Instructional Technology: The Research Field

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Abstract. Two aspects of the context for research in instructional technology are described—innovations in media technology, and educational requirements. A good deal of education, the survival part, appears to be acquired by *incidental learning*, and a number of prospects are discussed for research in that area, while more traditional learning research on *intentional learning* is currently conducted in the framework of cognitive information processing. An important concept to denote what is learned is the *schema*, and a number of possibilities are described for schema-based research on learning from text.

Evidences are all around us that the technology relevant to instruction is being developed at what appears to be an accelerating pace. As is usually the case, the hardware innovations outdistance the development of software—of procedures for use—so that we seem constantly to be in the position of asking how we can best employ this or that marvelous new invention.

For example, we scarcely have had time to contemplate the marvel of desktop computers, when we are made aware that the necessity of speaking to these computers in machine language is fast disappearing. While programming is, of course, still necessary, it is not being done by the user and is unlikely to be in the future. We appear to be at the point of communicating with these machines in our natural language, and even of having them address us in oral speech.

One more development is virtually upon us, not exactly hardware-based, but pertaining to programming logic. This is the artificial intelligence development that appears to make possible *intelligent* computer operation, or what some have called *knowledge engineering*. When applied to such tasks as medical diagnosis, one expects such systems to work through successive steps of a diagnostic problem, following the lead of the diagnostician, storing whatever specific knowledge has been uncovered, and displaying relevant knowledge at each step. Thus the intelligent computer system relieves the operator of memory burdens for (a) retrieving systematic problem-relevant knowledge, and also for (b) reinstatement of the rules of logic, thereby making possible the focusing of attention on each particular problem-solving step one at a time. If we are clever enough to avoid superficial and misleading analogies, it ought to be possible to develop intelligent computer-aided instruction. What will be needed for intelligent CAI is a system that truly helps the learner solve the problems of learning and remembering. Presumably, this will be done, not by assuming that learning is always like medical diagnosis, but rather by devising computer programs that truly help the learner take the various steps that we know are involved in learning—from gaining an initial intention, through the various encoding processes, to the verification of a newly acquired performance capability.

Of course, computers are by no means the only technology that is displaying this kind of rapid development. There are new techniques of display and communication of information. For example, continuing research is being done with the aim of improving the quality of TV picture displays; high-definition displays are already available, although costly. Digital processing of the signal is another possibility already with us, making available such interesting features as freeze framing, multiple-channel viewing, and zooming. Even the audio portion of television reception has undergone improvements that permit stereo and foreign language translation, through a multichannel sound system.

Surely, we are hardly able to appreciate the implications of the laser-optical video disc; a system that permits frame selection, slow motion viewing, audio accompaniments, and other flexible procedures. Another feature, not to be overlooked, is the high density of memory storage made available by the videodisc. Systems have been developed to store 20,000 pages of information on a disc as small as 12 inches.

Remarkable developments have also occurred, and are still occurring, in the area of transmission of TV signals. Videotape recorders are in widespread use, giving teachers control over what is displayed in the classroom. In addition, videorecorders make possible new ways of presenting instruction, such as the system of small group discussion with a tutor (Gibbons, Kinchelor, & Down, 1977). The many new developments in broadcast television will also have to be taken into account in considering how instruction can best be done. These include short-range broadcasting (called ITFS), cable technology, and satellite transmission. Singly and together, all of these new technologies make television into a system of information transfer that is greatly different and vastly more capable than is the TV we think of in the typical home-viewing situation.

Where is Education Headed?

Research on instruction is stimulated and defined by the media available for communicating with learners. The future trends of research are determined by the changes that are likely to take place in the kinds of hardware delivery systems that are invented, developed, and put into use. Research on instruction is also defined by the societal context in which instruction occurs or will occur in the future. Such research is constrained by what our society believes and values about education. What are

the purposes of education? When should organized education be given? How should it be supported? What relative priority should it have in calling upon the resources of our society? It is to meet the goals we call education that instruction is given. Accordingly, the societal context of education is bound to have a strong influence in determining what research is considered worth doing.

