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Viewpoint

Thoughts from the field of educational technology

The field of educational technology is experiencing such rapid change that even the literature of the field may be dated by the time of its publication. Current development in areas such as microcomputers, interactive video, satellite communications and the interactivity of various media forms provide an exciting challenge for the educational community.

The authors of this special issue of ***Educational Considerations*** have addressed the most crucial of the technologically oriented issues facing educators today. Soliciting and editing the contents of this issue have been stimulating and highly rewarding experiences.

Educational technology is still in its infancy as a professional area within education and training. As a result, a definitive view of the field is only now becoming accepted on a broad scale. Donald P. Ely of Syracuse University addresses the matter of defining this rapidly changing field in the issue's lead article. Gerald M. Torkelson of the University of Washington gives further meaning to the parameters of the field in his discussion of the current theoretical considerations of the utilization of media and technology in instruction.

Francis M. Dwyer of Pennsylvania State University, Ann DeVaney Becker of the University of Wisconsin and William D. Winn of the University of Calgary each discuss crucial concerns relating to visual dimensions of the field. John A. Hortin of Kansas State University provides some suggestions for practical applications of instructional design in today's schools.

Fred A. Teague and Doug Rogers of East Texas State University discuss how microcomputers moved rapidly into education and describe implications for instructional applications of emerging computer technology. More specific concerns associated with microcomputer application in matters centering upon instructional developments with LOGO are discussed in the article by Michael J. Striebel of Pennsylvania State University.

Crucial issues associated with making educational decisions relating to educational technology are articulated by Robert Heinich of Indiana University. The future of educational technology is discussed by Kent L. Gustafson from the University of Georgia. Finally, research needs and priorities for the near future are described by Richard E. Clark of the University of Southern California.

Special thanks are in order for the contributions each author made to this issue. Such a collection of original articles from authorities who are so highly regarded in educational technology should make a lasting contribution to the literature of this field.

The guest editors appreciate the opportunity to bring this collection of authoritative literature to the educational community. It is hoped that this special issue of **Educational Considerations** will help readers better understand the major issues associated with educational technology and enable many to use appropriately available technology to enhance and improve instruction.

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and
Fred A. Teague
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Guest Editors

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Current definitions seem to meet the tests of clarity, currency and utility in this field

The definition of educational technology: An emerging stability

by Donald P. Ely

The ferment over the definition of the field of educational technology seems to have subsided. The introspection which characterized the growth and development of this eclectic field has turned to other matters. Professionals in the field appear to be satisfied that current definitions are reasonably serviceable. Efforts are directed toward living out the definitions which have emerged in the past dozen years. In this period of relative calm, it seems appropriate to review the current state of definition and to identify the remaining issues which still need to be debated.

Why bother?

When James D. Finn wrote the foreword for one of the first official definitions of the field (1963), he chose the words of Confucius to lend weight to the need for definition:

> "If the Prince of Wei were to ask you to take over the government, what would you put first on your agenda?"
>
> "The one thing needed," replied the Master, "is the definition of terms. If terms are ill-defined, statements disagree with facts; when statements disagree with facts, business is mismanaged; when business is mismanaged, order and harmony do not flourish; when order and harmony do not flourish, then justice becomes arbitrary; and when justice becomes arbitrary, the people do not know how to move hand or foot." (p.iv)

Donald P. Ely is professor of instructional design, development and evaluation and director of the ERIC Clearinghouse on Information Resources at Syracuse University.

Definitions are required to give a consistent meaning to a word or term. This consistency provides a common referent for users of the word or term. It permits a universe of discourse among users and would-be users. A well-defined term facilitates communication. It serves as a shorthand for individuals who share a common meaning.

When a field is defined, individuals gain the benefits of a precise definition in their day-to-day operations. Such definitions help to indicate who is "in" and who is "out." The purpose of such a distinction in a broad field such as education is an aid to relating one area to another. Definitions do not create a field but, rather, help to explain its functions, purposes and roles to those within and those outside the area.

