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# *Research on Instructional Media, 1978-1988**

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## INTRODUCTION

This is the first of a series of annual reviews that will identify trends, discuss the implications of findings, and propose directions for future research in the area of instructional media. Although the reader may not find all relevant media studies discussed in this review, we will attempt to describe all important trends in the literature, focusing on research that defines *media* as technological devices employed for the purposes of instruction. However, we will also consider the relevance of emerging trends in research on instructional media for the development of a technology of instruction. We will begin by noting the paradigm shift that has occurred in research on instructional media during the past decade, from a behavioral to a more cognitive approach. We will briefly describe the argument for applying the new cognitive approach to media research and then expand on it in the body of the discussion. Next, we will introduce an extensive framework for organizing past and present research in a way that distinguishes between behavioral, cognitive, attitudinal, and economic issues relating to the use of instructional media. Finally, we will identify the most promising areas for future research.

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# PARADIGM SHIFT

In their recent review of the past decade of research on the use of media in teaching, Clark and Salomon (1986) noted that there has been a paradigm shift from behavioral to cognitive theories and corresponding research questions in instructional media research. This shift follows the transition in psychology from behavioral to cognitive theories of learning. A behavioral theory of learning focuses on environmental causes of changes in behavior without reference to the mental processes mediating such changes. In contrast, a cognitive theory of learning views learning as a constructive process, with the learner actively engaged in the process of integrating new knowledge with old. Factors that determine whether learning results from instruction are student traits such as general ability, prior knowledge, and motivation; learning task differences such as their procedural and declarative characteristics; and instructional methods that place more or less cognitive burden on learners. Within the new cognitive paradigm, learning may be defined as the degree to which previously learned knowledge and skills can be transferred to new contexts and problems.

## Instructional Media Research in the Behavioral Paradigm

Under the behavioral paradigm, research on instructional media centered on the means of instruction as independent variables and on learning outcomes in the form of knowledge or skill acquisition as dependent variables. Media comparison studies dominated the research journals. These studies emphasized comparisons of the learning impact of newer media such as television with more traditional media such as classroom instruction. Evidence from these studies usually favored newer media. Thus, during the early days of the motion picture, studies tended to favor movies over teachers. Later, similarly designed studies favored television over teachers, movies, or textbooks. Other studies, inspired by the behaviorist preoccupation with reinforcement, investigated the reinforcement value of various media. As a result of these studies, conducted largely in the quarter century between 1950 and 1975, the media movement grew and prospered. Sometime after the early 1970s, however, a change began in the media literature—a change that reflected the move to cognitivism in the psychological literature.

## Instructional Media Research in the Cognitive Paradigm

The cognitive paradigm acknowledges the interaction between external stimuli (presented by any medium) and internal, cognitive processes that support learning. Under the cognitive paradigm, cognitive processing is studied as a dependent or outcome variable, and learner characteristics are studied as independent or mediator variables. The assumption is that learners often affect the way they experience the instructional stimulus through their previously acquired beliefs, values, expectations, general ability, and prior knowledge of the subject matter. The cognitive paradigm ascribes to the learner a far more active and less externally controlled role in learning from instruction than did the behaviorist paradigm. So, with the advent of cognitive theories of learning, media comparison questions were discarded because they assumed that media alone contributed to learning. In the cognitive approach to research on instructional media, more attention is devoted to the way various media attributes (such as the imagery-evoking properties of visual presentations in memory tasks) interact with cognitive processes to influence learning. Thus, researchers began to examine how specific elements of an instructional message might activate particular cognitions for certain learners under specific task conditions. Aptitude-treatment interaction (ATI) research has been welcomed by media researchers who expect it not only to suggest which specific media attributes are most effective for whom but also to indicate the kinds of cognitions that are or may become involved in the processing of different types of symbol systems (Salomon, 1979).

Unlike previous research concerned with the comparison of different media, the next generation of researchers has investigated the way different modes of information presentation are processed by the learner and how these processing capabilities develop. The results of some of these studies appear to yield important implications for instruction. For example, Anderson and Lorch (1983) have found that children attend to televised material that is comprehensible to them, implying that comprehensibility determines attention rather than the other way around. This finding suggests that instructional production techniques should be oriented to convey comprehensible information rather than to attract attention. Newer media literacy programs are attempting to draw on this research and apply it to instructing children on how to get more selective knowledge out of mediated instruction (e.g., Dorr, Graves, & Phelps, 1980).

Generally, it appears that media do not affect learning in and of themselves. Rather, some particular qualities of media may affect particular cognitive processes that are relevant for students with specific aptitude levels to learn particular knowledge or skills. However, these cognitive effects are not necessarily unique to any particular medium or attribute of a medium. Later in this review, we will describe evidence supporting the claim that the same cognitive effect may be obtained by many media and media attributes. This suggests that media are functionally equivalent. This fact, discussed in detail in the next section, has led a number of researchers to claim that media do not influence learning but that they do greatly influence the cost (time, expense) of learning.