Several national reports have recently given us new knowledge about the state of education in the United States (National Commission on Excellence in Education, 1983; Boyer, 1983; Goodlad, 1984). Perhaps the best known of these is *A Nation at Risk*: A Report of the National Commission on Excellence in Education. This commission listed thirteen or fourteen indicators of deterioration in the educational achievements of students in our country. A decline in SAT scores was one of these, but there were several others that perhaps have greater validity. In revealing the current societal context of education, the commission made the following two statements:

> It is important, of course, to recognize that *the average citizen* today is better educated and more knowledgeable that the average citizen of a generation ago—more literate, and exposed to more mathematics, literature, and science . . . Nevertheless, the *average graduate* of our schools and colleges today is not as well educated as the average graduate of 25 or 35 years ago, when a much smaller proportion of our population completed high school and college (p. 11).

How are we to account for this contrast? On the one hand, people know more than they used to about the world they live in and the skills it takes to cope with it. On the other hand, the people who go to the trouble of seeking out and participating in programs of organized education and become certified graduates, are less well educated than such people were in, say, the 1950's. What factors, events, or trends can account for the startling contrast implied by these statements?

There are surely a number of reasons why we find ourselves in this position with regard to the status of education in the United States, and it would not be productive for me to try to identify them in detail. As a summary impression, though, what these statements tell us is something like this: A large percentage of young people we refer to as students are really not *participants* in educational processes, but would more accurately be described as *school attendees*. A smaller proportion do in fact become participants, and manage to acquire from planned, systematic instruction, the knowledge and skills that make them recognizable as educated men and women.

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Our education system is in trouble, the National Commission thinks—because while there is much learning going on, it does not often result in well-educated people. My extrapolation of these trends runs something like this: We must plan in the future for four kinds of education. First is education in the basic skills, whose importance is very great. If done properly, we should be able to assure mastery of these skills in virtually everyone by age 9 or 10. Second, we must decide what to do about what I would call *survival education*: a kind of basic education for that large portion of the population whose members do not wish to be considered "well educated." Third, we must provide the kind of classical education in language and the scholarly disciplines—the sort of curriculum Boyer writes about—for that smaller portion of our youth who want to be "educated people." And fourth, we must make provision for education in the practical arts, the trades, and the professions. This kind of education is for anyone who wants to be qualified and at any age—in house wiring, in real estate selling, in veterinary medicine, or whatever.

In these four kinds of education, there are two categories that seem to demand different approaches, and therefore pose different research problems. One category, including the basic skills of elementary education, the instruction of those who would become "educated people", and those who desire to qualify in an occupation, appears to require *intentional learning*. Those who learn by this route must have an identified intention to learn, and a willingness to undertake the mental effort that the process of learning requires. In a different category, all by itself, belongs common education, or what I have called *survival education*. Beyond the early exposure to the basic skills, this kind of education can, in our society, be acquired by *incidental learning*, without any intention to learn whatsoever.

It is noteworthy that the learning of survival knowledge used to require a certain number of years of schooling. In the early years of this century, a prevailing type of education was common-school education, considered as taking place in six grades, or later, eight grades. Graduates of common schools were not looked upon as highly educated—only as educated to an extent necessary for every day living and working—in other words, for survival. In part this was citizenship education, including civics, history, and geography. In those days, it took a common-school education to impart this kind of knowledge.

Nowadays, however, knowledge of the world, of government, geography, natural history, civic affairs, community services, and social and family relations, is gained by youngsters virtually entirely by incidental learning. As a result, it is common to hear the statement that children have enormously greater amounts of knowledge when they enter school than used to be the case. This kind of learning also accounts for the National Commission's statement that the average citizen today is more knowledgeable than the average citizen of a decade ago.

Common Education and Incidental Learning

According to my reasoning, then, a very large part of common education,

perhaps all except the basic skills, is nowadays being attained by incidental learning. Investigators of human learning may not be particularly happy to hear this. Despite the fact that a long line of research shows incidental learning of some kinds of material to be almost as effective as intentional learning, it is nevertheless the latter kind of learning that occupies most of the attention of learning investigators. So it has to be said that not very much is known about incidental learning.

