate a question with at least two, interactive independent variables: the media or representational mode used for presenting an instructional method (for instance, an example presented in pictorial or verbal modes or both), and the individual or group differences that would predispose learners to process the method easier and/or faster during learning (for instance, high visual but low verbal ability learners will likely learn faster from pictures than from narrative descriptions of examples). The cost of learning to the student and the instructional provider is, after all, one of the most important issues for those concerned with the delivery of instruction to large numbers of students.

Translating Cobb's suggestion leads to a possible generic hypothesis to guide new research questions in this new area: *Whenever any instructional method is necessary for learning to occur, different media or symbolic modes will have different learning efficiencies for different learners.* Let's consider some examples of this hypothesis and then explore ideas from various research traditions that might advance research on cognitive efficiencies.

The Value of Cognitive Efficiency Studies

To some extent, many of our past research on learning might have unexplored efficiency components. Very few researchers measure the time it takes their subjects to finish learning tasks. Most learning tasks are time limited so that individual differences in learning ability or motivation influence outcome variance. Very few studies report subjects' view of task difficulty and the amount of "mental effort" they perceived was necessary to succeed at various instructional treatments. The small subset of studies that collect information about "time to learn" or "instructional time" (e.g., Benjamin & Bjork, 2000; Reynolds & Walberg, 1991; Thiede & Dunlosky, 1999) and "perceived mental effort to learn" (e.g., Gimino, 2000; Paas, Van Merriënboer, & Adam, 1994; Salomon, 1984) could be plumbed for cognitive efficiency insights. Whenever treatments using similar instructional methods were presented in different symbolic modes or media produce

significantly different time and/or effort consequences, we'll find an example of an important cognitive efficiency.

This limitation will give an advantage to learners who more easily process information in the mode and format in which it is presented. If we allowed much more time, is it possible that those who initially failed to learn would catch up? This is one of the key issues debated in the research on the role of intelligence in learning (e.g., Ohlsson, 1998).

Examples of Cognitive Efficiency Questions

Cobb (1997) illustrates research in cognitive efficiencies by inventing a situation where we want to teach someone to recognize the song of a specific species of bird. He describes different media/modes of presenting bird songs to learners including audio recordings and musical notation. He asks "How many hours are needed to learn a bird song with a recording vs. with sheet music?" (p. 26). This approach is entirely consistent with my argument. Some isomorphic representation (example or simulation) of a bird song is a necessary method for recognizing a novel bird song. This method can be translated into a variety of sensory and symbolic modes. Cobb suggests that we show learners the musical notation for the song or play an audio recording of the song. If enough time is allowed for learners and if their motivation is adequate to support their persistence in difficult treatments such as the musical notation of the bird song, then all treatments should eventually produce learning. Yet few media specialists would consider teaching bird songs with musical notation to a majority of learners with adequate hearing and auditory discrimination ability. Is it possible however, that the two modes have different efficiency characteristics for different learners? While the example requires a stretch of the imagination, consider learners who have musical training and auditory discrimination problems. It seems plausible to assume that this small subset of learners might be able to recognize bird songs more efficiently with musical notation than with audio recordings.

Anderson's Economic Theory of Cognition

John Anderson's (1990, 1991) rational theory of cognition is another fertile area for understanding the cognitive efficiencies available from various symbolic modes or media. Anderson has presented compelling evidence that cognitive learning follows Bayesian Statistical formulations of the relationship between the perceived "cost" of mental effort and expected learning "gain." Like most of John Anderson's research, this the-

ory requires considerable effort to understand. His theory of expertise development (Anderson, 1993) was not well understood until it was explained by Ellen Gagne (Gagne et al., 1993). Yet the benefit of his theory for media researchers may be worth the cost of learning and extending it to media and symbolic modes. For example, Anderson presents compelling evidence that when learning concepts, our normative beliefs about the most efficient ways to identify the defining features of concepts control our scanning and selection of features in instructional displays. He suggests that these efficiency beliefs will control both the types of displays we will favor and the rules that we use to determine which of the many features of presented examples and non examples we will use to determine the central tendency of concept definitions. He also provides examples and explanatory economic formulas for the learning of principles and the solving of problems. These three types of knowledge content and tasks (concepts, principles and problem solving) are very similar to the knowledge types used in current instructional design and media production theories.

Five Conditions Needed to Investigate Cognitive Efficiencies

Research on cognitive efficiencies is a compelling opportunity. It seems possible that various features of old and new media may permit some people to learn quicker or with less mental effort. How might we go about investigating this possibility?

First, researchers need a way to conceptualize and measure the cognitive demand of instruction and learning task. The best approach has been described by John Sweller and his colleagues (Paas et al., 1994). Our measurement of mental effort must be consistent with the constructs found in the theories we are testing. We must challenge ourselves to go beyond the self-report of mental effort used in most motivation studies. Our operational definitions of effort must include direct and unobtrusive indicators as well as self report protocols. A recent study of the most promising methods of measuring mental effort during instruction was conducted by Gimino (2000).

Second, we need a commitment to the measurement of the amount of time it takes similar learners to achieve a specific learning criterion in instructional studies. These time measurements must be based on a careful analysis of the context where the learning is occurring and where it will be transferred when it is used (see, Benjamin & Bjork, 2000; Reynolds & Walberg, 1991; Thiede & Dunlosky, 1999 for examples).

Third, we must find temporary solutions to disputes about the measurement of "cognitive processes" during learning (Ohlsson, 1998). As in the

case of mental effort, our measurement of cognitive processes is now largely determined by self report which has been found to be inaccurate for more complex learning tasks (Gimino, 2000). We need more creative and more objective ways to observe and measure cognitive processing.

Fourth, we need cost-benefit and cost-effectiveness protocols that are conservative and are connected to research in other areas of learning and performance. I've been impressed with the careful work and excellent insights of Henry Levin from Stanford on the cost effectiveness of computer-based instruction (Levin, Glass, & Meister, 1987). His "replacement method" of determining costs is a very conservative estimate of the economic gains from using technology in a school setting. A recent article by Lombard et al. (1998) is a good place to start for those interested in the larger social costs and benefits of technology. While Lombard et al.'s approach is focused on health psychology and the economic benefit of psychological treatment, it can be adapted to our concern with cognitive efficiency in instruction.

Finally, we need a theory to guide our questions. My recommendation is that we begin with Anderson's (1990, 1991, 1993) rational theory and build on it. We all should remain open to other economically-focused theories of learning and performance. However, we should not be open to shallow, repetitive, narrow and atheoretical research in this area. Since our past research on media and learning suffered from a lack of theoretical focus, our future work on integrated visual and aural information and on cognitive efficiencies should not make the same mistakes.

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