The change in the basic paradigm for instructional media research is not from an instructionally centered (situational) approach to a learner-centered (personological) one. Rather, it is a shift from a unidirectional view to a reciprocal view. The new cognitive paradigm assumes that instructional powers do not reside solely in the media, for the way we perceive media influences what we learn from them. However, learners are not the sole power brokers, for their perceptions are founded on the kinds of information and instructional methods delivered by different media. This assumption of reciprocity is identical to the one underlying recent advances made in other related fields such as personality research (e.g., Kyllonen, Lohman, & Snow, 1984), spatial cognition (e.g., Olson & Bialystok, 1983), aptitude processes (Kyllonen, Lohman, & Snow, 1984), and person-environment interaction (Salomon, 1974b).

There have been at least two results of the shift to the reciprocal, cognitive paradigm for media research. First, researchers have been attempting to identify critical attributes of media that not only distinguish between media in meaningful ways but also affect learning relevant cognitions. This led to clearer distinctions between the means of information delivery and manipulation (e.g., radio, computers, television, books) and other components of media, notably their intrinsic modes of information presentation and the kinds of mental operations they afford. The second result of the shift in focus is the long-overdue development of theories of learning from media that could guide recommendations on the use of particular media for particular instructional objectives.

## FRAMEWORK FOR ORGANIZING RESEARCH ON INSTRUCTIONAL MEDIA

Research on instructional media can be classified according to the main independent and dependent variables studied. There are four main types of dependent variables of interest to researchers in this area: performance outcomes, cognitive processing, efficiency/costs, and equity of access to instruction. Although there are many acceptable candidates for a list of media research variables, three main types of independent variables frequently arise in the existing research: media characteristics (including type of medium, specific attributes of a medium, symbol systems available within a medium), student characteristics (including general ability, attributions, preferences, and prior knowledge), and instructional method.

Any combination of these dependent and independent variables may be investigated in a particular study.

The research of the past decade has included the following combinations, which relate to four distinct types of issues:

- Behavioral Issues: effects of type of medium on achievement
- Cognitive Issues: effects of media attributes on cognitive processing and on achievement

  effects of instructional method on cognitive processing and achievement

  interactive effects of student aptitudes and instruetional method on cognitive processing and achievement
- Attitudinal Issues: interactive effects of student attitudes/attributions/expectations and instructional method or medium on cognitive processing and achievement
- Economic Issues: effects of type of medium on cost of instruction

  effects of type of medium on time for instruction.

These four types of issues are used here as the framework for organizing the research of the past decade.

# RESEARCH RELATING TO BEHAVIORAL ISSUES

## Media Comparison Studies

Until recently, a typical study in the area of instructional media compared the relative achievement of groups who received similar subject matter from different media. With the advent of each new instructional medium, a new crop of such studies emerges, comparing the new medium with an older one. During the past decade, television research has diminished considerably, being replaced by computer-assisted learning studies, which belong to the familiar but generally fruitless media comparison approach. Each new medium seems to attract its own set of advocates who make claims for improved learning and stimulate research questions that are similar to those asked about the previously popular medium. Most of the radio research approaches suggested in the 1950s were very similar to those employed by the television movement of the 1960s (e.g., Schramm, 1977) and to the more recent reports of the computer-assisted instruction studies of the 1970s and 1980s (e.g., Clark, 1985). It seems that similar research questions have resulted in similar and ambiguous data. Media comparison studies, regardless of the media employed, tend to result in "no significant difference" conclusions. These findings have been incorrectly offered as evidence that different media are equally effective as conventional means in promoting learning. No significant difference results simply suggest that changes in the outcome scores (e.g., learning) did not result from any systematic differences in the treatments compared. In these studies, media are mere conveyances for the treatments being examined. Although media often are not the focus of study, the results are erroneously interpreted as suggesting that learning benefits had been derived from various media. So, for example, when a booklet containing a version of programmed instruction resulted in more learning than a teacher's lecture (minus the programmed instruction feature) on the same topic, the results are often

interpreted as favoring the medium of books. The active ingredient, in studies that find one medium superior to another, is usually some uncontrolled aspect of the instructional method (e.g., programmed instruction) rather than the medium. In the 1970s, skepticism about media comparison studies, still being conducted in apparently large numbers, began to grow. Levie and Dickie (1973) noted that most overall media comparison studies to date had been fruitless and suggested that most learning objectives could be attained through "instruction presented by any of a variety of different media" (p. 859). This observation was echoed by Schramm (1977), who says, "learning seems to be affected more by what is delivered than by the delivery system" (p. 273).

During the past decade, more effort has been made to analyze and refocus the results of existing comparison studies. The statistical technique called meta-analysis has proved to be a most useful approach to summarizing instructional media (and other kinds of educational) research. The current meta-analyses of media comparison studies provide evidence that any reported significant differences in performance have been due to confounding in the treatments employed in the studies. Because this claim is somewhat controversial and the use of meta-analysis is expected to increase in the next few years, the next section presents a discussion of the advantages and disadvantages of meta-analyses when applied to media comparison studies.

## Reviews and Meta-Analysis of Media Studies

A comprehensive and often-cited review by Jamison, Suppes, and Wells (1974) surveyed comparisons of traditional instruction with instruction via computers, television, and radio. Their survey used a *box score* tally of existing studies, evaluations, and reviews of research. They concluded that a small number of studies reported advantages for media and others indicated more achievement with traditional instruction, but the most typical outcome was no significant difference between the two. As they explained, "when highly stringent controls are imposed on a study, the nature of the controls tends to force the methods of presentation into such similar formats that one can only expect the "no significant differences' which are found" (p. 38).