If common education is indeed largely acquired by incidental learning, what are the situations in which such learning occurs? Mainly, these situations seem to me to be the following:

1. Children engage in incidental learning when they hear people talk. Adults may be talking to them (as in a school classroom), or around them (as in a home conversation).

2. Youngsters learn incidentally from a number of people in places where they are required to be. That is, they learn from teachers and fellow-students just by hearing them talk and watching what they do. Or, if they are required to attend church or Sunday School, they learn incidentally from the people with whom they are in social contact. If they are unfortunate enough to go to jail, they learn from those people. I am still speaking of learning that takes place without intention.

3. Everyone learns an enormous amount incidentally by watching television. We are often reminded of the fairly large number of hours spent watching television by the average young person of school age. Many things are learned about the geography and history of the world, about families, about parent-child relationships, about certain kinds of artistic pursuits, and an enormous variety of other knowledge. Also learned, just as obviously, are attitudes—toward adults, towards babies, toward policemen, toward medicine and hospitals, towards love and marriage.

4. Presumably, some intellectual skills are learned from television. Because this medium does not provide for learner interaction, the skills learned are few and perhaps somewhat odd. Very cleverly, *Sesame Street* and *Mr. Roger's Neighborhood* tease children into postures of interactive responding, and thus are able to get across some very simple basic skills—letter recognition, for example, or some elementary social manners. Otherwise, the skills learned seem likely to be grotesque ones, such as how to fasten handcuffs, how to hold a handgun steady, how to address a judge in a courtroom, how to open a metal can, how to pour soap powder into a washing machine, and the like.

Some Research Questions for Incidental Learning

Considering these various sources and settings for incidental learning, we are evidently faced with a great many problems to be investigated. Although we are quite sure much learning occurs this way, there are many things we don't know about it. Here are some research questions.

1. How can the knowledge that is incidentally learned be described, categorized, and measured? If it is true that the average first-grader, say, has much more knowledge now than he or she used to have, what is the nature and extent of that knowledge? Since modern learning research indicates the great importance of prior knowledge for new learning, understanding what such prior knowledge amounts to is likely to be of critical relevance to the design of instruction in the school—that is, for the design of subsequent intentional learning. A method of accurately describing and classifying knowledge would, of course, have very general usefulness beyond the domains served by media and the methods of instructional technology. However, it would appear to be convenient and feasible to study the question initially by way of the learning supported by television watching. This line of thought leads to some more specific questions such as those that follow.

2. When news and sports programs are excluded, what kinds of knowledge are potentially transmitted by a typical day-long viewing of home television? What categories of knowledge are exhibited, and how do these compare with categories of knowledge that have been identified as constituting survival knowledge? Can a test, indicating how much knowledge in these various categories is acquired from television viewing, be designed?

3. The same question, applied specifically to intellectual skills. If a child, or a person of any age, watched commercial entertainment (network) television all day long, what kinds of intellectual skills would be potentially learnable?

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4. The same question, but applied to the very interesting domain of attitudes. There have been a good many studies of particular attitudes presumably affected by television, such as attitudes toward personal violence, sexual relations, law and justice. The question I describe here is not oriented toward any particular attitudes; instead, it is a question of what are the attitudes communicated by entertainment television—any and all of them, good or bad, socially desirable or undesirable. I would guess that many socially desirable attitudes are conveyed by entertainment television, besides some that are often considered undesirable, or those more specific ones oriented toward the choosing of particular commercial products. Soap operas, for example, may convey attitudes of loyalty to friends and family, candidness in personal interactions, responsible caring for children, as well as some others that are less favorable.

5. Similar questions about what kinds and amounts of knowledge are being displayed can be asked about educa-

tional TV programs, although in this case the questions are of a finer grain and apply to single programs, rather than to day-long viewing. What can be learned from the viewing of a documentary program such as one of the NOVA series? And if this question is answered, then how much of what is available is actually learned, assuming that incidental learning is still the question?

Actually, some techniques appear to be available to make a beginning on such questions. The text-analysis procedures described by a number of investigators (Britton & Black, 1985) make it possible to describe prose passages exhaustively in terms of their content of ideas (propositions). This means that the learning of these ideas can be measured on an absolute scale having a zero point and a 100% point. At Florida State, several studies have been done with adults and with college students providing measures of how much is learned of the spoken portion (the sound track) of some TV documentaries, when these are being viewed as entertainment programs. This amount, in several studies, turns out to be around 54%.