Some major decisions rest upon the adequacy of a definition. For example, in determining content of a professional curriculum and potential overlap of one area with another, a definition can assist in charting the territory. Certification requirements for personnel are sometimes predicated on definitions which have been prepared and sanctioned by professional groups. Job descriptions may be written around definitions as functional responsibilities are inferred from the words used.

A 50-year perspective

Definitions have followed the changing paradigms of the field. Definitions have been tied to the prevalent labels of the field. In the pre-World War II period, the visual education or audiovisual education term was used. The definition of Hoban, Hoban and Zisman (1937) was illustrative of the various definitions which emphasized the products or things of the field. Lumsdaine referred to this perspective as the physical science approach to the field (1964).

"A visual aid is any picture, model, object or device which provides concrete visual experience to the learner for the purpose of (1) introducing, building up, enriching, or clarifying abstract concepts, (2) developing desirable attitudes, and (3) stimulating further activity on the part of the learner." (p. 9)

This definition persisted through the post World War II period and well into the 1960s. In some quarters its strength was evident in part of the definition of educational technology offered by the Presidential Commission on Instructional Technology (1970). The Report said that the field could be defined in two ways.

"In its more familiar sense it means the media born of the communications revolution which can be used for instructional purposes alongside the teacher, textbook and blackboard . . . the pieces that make up instructional technology: television, films, overhead projectors, computers and the other items of 'hardware' and 'software.' " (p. 21)

This concept presented a stumbling block to professionals who were attempting to accelerate the evolution of the field to a more contemporary interpretation. Even as the communications emphasis emerged in the late 1950s and early 1960s, there were attempts to bring this major conceptual contribution into the definition of the field. In 1961, during his presidential term of the Department of Audiovisual Instruction (DAVI), James D. Finn established the Commission on Definition and Terminology. The work of this Commission was supported by the Technological Development Project, a USOE-funded program within the National Education Association. The Commission report (1963) was published as Monograph #1 of the Project and was issued as Volume 11, No. 1 of **AV Communication Review.**

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The 1963 definition drew upon learning theory and communication and used the term audiovisual communication as a temporary expedient.

"Audiovisual communication is that branch of educational theory and practice concerned primarily with the design and use of messages which control the learning process." (p. 18)

The strong behavioral emphasis at the time seemed to call for the word "control," but the objections from the field were many and the definition was altered by some users to "facilitate" rather than "control."

The work of the Commission continued for another 15 years with one interim definition in 1972 prior to the current monumental work, *The Definition of Educational Technology* (1977). The 1972 definition seemed to be a natural evolution and incorporated the new directions in which the field was moving. The behavioral science aspect of the field was becoming evident.

"Educational technology is a field involved in the facilitation of human learning through the systematic identification, development, organization and utilization of a full range of learning resources and through the management of these processes." (p. 36)

The Association for Educational Communications and Technology (AECT, formerly DAVI) was responsible for the major definitions of the field from the establishment of the Commission on Definition and Terminology to the present. The one highly visible effort outside the professional field was the Presidential Commission on Instructional Technology which reported its findings in 1970. The first part of the definition (stated earlier) focused on the products of the field; the second part recognized the metamorphosis which was taking place.

"(Instructional technology) . . . is a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication and employing a combination of human and nonhuman resources to bring about more effective instruction." (p. 21)

This definition has been widely used. It is often quoted as *the* definition of the field even though AECT has published its definitive work. The AECT definition stemmed largely from the work of Silber (1970) and was further developed by a diligent and hardcore group within the Definition and Terminology Committee. The definition first appeared in 1977 after drafts had been discussed by the educational technology community within AECT and revised several times by the Committee. The first sentence of the definition is often used to represent the entire statement.