However, there have been criticisms of the box score method of summarizing past media research (e.g., Clark & Snow, 1975). Many of these criticisms have been accommodated by newer meta-analytic methods of teasing generalizations from past research. A recent series of meta-analyses of media research was conducted by James Kulik and his colleagues at the University of Michigan (Clark, 1985, contains citations for these meta-analyses). Generally, meta-analyses allow for a more precise estimate of treatment effect sizes than was possible a few years ago. Meta-analytic procedures yield *effect size estimates* that are converted to percentage of standard deviation gains on final examination scores due to the more powerful treatment, if any. Most of the meta-analytic surveys of media research demonstrate a typical learning advantage for newer media of about one-half a standard deviation on final examination performance, compared with conventional (i.e., teacher presented) treatments. In the case of computer-based instruction studies in college environments, for example, this advantage translates as an increase from the 50th to the 66th percentile on final examinations in a variety of courses. This is an impressive accomplishment if we accept it at face value. Closer inspection of these reviews, however, reveals that most of the large effect sizes attributed to computers in these studies are actually due to poorly designed studies and confounding (Clark, 1983, 1985).

According to Clark (1983), the most common sources of confounding in media research seem to be the uncontrolled effects of (a) instructional method or content differences between treatments that are compared, and (b) a novelty effect for newer media, which tends to disappear over time. Evidence for each of these controlled effects can be found in the meta-analyses and will now be considered.

## Uncontrolled Method and Content Effects in Meta-Analytic Studies of Media

In effect size analyses, only adequately designed studies are supposed to be included in the statistical analyses. Studies chosen for the Kulik analyses represent a great variety of design features, subject matter content, learning task types, and grade levels. The most common result of box score surveys is a small and positive advantage for newer media over more conventional instructional delivery devices. However, when studies are subjected to meta-analysis, our first source of rival hypotheses, medium and method confusion due to poor research design, becomes evident. The positive effect for newer media more or less disappears when the same instructor produces all treatments (Clark, 1985). Different teams of instructional designers or different teachers probably give different content and instructional methods to the treatments that are compared. If this is the case, we do not know whether to attribute the advantage to the medium or to the differences between content and method being compared. However, if the effect for media tends to disappear when the same instructor or team designs contrasting treatments, we have reason to believe that the lack of difference is due to greater control of nonmedium variables.

Clark and Salomon (1986) cited a number of researchers in the past who have reminded us that when examining the effects of different media, only the media being compared can be different. All other aspects of the mediated treatments, including the subject matter content and method of instruction, must be identical in the two or more media being compared. In meta-analyses of college level computerized versus conventional courses, an effect size of one-half a standard deviation results when different faculty teach the compared course. Clark (1983) found that this effect reduces to about one-tenth of a standard deviation advantage when considering only studies in which one instructor plans and teaches both experimental and control courses. Presumably, this very weak but positive effect for college use of computers over conventional media is due to systematic but uncontrolled differences in content and/or method, contributed unintentionally by different teachers or designers.

The evidence in these meta-analyses pointing to **confounding** is that it is the method of instruction rather than the choice of medium that leads directly and powerfully to learning. The conclusion that media do not influence learning directly can be summed up in an analogy: In instruction, media serve a function similar to the different forms in which prescription medicines are delivered. One would not claim that a tablet or a liquid suspension of a drug altered the effects of the drug on human biological functions (except to make it more or less efficient). Nor is it important, except for efficiency purposes, whether a drug is administered by the medium of injection or by oral ingestion. It is the prescription compound that influences biology, not the medium of delivery. Here, the drug medium (tablet or liquid suspension) is analogous to the instructional medium of computer or teacher in education. It is not the computer that alters learning any more than the tablet influences biological processes in a different way than the liquid form of a drug. Both the choice of drug medium and instructional medium influence the efficiency and the cost of delivering the active ingredient. In neither case is the essential biology or psychology of the target systems influenced. The active compound in a drug is a mixture, analogous to what most of us call a combination of instructional method and information. It is the method, not the medium that influences the psychological processes that produce learning.

Since the inception of cognitive theory, methods are defined as external representations of the cognitive processes that are required for learning. Examples and analogies are instances of instructional methods as is the structure imposed on information that is presented during instruction. An example provides external support for one variety of a cognitive process that has been called *connecting*. Examples encourage us to connect new information with relevant prior experience. Analogies support a different type of cognitive connecting process. The analogy allows us to connect a current problem with the solution to that problem, which, while it is in our experience, we do not notice as relevant. When we first encountered mathematics, many of us profited from the analogy that adding and subtracting

fractions was similar to slicing pie. Familiar teaching methods such as giving examples and analogies may be delivered by any of a variety of media with the same learning effects.