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We have an idea, then, of how much is learned from the sound track, but we don't yet know how much is learned from the picture, or from the combination. So here is a challenging research question—how can we describe and measure the contents of pictures in a way that is at least comparable to the procedures used to describe prose passages? This question refers to the *information content* of pictures, not to their quality or their artistic merit. An interesting study bearing on the question has been reported by Nugent (1982), who presented various combinations of visuals, print, and audio to school children in elementary grades, beginning with a nonverbal film about the life of a cheetah. Although this investigation didn't propose a way to describe and measure the information in visuals on an absolute scale, it did provide interesting contrasts between various combinations such as visual alone, visual with print, and visual with audio.

6. These questions about incidental learning from educational TV documentaries have a practical orientation, although they pose some rather fundamental problems, such as how to measure the contents of a picture. Still another form of the question about learning from TV has been with us for a long time: In a TV documentary, what is contributed by the picture? Does the picture enhance the audio message by a *redundancy* process, or a *dual-storage* process? Does the picture contribute to learning by a process that could be identified as *elaboration*? Can a picture produce *interference* in the learning of the audio message; alternatively, can it function to produce what is called *release from PI*? Questions like these are for basic research. As opposed to the descriptive kinds of research previously mentioned, these questions would presumably require experimental types of studies, in which specially prepared TV versions of the same documentary are compared in matched groups of viewers. This kind of research reminds us of the studies of investigators like Lumsdaine and Carpenter, now out of favor for 25 years or so. I believe it will be profitable to return to such approaches once we are able to measure the contents of both picture and sound track, and to measure the learning that results from the display of their combined effects.

7. There are comparable opportunities for basic research in the area of attitude establishment and change. The research I have previously mentioned would attempt to find out what kinds of attitudes are being communicated by TV, both the commercial type and the educational variety. Once it is possible to assess what is happening in this domain, some basic research studies can be designed to investigate problems of effectiveness of TV presentations. Of course, years of study and experience have put this area of TV development on a fairly firm footing. Much has already been learned about using television to establish and change attitudes, so that research will now need to be designed to build upon this existing technical knowledge.

Bandura's work (1969, 1977) has demonstrated the crucial effects of the human model on the establishment and modification of attitudes. Observational learning occurs when the potential learner views a human model telling about or showing certain choices of action. For attitudes, learning is most effective when the model is perceived as admirable, powerful, and credible. Imitation is most likely to occur when the model is seen to be rewarded for the action choices made. According to Bandura's social learning theory, the learner comes to adopt standards of self-reward that are similar to those of the model. Thus, suitable use of presentations with human models can lead children to imitate and adopt the type of moral standards exhibited by an adult model.

Of course there are many particular ways of presenting human models and their action choices to potential learners, whether children or adults. Models can appear in direct presence, or, at the other end of the continuum, by being read about in printed pages. Obviously, the presentation of human models and their behavior is something that television, or any similar combined visual-sound medium, can accomplish with enormous virtuosity. It is this capability of television that leads to the many questions about the social effects of this medium—good and bad. There is a substantial line of research on the antisocial and prosocial effects of television viewing (Rubenstein, 1978), and many questions still to be answered concerning the attitudinal influences of personal violence, violence involving physical objects, personal intimacy, and stereotypic roles of men, women, and members of ethnic groups. The efficacy of television in establishing attitudes is well known and scarcely open to question. Still to be investigated, however, are the variables made apparent by social learning theory: the relation of the human model to the viewers, the in-

fluence of the context with which the model is presented, the nature of the "message" with respect to the kind of action choices being dealt with, and the relation of the message to various background factors in the memories of potential learners.