"Educational technology is a complex, integrated process, involving people, procedures, ideas, devices and organization, for analyzing problems and devising, implementing, evaluating and managing solutions to those problems, involved in all aspects of human learning." (p. 1)

The introductory sentence before the definition itself states that "The following definition—all 16 parts—are meant to be taken as a whole; none alone constitutes an adequate definition of educational technology." (p. 1) This warning has caused some concern among those who are accustomed to terse dictionary definitions and may have led to reduced usage among members of the profession.

Issues

There appears to be no hue and cry for a new or revised definition of educational technology. It could be that the silence connotes satisfaction with the definitions which now exist. It could be that there are more important matters before the community. It could be that those who were so vitally concerned with definitions are tired and have moved on to other projects. There is a Definition and Terminology Committee of AECT, but there do not seem to be any major issues on the agenda. What are the issues regarding definition for the educational technology professionals?

1. **Which definition will survive?** Clearly, the 1977 AECT definition—all 16 parts of it—serves as the official statement of the profession. The publication has gone through several printings and is in high demand throughout the world. It serves as a comprehensive explication of what the field is about. Neophyte professionals study it as the fountainhead of the field's origins and scope. It will persist for many years and will be the touchstone for any future efforts. The need for a shorter dictionary definition will probably be filled by the second definition of the Presidential Commission on Instructional Technology (1970).

It is succinct and self-standing. Its simple elegance communicates the purpose, processes, and fundamental elements of the field. It carries the weight of a distinguished panel who made up the Commission. The 1970 definition has withstood more than a decade of use and has not been seriously challenged.

It is likely that both definitions will survive but for different purposes. They are not basically incompatible, but it is unfortunate that there cannot be a single definition which binds the profession and is widely accepted by all.

2. **Who is In and Who is Out?** The rapid development of the computer in schools has brought about the emergence of a new group of specialists who are calling themselves "educational technologists." They have embraced the label but not the concepts of the field. The current crop of computer specialists in education consists primarily of teachers and professors who have acquired skills with the microcomputer and feel compelled to share this knowledge with others. There is nothing wrong with this advocacy but to call such people "educational technologists" is to violate the prevailing definitions of the field.

There is a familiar ring to the enthusiasm for one medium or device. Educational technologists who have been active for many years have seen the single issue zealot who pushed films, radio, television, programmed instruction and several other media during the past 50 years. The people in education who advocate microcomputers demonstrate some of the same characteristics as their earlier colleagues who believed that one medium or another was about to revolutionize education. They feel that they have discovered a device or medium which will engage the learners as no teacher has ever done; they see potential for optimum learning by creating replicable instructional packages which can be used throughout the nation; and they feel that the use of microcomputers is consistent with the American technological psyche, which embraces new technologies as new religions. There is nothing inherently "wrong" about these perceptions; they are simply naive in light of the history of innovations in schools.

3. **Are the prevailing definitions of educational technology too broad?** To "outsiders," the first impression of the 1977 AECT definition is one of brash overextension. Colleagues in education argue that the definition includes

all of education: " . . . (an) integrated process, involving people, procedures, ideas, devices and organization, for analyzing problems and devising, implementing, evaluating and managing solutions to those problems, involved in all aspects of human learning." That involves **all** of education, especially teaching. It is difficult to counter such arguments except to say that the definition goes on for seven pages and that all sixteen parts must be read to get the complete statement.

The future of educational technology definitions

Educational technology as a field of study is relatively new among the fields and disciplines. It is a field marked with significant changes during the past 50 years. The attempts to define the field have reflected a concern for its raison d'etre. A healthy exploration of the rationale and concepts of any field must be to its credit. Educational technology has been diligent in serious contemplation of its roots and its future direction. The definitions which have surfaced in the past two decades show maturity and growth. Even though the past five years have been relatively calm in regard to definition, it has been a time of testing. The 1977 AECT definition appears to be serving the profession well. The 1970 Presidential Commission definition provides the succinct statement which many people require to communicate the essence of the field.

It does not appear as if new efforts to define the field will develop as long as the current definitions meet the tests of clarity, currency, and utility. Confucius would be pleased.