## Uncontrolled Novelty Effects with Newer Media

A second, though probably less important, source of confounding in media comparison studies is the increased effort and attention research subjects tend to give to media that are novel to them. The students' increased attention sometimes results in an increased effort or persistence, which yields achievement gains. If attentiveness is due to a novelty effect, these gains tend to diminish as students become more familiar with the new medium. This was the case in reviews of computer-assisted instruction at the secondary school level (grades 6 to 12). An average computer effect size of three-tenths of a standard deviation (i.e., a rise in examination scores from the 50th to the 63rd percentile) for computer courses tended to dissipate significantly in longer duration studies. In studies lasting four weeks or less, computer effects were one-half a standard deviation. This reduced to three-tenths of a standard deviation in studies lasting five to eight weeks and further reduced to the familiar and weak two-tenths of a standard deviation computer effect after eight weeks of data collection. Effects of two-tenths or less account for less than 1 percent of the variance in a comparison.

The Kuliks report a similar phenomenon in their review of visual-based instruction (e.g., film, television, pictures). Although the reduction in effect size for longer duration studies approached significance (about .065 alpha), there were a number of comparisons of methods mixed with different visual media, which makes interpretation difficult (cf. Clark & Salomon, 1986). In their review of computer use in college, the Kuliks did not find any evidence for this novelty effect. In their comparison of studies of one or two hours duration with those which held weekly sessions for an entire semester, the effect sizes were roughly the same. Is it possible that computers are less novel experiences for college subjects than for secondary school students?

## Conclusions and Applications of Media Comparison Research

General media comparisons and studies investigating the relative learning effectiveness of different media have yielded little that warrants optimism. Even in the few cases where dramatic changes in achievement or ability were found to result from the introduction of a new medium such as television or computers, it was not the medium per se that caused the change but rather the curricular reform that accompanied the new medium. This in itself is an important observation. A new medium often seems to encourage the support of expensive instructional design, curriculum changes, and/or organizational changes in the educational establishment. This pattern seems to recur throughout history with the advent of each new medium. Such a pattern can be useful for reformers who wish to attract support for efforts to improve instruction, revise curriculum, and/or reshape ossified organizational structures: Wait for a new medium and then attach reform proposals to requests that the new medium be adopted.

However, media researchers are cautioned against arguing for newer media and accompanying reforms by promising (even implicitly) that the new medium can be expected to produce learning advantages. If government or education officials have historically been willing to support expensive instructional development and curriculum reform only when a new medium is adopted, we should be willing to encourage such reforms when needed. However, the research clearly indicates that any learning gain associated with a new medium cannot be said to be caused by the choice of medium.

# RESEARCH RELATING TO COGNITIVE ISSUES

Cognizant of the limitations of media comparison studies, researchers turned their attention to other types of questions. These newer approaches focused on a study of the attributes of media and their influence on the way that information is processed in learning. In this approach, many media were thought to possess attributes such as the capacity to slow the motion of objects or *zoom* into details of a stimulus field or to *unwrap* a three-dimensional object into its two-dimensional form. These attributes were thought to cultivate cognitive skills when modeled by learners, so that, for example, a child with low cue-attending ability might learn the cognitive skill of zooming into stimulus details (Salomon, 1974a), or novice chess players might increase their skills in recognizing potential moves and configurations of chess pieces through animated modeling of moves and patterns. Because this type of question dealt with the way that information is selected and transformed in the acquisition of generalizable cognitive skills, many believed that the possibility of a coherent theory dealing with media attributes was forthcoming. In addition, it was exciting to imagine that these media attributes might result in unique cognitive skills because they promised to teach mental transformations that had not heretofore been experienced.

The promise of the media attributes approach is based on at least three expectations: (a) that the attributes are an integral part of media and would provide a connection between instructional uses of media and learning; (b) that attributes would provide for the cultivation of cognitive skills for learners who needed them; and (c) that identified attributes would provide unique independent variables for instructional theories that specified causal relationships between attribute modeling and learning. The final point (c) is most important because it represents a renewed search for evidence of a connection between media (or media attributes in this instance) and learning. The discussion of media attributes that follows is an attempt to explore the evidence for each of the three expectations listed above.

## Are Media Attributes the Psychologically Relevant Aspects of Media?

The first expectation was that media attributes would somehow represent the psychologically relevant aspects of media. However, few of the originators of the media attribute construct (Salomon, 1974b) claimed that they were more than correlated with different media, that is, that any one media attribute was available from more than one (and often many) media. Because they are not exclusive to any specific media and were only associated with them by habit or convenience, media attributes are not media variables any more certainly than the specific subject matter content, format, organization, or layout of a book is part of the definition of a book. In fact, the early discussions of media attributes most often referred to symbol systems or symbolic elements of instruction. All instructional messages were coded in some symbolic representational system, the argument went, and symbols vary in the cognitive transformation they allow us to perform on the information we select from our environment. Some symbolic elements (animated arrows, zooming) permit us to cultivate cognitive skills. However, many different media can present a given attribute so there is no necessary correspondence between attributes and media. Media are mere vehicles for attributes so the term media attributes is misleading.