Some Research Questions for Intentional Learners

I turn now to the kind of learning called intentional learning, a type that has for many years received the greatest attention of research investigators. There is, of course, a vast amount of research literature on intentional learning. However, when one realizes that and proceeds to dig into it with the intention of answering the question, what do we know about learning, one is likely to be brought up short with the second question, what were all these experimental learners intending to learn? Here are some things they were *not* intending to learn:

1. They were not asked to learn the meanings of sentences, paragraphs, or longer prose passages (with few exceptions).
2. They were not asked to learn procedures, such as those involved in learning to read, to write, or to calculate with numbers.
3. They were not asked to learn how to solve common problems requiring thought, such as occur in arithmetic word problems or in the task of writing a sonnet.
4. They were not asked to learn strategies of learning, such as how to commit names to memory, how to use images, or how to divide learning tasks into parts.

What experimental subjects were asked to learn, usually, were associations between one stimulus event and another, presented together or in close time proximity. The basic conception of this learning might have been the conditioned response, the associative bond, or the stimulus-response paradigm (S-R). My estimate is that there is a good deal of systematic knowledge in the journals dealing with this kind of learning, but it is knowledge about how *associations* are formed, maintained, and weakened. If one applies to this body of research findings the question, what have we learned, my guess is that there are two prominent, generalizable findings. One is the Law of Effect, or the principle of reinforcement contingencies, if you prefer that language, and the second is the set of principles called interference. While these principles have still not attained the explanatory power that one would wish, the phenomena of interference are nevertheless ubiquitous, general, and scarcely to be ignored as significant events in learning.

For quite a number of years, investigators attempted to view the intentional learning that might have been presented by a textbook, a film, or by other media, within this framework of associative learning—labels and lists. During the last fifteen years or so, however, we have all become used to dealing with learning as a matter of change in cognition by the processing of information. Cognitive learning psychologists have been persuaded by the research on artificial intelligence, and by their own research on computer models, that accounting for the intellectual functioning of human beings requires the postulation of a variety of processes and states internal to the learner. Therefore, we deal now with long-term memory, with short-term memory, and with the working memory and its attentional capacity. We are accustomed to the inference of such processes as pattern recognition, semantic encoding, rehearsal, elaboration, retrieval, and the formation of schemata, in addition to the more familiar process of reinforcement.

These new concepts of information processing provide a virtually new world of research questions about learning and the factors that lead to learning effectiveness. There are several possible frameworks within which to formulate these questions. Psychologists tend to phrase their research questions in terms of theoretical constructs, such as memory structures, schema formation and tuning, knowledge generalization, and the like. But in terms of what I am attempting here, I shall try to adopt a framework of *media* and their capabilities for affecting learning of the intentional sort.

Intentional learning differs from incidental learning by requiring that some feedback to the learner be provided for any or all of the processes involved in learning. Whereas incidental learning occurs simply with learner viewing of a scene or presentation, the learner responses required in intentional learning may be viewed as evidences of the learner's intent. It has been known for many years that such learner responses must be followed by feedback, else learning of any dependable sort does not occur. For instructional technology, the implication is that the medium for presentation of the instruction must allow for learner interaction. Accordingly, for my discussion of research on intentional learning, I turn to the medium that includes the computer, in the configuration we call computer-based instruction. I used TV presentation as a prototype for incidental learning, so I will use computer-based instruction (CBI) as the model for intentional learning, assuming also that this model can include the presentation of realistic pictures, as in the combination of computer and videodisc. My purpose will be to indicate the research questions to be solved, to assure the most effective intentional learning, given that an interactive medium is available. Notably, these questions involve the direct consideration of the processes postulated by modern cognitive learning theories.

Learning from Pictures

The first category to be considered as a research area is called learning from pictures. The general questions are (1) what various outcomes can be learned from pictorial or diagrammatic presentations, and (2) how can pictures be designed to make these varieties of learning most effective?