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Which theoretical constructs about media and learner characteristics offer the most promise of significant increases in learning?

Media applications to instruction: Current theoretical considerations

by Gerald M. Torkelson

The problem confronting every teacher or researcher concerned with the contributions of media to instructional practice and learner achievement is one of determining which theoretical constructs about media and learner characteristics offer the most promise of significant increases in learning. This is a problem of long standing—traceable to early research efforts at the beginnings of this century and even earlier in philosophical discussions. The search is as current today as it was years ago. A major difference between today and yesterday, however, is that so much knowledge has been accumulated about the nature of media and the nature of learners that old notions have changed about media/learner relationships and about the utility of some of the more traditional research/theoretical orientations.

To reduce the problem to its essentials, it seems reasonable to focus on two main aspects of the relationship, i.e. (a) current conceptualizations about the nature and functions of media (information forms)[1], and (b) current understandings and theoretical observations about learning which, in turn, affect conceptualizations about media and their uses.

In considering media applications to instruction, it is important to first address changes in conceptualizations about the processes of learning because it is against this backdrop that media must be examined.

Gerald M. Torkelson is professor of education and chairman of the graduate program in educational communications at the University of Washington, Seattle.

The major source of new ideas in recent years concerning how learning may be viewed has been provided by theories related to information processing, storage, and retrieval and to computers to which they are linked (Travers, 1982).

Most studies of media applications to instruction in the first five or six decades of this century were built upon earlier theoretical positions. That is, the effects upon learners of exposure to media of various kinds under varying conditions were analyzed primarily as stimulus presentations which were to aid in making connections between the learner's repertoire and the new material to be learned. In the S-R model of research, for example, the assumption was made that media were primary sources for changes in learner behavior, that there was a direct "connection" between the stimulus acting upon the perceptual system and learner response with minimal concern about the internal processes and memory stores which affected the change.

This earlier period of research was also characterized by the "gross-comparative" model, such as comparing the effects upon learners of a motion picture with the effects of a film strip. The results of this research have been summarized in an analysis of the 25-year history of **Audio Visual Communication Review**[2] (Torkelson, 1977). In the great majority of cases, conclusions of gross-comparative studies were of no significant differences among variables. While it is not my purpose here to elaborate upon this earlier research, I make reference to it to suggest that its theoretical bases were generally inadequate for determining the actual functions of media in processes of learning. With some exceptions, most of the research did not attempt to gather evidence about the effects of varying the internal structure of media or of the effects of learner idiosyncracies upon media effectiveness.

Support for a refined look at media/learning relationships came from a number of quarters. Government sponsored research in motion picture characteristics as related to learning in the late 1940s and 50s was one source; another was the programmed instruction movement which examined the effects of modifying elements within frames of information on learner performance. This attention to variables within information forms also led to a growing awareness that it was necessary to look more closely at the internal conditions of learners as factors affecting reactions to information.

Thus, there has developed a theoretical position that currently focuses upon learning as a processing of information, an orientation deemed more productive for discovering the relationships of media to processes of learning than was possible in earlier associationist theories. Impetus was given also for this theoretical change by expanding knowledge about the physiological, perceptual and cognitive mechanisms that learners use to receive, process, store and retrieve information.

If learning is regarded primarily as the processing of information, then teaching—the other half of the relationship—may logically be thought of as information presentation. As Derr (1979) has said, teaching can do nothing more than induce learning; it cannot presume to expect that learning will occur automatically. Learning is a private

[1] The word "media" should be interpreted as a convenience term for all forms of information.

[2] **Educational Communication and Technology Journal** is the successor to AVCR.

affair, subject to the whims and repertoire that the learner brings to bear on the information at hand.

As is true with most theoretical formulations, there are progenitors that go back into history. The caution that one must look at the characteristics of learners, their past experiences, their value systems, and their predilections as bases for discovering principles of media usage is not new. Such a caution was voiced in **AVCR** from its beginnings in 1953. The first issue of the periodical contained a discussion by Norberg urging the need to study the intricacies of human perception as a basis for determining functions of media. By 1961 and 1962, respectively, **AVCR** had produced two special issues on learning and on perception theory.