## Do Media Attributes Cultivate Cognitive Skills?

The second expectation of the attribute approach was that attributes would provide for the cultivation of cognitive skills for learners who needed them. Salomon (1979) and more recently Greenfield (1984) have reviewed research where symbolic features of mediated experiences and instruction were shown to affect differentially the skills activated in the service of knowledge acquisition and the mastery of these skills. Such research was inspired, in part, by Jerome Bruner's (1964) argument that internal representations and operations partly depend on learning "precisely the techniques that serve to amplify our acts, perceptions and our ratiocinative activities" (p. 2). Such a view implies that unique coding or structural elements of the media (e.g., filmic causal sequences) or uniquely afforded activities (e.g., computer programming) may have unique effects on related mental skills. Thus, employing a coding element such as a close-up, or the allowing for students' manipulation of input data may activate specific mental operations that facilitate the acquisition of knowledge as well as improved mastery. In one study by Salomon (1974a), students who had difficulty attending to cues in a visual field learned the skill by seeing it modeled in a film where they saw a camera "zoom" from a wide field to close-up shots of many different details. An analysis of the task suggested that effective cue attending required an attention-directing strategy that began with a view of the entire stimulus and then narrowed the stimulus field until a single, identifiable cue remained. For those students with low cue-attending skill (the requisite cognitive skill to perform the task), Salomon (1974b) reasoned that the required instructional method would be modeling. In this case, the construction of the model followed an analysis of the symbol systems, which allowed this particular method to be coded for delivery to the students. Although the zooming treatment used was available in many media (e.g., film, television, videodisc), the students seemed to model the zooming and used it as a cognitive skill that allowed them to attend to cues.

However, in a partial replication of this study, Bovy (1983) found that a treatment that used an *irising* attribute to provide practice in cue-attending was as effective as Salomon's zooming in cultivating the skill during practice. Irising consisted of slowly enclosing cues in a circular, gradually enlarging, darkened border similar to the effect created by an iris which regulates the amount of light permitted through a camera lens. More important, however, was Bovy's finding that a treatment that merely isolated cues with a static close-up of successive details singled out by the zooming and irising was even more effective in cultivating cue-attending skill than either zooming or irising. It may be that only the efficient isolation of relevant cues is necessary for this task.

In a similar study, Blake (cf. Clark, 1983) taught chess moves to high or low visual ability undergraduates through a standard narration and (a) still pictures, (b) animated arrows with the pictures, or (c) a motion film from which the still pictures were taken. While all three conditions worked for the higher ability students, low visualizers learned the chess moves equally well from the arrow and the motion treatments, which were significantly better for them than the static pictures. Here, as in the Salomon (1974a) study, we presume that the modeled chess moves compensated for the low-ability student's lack of spatial visualization. Unlike Salomon's, Blake's subject profited from two different operational definitions of the necessary model, animated arrows and moving chess pieces. Different stimulus arrangements resulted in similar performances but, as we might expect, led to nominally different cognitive processes being modeled. The necessary process for learning chess moves, the visualizing of the entire move allowed each piece, could therefore be operationalized in any of various sufficient conditions for successful performance. Therefore the recommendation is to exercise caution in future research on symbolic elements of media.

The possibility of skill activation and cultivation from specific media attributes raises new conceptual and empirical questions. If media's symbolic modes of information presentation can activate, even cultivate, mental operations and skills, are these skills unique? What is their utility? How far do they transfer, if at all? These questions are of particular interest

with respect to the use of computers in instruction for many computer-afforded activities are rationalized in terms of their unique effects on transferable skills. One would need to distinguish between, say, the acquisition of a particular image or operation, on the one hand, and the cultivation of imagery ability or generalized skill, on the other. It is one thing if children learn from televiewing only how to become better televiewers or from programming in Logo how to be better Logo programmers; it is another if they show skill cultivation that transfers beyond the boundaries of that medium or activity.

Work by Scribner and Cole (1981) concerning the effects of acquiring basic literacy skills in nonschool settings serves as a warning against unwarranted optimism here. Contrary to earlier claims, they found no evidence to show that literacy acquired in nonformal education affected abstract thinking or, for that matter, any other generalizable ability. The subjects they studied were denied the opportunity to acquire and practice reading and writing in the variety of contexts that may amplify the effects of basic literacy into transferable skills regardless of the medium or symbol system used in the instruction. Varied and prolonged practice would presumably enable the literate individuals to apply the initially specific operations in a variety of complex tasks and situations, thus to allow the generalizability of these skills.

The road from possible to actual transfer is fraught with difficulties. It is certainly not a matter of one-shot, brief experiences and encounters, except in the unlikely event that considerable mental effort is expended in reaching transferable conclusions, formulating rules, or generating guiding metacognitions. In all, it appears that media's symbolic forms and computers' afforded activities may have skill-cultivating effects, but these are not necessarily unique nor easily transferable. Future research, particularly that concerned with computer-afforded learning activities, will do well to ask not just whether particular skills are acquired but also how else they could be developed, and under what instructional, contextual, and psychological conditions they can be made to transfer. The problem lies not in the fact that symbol systems can be made to cultivate skills but in whether these symbolic elements or attributes are *unique, exclusive to any particular medium, or necessary for learning*. If the attributes identified to date are useful in instruction, they are valuable. However, theory development depends on the discovery of basic or necessary processes of instruction and learning. It is to this point, the third expectation of media attribute theories, that the discussion turns next.