1. One kind of task that requires the use of pictures is the learning of spatial relations of objects. Of course, the most obvious task of this sort requires learning of locations on terrain maps, but there are also astronomical maps, maps of the locations of organs in vertebrate animals, and many other kinds. Some recent work has been done by Thorndyke and Stasz (1980) on strategies of learning spatial locations in maps. Additional research is needed on techniques of presentation that will improve learning of spatial relations of this general sort.
2. A second kind of outcome from pictorial learning is the learning of shapes, ranging from regular geometric forms to highly irregular organic forms. The work of Dwyer (1970) comes to mind, indicating that recognition of shapes in pictures of the heart was best accomplished by outlined drawings of the major components. This seminal finding opens up an area of research which is by no means fully explored, particularly when we consider the infinite variety of diagrams and diagram

changes that can be designed by the computer. The questions here can well be framed in terms of the intellectual process called *pattern recognition*, on which there is already a line of interesting research. Stated in terms that would fit computer-based instruction, the research question takes the following form: If what is to be learned is recognizing an irregularly shaped object (e.g., an organ of the body, or a particular piece of equipment), what variations of features can be used during instruction to bring about most effective learning?

3. A third variety of learning from pictures is the learning of concepts. It is notable that pictures can depict concrete objects, such as birds and flowers and their parts; and also abstract concepts. The latter can sometimes be learned from verbally stated definitions, but they can also be shown in pictures. For example, a picture of an adult and a child can illustrate such abstractions as threat, sadness, or merriment. Regarding concrete concepts, such as edge, cutting tool, equilateral triangle, and such, much good research has been done, by Tennyson and associates (Tennyson, Woolley, & Merrill, 1972) and by Klausmeier and his associates (Klausmeier, Ghatala, & Frayer, 1974). Their work, however, has left a legacy of an unresolved research question: Are such concepts best learned by instruction on their *attributes*, by presentation of a *prototype*, or in some other way? Evidently, a concrete concept *can* be learned by either method. The question is, given a good definition of what "knowing the concept" means, how can instruction be most efficiently designed? Here again the potentialities of the computer with accompanying pictorial display would seem to be of high value.

Turning to the question of abstract concepts, I think it would be very interesting to attempt to find out what concepts can be learned from pictures alone. Consider a picture showing a heavy safe falling from an upstairs window, aimed at an unsuspecting pedestrian below. Surely, such a picture implies "danger" or "dangerous situation". As I have pointed out previously, such concepts can probably be acquired by incidental learning, but perhaps dangerous situations such as those that may occur in automobile driving could also be conveyed by pictures. If so, we should probably prefer that this be done by intentional learning, since safe driving is a part of what we want to assure for all drivers. For intentional learning, what has to be added to a picture (if anything) in order to instruct learners in the various driving situations that are dangerous? What varieties of situations must be employed? Do verbal definitions, or other verbal directions, have to be used? What kind of interaction of the learner with the picture, and what kind of feedback, can most effectively be employed?

Of course, this is only one example of an abstract concept. There are many that must be acquired by intentional learning, by children in school, and by adults in school and out. Pursuing this line of questioning—what can be learned from a picture—takes us back to the question posed earlier in connection with incidental learning. What does a picture contribute to a sound-picture combination such as a television program? Part of the answer, no doubt, will derive from research that seeks to find out what can be learned from pictures alone.

Learning from Printed Text

The other kind of display that can be made to the visual sense is *print*. There is, of course, a fairly large body of research dealing with the question of how to present instruction in printed form, in textbooks, workbooks, worksheets, outlines, and so on. For this reason, some of the major variables have been investigated, and some replicable findings have been obtained. But, while printed texts can be made to be interactive (as in programmed books), they obviously do not have the inherent flexibility of interaction that is possible to arrange with the computer.

In computer-based instruction, the form of presentation for print is a printed text displayed on a screen. The physical limits of this text display help to define the problem—we shall be dealing with learning from screen-displayed text. Obviously the baseline condition is the display of so many lines of printed text on the screen. The text itself may be what is called descriptive, expository, or of some other form. The question for instructional development is: How can the presentation of text be designed to aid learning and retention?

It seems to me that one way to view the acquisition of knowledge in this situation is in terms of the concept of *schema*. A schema is an organized body of knowledge, conceived theoretically as a set of interconnected propositions centering around a general concept, and linked peripherally with other concepts. It is assumed that learners come to the learning situation with various schemas (schemata) already in memory. Some of these, however, may be quite threadbare (as when a non-biologist learner encounters the concept *brachiopod*), whereas others may be richly connected (as when a baseball fan encounters the concept *National League*). Were we to undertake to instruct a learner of the first sort about brachiopods, we could legitimately speak of the learner *acquiring* a new schema; in the second case, some new descriptive information being added to an existing schema would be *accretion* or *tuning* (Rumelhart & Norman, 1978).