## Unique Media Attributes and Theories of Instruction

From our discussion so far, it seems reasonable to assume that media are best conceptualized as delivery vehicles for instruction and not as variables that directly influence learning. Although certain elements of different media, such as animated motion or zooming, might serve as sufficient conditions to facilitate the learning of students who lack the skill being modeled, symbolic elements such as zooming are not media and merely allow us to create sufficient conditions to teach particular cognitive skills. All of the attributes investigated so far are only correlated with media (each attribute is available from a number of media) and no attributes have been found to produce unique cognitive effects. In science, sufficient conditions are those events that were adequate to produce some outcome in a past instance. There is no guarantee, however, that sufficient conditions will ever produce the outcome again because the variable that caused the outcome was merely correlated with the condition. For example, a computer might be sufficient to produce the desired level of achievement in one instance but might fail in another. The determination of necessary conditions is a fruitful approach when analyzing all instructional problems, and it the foundation of all instructional theories. Once described, the necessary cognitive operation is a specification, or recipe, for an instructional method. We can employ a great variety of media and, possibly, a similar variety of symbol systems to achieve the same type of learning. However,

we cannot vary the requirement that the method somehow model the crucial cognitive process required for the successful performance of the task.

It is the identification of the critical features of necessary cognitive processes that underlies the construction of successful instructional methods and the development of instructional theory (Clark, 1983). The cognitive process features must be translated into a symbol system understandable to the learner and then delivered through a convenient medium. The cognitive feature in the chess study was the simulation of beginning and ending points of the moves of the various chess pieces. In the cue-attending studies by Salomon and Bovy, the cognitive features were probably the isolation of relevant cues. It is the external modeling of these features in any symbol system understood by the student that yields the required performance. When a chosen symbol system is shaped to represent the critical features of the task and other things are equal, learning will occur. When a medium delivers a symbol system containing this necessary arrangement of features, learning will occur also but will not be due to either the medium or the symbol system. This issue is related to the problem of external validity.

Although it is often useful instructionally to know about sufficient conditions for producing desirable levels of achievement, our theories seek necessary conditions. Without necessary conditions we run the risk of failing to replicate achievement gains when we change the context, times, or student clients for instruction. Instructional theory (Shuell, 1980) seeks generalizations concerning the necessary instructional methods required to foster cognitive processes. Instructional media attribute research to date has not led to such generalizations and does not promise to do so in the future. However, an area where there is a great deal of promise for applying past research and for new directions is in research on attitudes toward media.

# RESEARCH ON ATTITUDES TOWARD MEDIA

In recent years there has been a great deal of interest in the effects of learner values, attitudes, and beliefs toward media. This section briefly reviews that research. Before presenting a model for understanding these studies however, we caution the reader to note that, in attitude studies, the independent variable is *not* media but our beliefs or values related to media. Therefore, if there are learning or motivation benefits uncovered in these studies, they may not be attributed to media. Attitude variables are learner variables and learning gains must be attributed to individual differences or learner traits.

Attitude research has a long history. Critics of the area have noted a number of serious flaws in study design and have disputed the utility of research results for the development of instructional prescriptions. Recently, however, there has been a promising series of developments that have resulted from the growth of cognitive theories of learning. Although space does not permit a detailed account of these developments; a brief summary of them follows.

In general, researchers believe that our attitudes, beliefs, and values influence our motivation to learn. Motivation is typically measured by either our willingness to engage in a task (i.e., to choose one task over a number of things that compete for our attention) and/or to invest effort in a task we have selected to perform. Effort investments can range from very shallow (i.e., when we perform automatically, mindlessly, and without much thought) to very deep (i.e., when we give all our attention and intelligence to a task). Motivation is one of the necessary components of learning. We may have all the necessary ability for learning without the motivation to invest effort. Similarly, we may have motivation and lack ability. The difference between motivation and intelligence is analogous to the difference between gasoline and the engine of an automobile. Although the analogy fails in a number of areas, the best engine will not run on an empty tank and the highest octane gas will not cause a car to run when the engine has a mechanical problem. If learning is enhanced when values,

beliefs, or attitudes change, it is because the learner gains motivation to engage in a task or invest the required level of effort—the engine gets gas. If an increase in motivation does not increase learning, the problem may have been a lack of ability—the engine malfunctions.

Attitude research has resulted in some very confusing results. Although our expectation of a positive relationship between attitude and learning is generally borne out in the research literature, we find a number of studies where the reverse is true. There is a significant group of well-designed studies where more positive attitudes toward a medium result in less learning and other studies where negative attitudes result in more learning. Clark and Salomon (1986) reviewed a number of specific studies with these conflicting and counter-intuitive results. The outcome of an analysis of these studies suggests that the relationship between attitude (and our resulting motivation to learn) on the one hand and learning on the other is not direct or monotonic.

## A New Cognitive Theory of Motivation to Learn from Media

The most exciting new cognitive *self-efficacy* theory of motivation (Bandura, 1978; Salomon, 1981) suggests that the relationship between attitude toward media and learning is best conceptualized as an *inverted U*. This theory suggests that students invest effort on the basis of their beliefs about, or attitude toward, two factors: (1) the requirements of a task, and (2) the students' assessment of their own skills related to task requirements. Salomon calls these two factors *perceived demand characteristics* (PDC—for task requirements) and *perceived self-efficacy* (PSE—for self-assessment of required skills). Drawing on Bandura's theory, Salomon hypothesizes that as a student's perception of the difficulty of a medium increases from low to moderate, the effort he or she will invest in learning from that medium increases from very low to its maximum level. The same result occurs when a student's perception of his or her own skills increases from low to moderate. However, when a student's perception of the difficulty of a medium reaches a very high level or judgment about his or her own skills at learning from a medium is very high, the effort investment falls to very low levels. It is moderate levels of PDC and/or PSE that result in the greatest level of motivation. In addition, there may be large national and cultural differences in PDC and PSE judgments. Salomon (1984), for example, notes that North American students generally believe that television is an easy medium while books are difficult. Although there is nothing essentially more difficult about books, students will generally invest more effort in learning from them than from a televised presentation. Salomon notes that Israeli children, who have a different perception of the demands of televised instruction, do not make the same distinctions.

This new motivation theory may go some distance in explaining the often counterintuitive research findings in previous research on attitudes, values and beliefs about media such as those described by Salomon (1981, 1984) and Clark (1983). For example, studies that have shown increases in motivation (or learning) with decreases in attitude toward a specific medium are now predictable given the self-efficacy theory.

## Research on Liking or Valuing Different Media

One of the areas not adequately addressed by attitude theory is the construct of *value*. We may value a medium and prefer to learn from it simply because we like it, not because it represents an easier way to learn or because the learner perceives him or herself as more or less capable with it. There is currently very little research on values for learning from one or another medium. There is a budding interest in values, however, in current cognitive theories of learning. Researchers interested in this area might consult studies by Dweck and Bernechat (1983) for direction. Generally, we suspect that a student's values will influence his or her decision to engage in learning from a specific medium (or a learning task) but not the

amount of effort they invest (recall the distinction made earlier between engagement and effort in motivation theory). We may have ability and an attitude that would allow for effort to be spent at a medium but simply value some other medium so much more that we refuse to choose to learn from the medium employed for instruction. This may have been the case in attitude studies reported by Saracho (1982) and Machula (1978-79). These and other studies (Clark, 1983) suggest that student values for or against certain media may change radically over a brief span of time within the same instructional module. One indication of these changes is the extent to which student attention and engagement in tasks wanders on and off their tasks as they choose to think about things other than the instructional task. Indications that values change in a brief span of time suggest that the design of studies in this area contain measurement techniques that are sensitive to such changes.

## Conclusions about Research on Attitudes toward Media

Cognitive theories of motivation have brought a measure of clarity to research on attitudes, values, and beliefs about media. Previous research results that seemed conflicting and counterintuitive are now more understandable. Generally, attitude research is better conceptualized as part of motivation theory, and media researchers interested in attitudes or values are urged to master the growing and vigorous literature on cognitive theories of motivation—particularly the work that has resulted from Bandura's self-efficacy theory and the extensions of that theory by Salomon (1981, 1984). Basically, the cognitive theories suggest that all motivation results from the answer to three largely implicit questions learners ask themselves: (1) Do I like this medium (or learning task)? (2) What skills are required to learn from this medium (or learning task)? and (3) Do I have the skills that it takes to learn from this medium (or learning task)? The answer to the first question leads learners to choose to learn from one or another valued medium. The answers to the second two questions influence the amount of effort they invest in learning from any given medium.

Researchers in this area are urged to focus on a careful measurement of engagement, level of effort, values and related constructs such as perceived demand characteristics, and perceived self-efficacy. In addition, researchers are urged to separate learning from motivational issues in studies. This can be accomplished by insuring that motivation studies are not confounded by ability or prior knowledge differences on the part of subjects. In this way, the motivational influences on achievement will be separated from the contribution of general and specific abilities.

One final suggestion is in order. We suspect that these new cognitive theories of motivation imply some changes in our understanding of research on feedback during instruction. This is particularly important in the design of research on the interactivity advantages of computer-based instruction (CBI). Many CBI studies are designed to investigate different forms of interaction between learner and computer courseware. The feedback given by the computer may be conceptualized in many ways, but if researchers think of it as answering one or more of the three motivation questions (in addition to other questions), the literature in this area may become more productive. In other words, feedback might be about values, media demands on the learner or the learner's capabilities to learn from one or more media—depending on whether the researcher wanted to manipulate engagement with a medium or the amount of effort invested in learning from a given medium.

# ECONOMIC ISSUES IN MEDIA RESEARCH

One of the least obvious yet most compelling aspects of the media research conducted during the last decade is the large number of economic questions and the scarcity of economic studies. There is a growing consensus that past media comparison, media attribute, and motivation studies indicate that media do not influence whether someone learns from instruction. Learning seems to be due to factors such as task differences, instructional methods, and learner traits (including attitudes) but not the choice of media for instruction. Another way to state this conclusion is that media do not influence the psychological elements of learning and have no place as independent variables in attempts to predict learning outcomes. Yet, it seems that there is equally dramatic evidence that media do influence the economic elements of learning. That is, under certain conditions media can dramatically influence the cost of learning. Here, *cost* can be defined in any of a variety of ways—as the amount of time it takes a learner to reach an achievement criterion or a development team to develop, revise and/or present instructional programs; as the cost in resources (such as dollars, committed facilities, or the drain on an organization); and/or as the cost of access to instruction by different types of learners (in dollars, effort, or time). For example, comparisons of computer and conventional instruction often show a 30 to 50 percent reduction in time to complete lessons for the computer groups (Clark & Salomon, 1986). Although some of this dramatic economic advantage of computers may be due to a novelty effect that disappears over time, not all time savings are attributable to research design errors. One of the reasons for exploring these cost of media issues is that they allow for additional analyses of the psychologically based effectiveness studies or what economists call cost-effectiveness research.