New concepts of information processing provide a virtually new world of research questions.

Let me just take a moment to review the characteristics of a schema, which I quote from Richard Anderson (1984). I do this because these characteristics are what will tell us when new knowledge from text has been learned.

1. *A schema provides ideational scaffolding for assimilating text information.* The idea is that a schema provides a niche, or slot for certain text information.

2. *A schema facilitates selective allocation of attention.*

3. *A schema enables inferential elaboration.*

4. *A schema allows orderly searches of memory.*

5. *A schema facilitates editing and summarizing.*

6. *A schema permits inferential reconstruction.* (p. 248).

I suggest, then, that learning from text means acquiring new information that

has the properties of a schema. What has been learned is in a form that can have all these things done to it by the learner—summarizing, inferring, elaborating, searching, and reconstructing memory.

Questions about Learning, Beginning with a Text

Learning from text alone *can* result in the acquisition or accretion of this sort of schema. The question I want to deal with, though, is how can the presentation of text in an interactive medium make such learning easier, more rapid, more assured of completeness? Evidently, one way that this may be brought about is by *adding* something to the text, or in some way modifying the text so that it is no longer simply so many lines of print. Of course this is by no means an absolutely new idea. One thinks immediately of the variations of this sort that have been done with print on paper. Pictures have been added, questions have been added, elaborative ideas have been added, practice examples have been added. Naturally, I would not propose that all of these questions be asked over again, simply because the text has been moved from a page to a screen. We do seem to have some dependable and generalizable knowledge about text enhancements arising from previous research, and I should not expect that to be thrown away. However, as many researchers have pointed out, much of this knowledge is not as robust as it might be. Much of it is suggestive of the need for additional research, of the sort that will identify the assumptions and limitations of the generalizations that have already been suggested.

For example, consider a question of central interest to educational technologists—does the addition of a picture or pictures facilitate learning from text? Suppose, for example, that what is being learned is a description of William Tecumseh Sherman (not his appearance, but his place as a figure in U.S. history). Do pictures help the acquiring or accretion of a schema about this man? We really do not have an adequate answer to this question. We may be able to identify some learning tasks in which pictures do help (e.g., learning foreign vocabulary lists), but we cannot confidently answer this question about pictures in learning from a text describing a thing, a place, or a man like William Tecumseh Sherman. This is what I mean when I say that our knowledge is not very robust.

The kinds of deliberate enhancements of text that need to be investigated, and that lend themselves particularly to computer-based design, include the following:

1. A first category is what can be introduced, relevant to the text, before the text itself is presented. These are pre-presentation treatments. The *pre-existing schema* of the learner could be examined with reference to the characteristics I previously mentioned, and its properties related to ease of acquiring or tuning a new schema. Another way to approach pre-presentation treatments is by way of *advance organizers*. Again here, the research question is which characteristics of advance organizers facilitate learning, and which do not.

2. A second category of text enhancements is *insertions*. One thinks first of inserted *pictures*. There are many unanswered questions about accompanying pictures, as I have already mentioned. Another kind of insertion is *questions*. Regardless of the fine work of Rothkopf, Frase, and others a few years ago, there are good research questions to be answered about inserted questions. For example, if what is learned is conceived as a schema, one can ask questions that reveal the "slots" in the schema, or that require inferences, or that suggest elaborations. The kind of feedback given to inserted questions is another area apparently in need of further investigation. For example, what sort of *corrective feedback* is most effective? Should there be a kind of rational explanation or merely a comparison with a model answer?

Still another kind of insertion is *verbal elaboration*. While the notion of elaboration has some experimental support, we know of its effects only in general terms. What kind of elaboration? The text can be paraphrased, enhanced with concrete examples, analogies can be inserted, or the learner can be asked to *supply* an elaboration by summarizing, by supplying examples, or in some other way.

3. A third general category of text enhancement may be called *text variations*. Of course, there are many kinds of these that might be thought about. In terms of the concept of the schema, some particular kinds of variations come to mind. If a schema has "slots" for traditional aspects of its central idea (the traditional items expected in dining in a restaurant, or in solving a murder mystery), one kind of variation of text would be to place special emphasis on these "slotted" items, as opposed to presenting the text straightforwardly. Another variation is called *mapping* (Armbruster & Anderson, 1980), and refers to the structuring of the text so that certain spatial positions and certain standard symbols are made to stand for certain relationships among the ideas of the text. Thus, new concepts might always appear in a particular screen position, while causal effects might be represented by a particular symbol.

4. The learning effects of any or all of these types of text enhancements are going to be revealed by some dependent measure. What has been learned from the presentation of text? What is the result of intentional learning? I cannot conclude the subject without pointing out what a good deal we still don't know about how to measure the results of learning from text. *Free recall* of the contents has received much attention, and methods for the scoring of literal content are rather widely known. Methods for scoring cued recall are not nearly so well developed, and we do not know their relation to free recall methods. Referring again to the concept of the schema, its characteristics suggest still other methods for the assessment of learning results. Remember that the schema presumably makes possible the selective allocation of attention, the making of inferential elaborations, editing and summarizing, and inferential reconstruction. These characteristics might form the basis for one or more new techniques for determining how much has been learned from the presentation of text. And we should not ignore, probably, the potential provided by the computer for obtaining measures based upon speed of responding.

Summary

What I have tried to do is to reflect upon the opportunities for research that seem to be provided by the present state of media hardware technology, as well as by its still rapid pace of development. I mean, of course, research related in an ultimate sense to the meeting of educational requirements.

I have described educational requirements as falling into two major categories. There is what I call survival education, composed of the basic skills and what used to be called common school knowledge. The latter category I believe can be and is being acquired nowadays almost entirely by *incidental learning*. In producing this type of learn-

ing, television plays a highly important role. I suggest, therefore, that there are many research questions to be asked and answered about learning from television. What are children learning when they watch television—what kinds of declarative knowledge, procedural knowledge, and attitudes? Without attempting to change this medium into an interactive type, how can presentations be made most effective for incidental learning? And with particular pointedness, how can pro-social attitudes be most effectively conveyed by this means?

The other set of educational requirements divide themselves into several subsets. Basic skills belong in this category. But other subsets pertain to the attainment of vocational and professional competence, and to the acquiring of masses of organized knowledge that characterize the "educated person". These categories of knowledge must be learned as *intentional learning*, and if such learning is to be done efficiently, feedback to learner responses is required. This means that the media employed, whether with or without an instructor, must assume the conformation called *interactive*.

There are many opportunities for research on intentional learning. The great mass of psychological research on this kind of learning, in the period 1930 to 1960, includes very little content on relevant declarative or procedural knowledge. We are only beginning to learn how learning takes place for many of the intellectually demanding tasks of intentional learning, such as those reflected in the curricula of the schools. The interactive media of the computer and the computer-videodisc combination are continuing to provide promising means for investigating the many problems of designing presentations that increase learning ease, rapidity, and effectiveness.

In considering the kinds of research that is needed and could be done with interactive media, I have confined my suggestions to the commonly encountered situation of *learning from text*. There are, of course, other kinds of situations and other kinds of outcomes that could be discussed. Within this particular framework, however, I have suggested that a variety of questions need to be investigated, falling into the general category of *text enhancement*. Text can be enhanced in various ways—by altering the pre-presentation treatment or by inserting pictures, questions, or elaboration statements. Variations in the text itself may be undertaken, including paraphrasing and structural mapping, and any of these kinds of treatment of printed text will need to be assessed in their effects in ways that extend beyond the narrow confines of achievement testing as it is usually conceived. The properties of the schema, in providing a *slotted* structure (the basis for reconstruction and inferential processing), suggest some of the new ways to be sought for assessing the outcomes of learning from text.

In meeting the requirements of education of all types, educational technology will undoubtedly play an increasingly important role in the years to come. A great deal of research on instruction should be added to this body of practical knowledge. As I'm sure we all agree, hardware itself can only accomplish whatever the human imagination can invent for its use.

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