## Cost-Effectiveness Studies of Computers in Primary and Secondary School Settings

A recent review of cost-effectiveness studies of media use (primarily devoted to computer-based instruction) has been conducted by Henry Levin (1986; Levin & Meister, 1985) at Stanford University. He has reanalyzed a number of recent, comprehensive, cost-effectiveness studies that were conducted in elementary and secondary schools. His conclusions note that computer-based instruction cost-effectiveness is relatively poor in most of the better evaluation studies. However, when sites made a determined effort to promote full utilization of the medium and software, the cost-effectiveness ratio increased by a factor of 50 percent. Levin also found evidence that there are dramatic cost-effectiveness differences for the same CBI program at different implementation sites. That is, when the same program is implemented at different schools or cities, the cost-effectiveness ratio changes significantly—by as much as 400 percent. This strongly suggests that different strategies for managing media systems and the implementation of mediated instruction can greatly influence the cost of achievement from computers (and perhaps other media as well). Because we would expect that the media courseware would produce the same level of achievement at different sites, management and organizational factors are most likely to influence cost and, in some cases, inhibit achievement.

## Media Economics Research Design Suggestions

Levin cautions researchers in this area that a great number of flawed cost-effectiveness studies have been conducted. He located reports of about 80 studies but was only able to use 8 of them for his analysis. In his view, 72 of the studies were so seriously flawed that they could not be used. He also presents a very engaging discussion of the issues surrounding CBI

implementation—a discussion that all media researchers interested in conducting studies in this area should read. He notes, for example, that elementary school computer systems tend to be more fully utilized than those in secondary or college settings, which may account for the typically larger achievement effect sizes found in the primary school meta-analyses by the Kuliks (Clark, 1985).

We strongly recommend increased research on the economics of instructional media in the next few years. Although school systems in the United States are not forced to rationalize their plans in terms of cost-effectiveness yet, we seem to be moving in that general direction. We may find that some media make certain instructional methods cheap enough for broad implementation. For example, computers and videodisc media may provide the constant interaction that individualized instruction requires but has only been previously available from expensive, live teachers. In this case it would not be necessary to claim that computers made a unique contribution to learning in order to rationalize their use in education. It would be sufficient to provide evidence that a medium made some necessary instructional method cheap enough to be affordable within current levels of support.

# SUMMARY AND CONCLUSION

Since the mid-1970s there has been a movement away from research questions and studies inspired by a behavioral view of learning. The trend in the past decade has been toward scholarship that is rooted in the new cognitive theories of learning from instruction. The results of media comparison studies and, more recently, media attribute studies indicate that media are best conceptualized as delivery vehicles for instruction and not as variables that directly influence learning. In general, most previous research on instructional media has identified some sufficient conditions for learning and for the cultivation of cognitive learning skills. Future research should aim to determine necessary conditions for learning, i.e., the unique aspects of a medium or of the instruction delivered by the medium that models the cognitive processes required for successful performance on particular learning tasks. We might also adopt a broader definition of the outcomes of learning—one that includes levels of transfer of knowledge and skills desired.

Our reading of the past decade of media research strongly suggests that the learning that occurs from well-prepared media presentations is actually due to three factors or types of variables: (1) learning task type (e.g., more procedural or more declarative tasks); (2) individual learner traits (e.g., motivation, general ability, and prior knowledge); and (3) instructional method (e.g., the way that the instructional presentation compensates for deficits in learner traits that are required for learning). Instructional technology research in the next decade might profitably focus on interactions between these variables. In these studies, media should be employed as delivery devices that will aid the researcher's control of treatment duration, reliability, and quality.

The motivational effects and the cost-effectiveness of instructional media have remained largely unexplored. Attitudinal studies have been conducted in large numbers but with conflicting results and without the benefit of theory. Now that cognitive research has provided motivational theories such as Bandura's and Salomon's, future motivation research with media will be more fruitful. Researchers interested in motivation issues are urged to clarify some of the measurement problems in past research on variables such as *engagement, level of effort*, and *values* in relation to media presentations. In addition, motivational research should avoid direct measurement of learning outcomes. Current cognitive theory assumes that motivation influences either engagement in a task and/or the amount and quality of effort expended to learn. Therefore, research in this area should use engagement and effort expended as dependent variables that, in turn, are presumed to influence learning.

The limited research available on cost-effectiveness of instructional media indicates that, under certain conditions, media can dramatically influence the cost of achievement. There is a great need for research to identify and quantify the management, implementation, and organizational factors that influence the cost-effectiveness of various instructional media for various kinds of subject matter, instructional methods, and students. We strongly support and urge an increase in the amount of economic research on media. These are the studies that, in the long run, may prove to be the most fruitful for media researchers.

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