More recently (1975), **AVCR** published a special issue on aptitude treatment interaction (ATI) in recognition of a growing interest in this type of research and as an offshoot of the programmed instruction movement. ATI represents the theoretical position that having knowledge of the interactive effects of learner aptitudes with instructional treatments would make it possible to predict the proper types of treatments (methods and materials) that would insure given learner responses. But ATI has also had its problems in establishing absolute interactions among almost infinite numbers of learner variables that are the result of idiosyncratic physical, mental, maturational and cultural conditions. Also, in ATI one must face the dilemma of predicting over time the behavior of dynamic, changing individuals by means of aptitude measures that tend primarily to be slices of a spectrum of aptitudes (see Cronbach & Snow, 1977).

Salomon (1979, 1981) has published two books which explore media as symbol systems that interact with the cognitive, social and psychological aspects of learners. This theoretical approach supports the idea that media must be viewed more as agents for presenting information than as agents that become direct stimuli for given responses. As has been aptly expressed along this line (Clark, 1982) in a critical review of a recently published critique of 60 years of research in media:

> We cannot claim any advantage of one medium over another when student achievement is the issue. Media do not contribute to learning any more than the vehicles that deliver experts to a problem-solving conference contribute to the eventual solution of the same. The choice between instructional mediums is based simply and finally on their capacity to carry the intended message and our resources.

I am presuming that "our resources" refers to the learner's repertoire.

If we accept current conceptualizations of learning as information processing and the idiosyncracies of learners as crucial factors in receiving, processing, storing and retrieving of information—then what logically become the functions of media?

First, we must dispel the notion, as Clark has indicated, that media are the primary agents that promote learning in and of themselves. Media, in fact, act primarily as agents for providing information. This means, also, that instead of accepting only the traditional five senses as avenues for gathering information, we need to expand our considerations to include what Travers (1982) labels as the five information collection systems. He separates visual and auditory as two of the systems, but he combines taste and smell into one and discusses the touch receptors in the skin and joints as "haptic" and the basic orienting system as the fifth category. The latter refers to two sets of three canals in each inner ear, not as part of the hearing mechanism but as an information collection system. There is also a reference to pain as another information system, although not as clearly understood as the others. It becomes obvious that one must look carefully at the spectrum of information sources through which learners acquire knowledge of their world. An analysis of media (information forms) in such a context requires going beyond traditional audiovisual terminology and also requires an expanded, more generic interpretation of media functions.

Considering that teaching may be likened to information presentation and learning likened to information processing, terminology to express these conceptualizations ought to reflect this broader orientation. Given this need to name generic conditions, for the past decade or so I have been urging the use of the terms **message, message forms and message carriers** as designators for the broad spectrum of information and information transmission systems. Messages encompass any and every kind of information that one person may wish to transmit to any other person. **Message forms** also include a subcategory of codes or signs that combine to give the message substance or to which the learner must attend as sources of information. Codes are such things as lines, edges, color, texture, shape and so on, which learners use to differentiate forms and kinds of information. This notion of codes is used by Salomon (1979) when he discusses media as symbol systems and when he promotes the notion that the greater the isomorphism or similarities between the coding systems in the message and the coding systems available in the learner's repertoire, the more likely that learning will take place and that the learner may use these coding systems to aid in the processing of information.

Message carriers, referred to above, differentiate the message form from the instrumentation used to make the messsage form available to the learner. For example, an overhead projector is a message carrier in that it is the mechanism for projecting an image (message form). While it is convenient to separate message forms from message carriers for purposes of considering their separate contributions to learner perceptions, there are undoubtedly subtle effects of types of transmission upon perception of the message conveyed. Viewing a television image in one's living room would probably have different effects upon interpretation of the message than would be the effect of viewing the identical image in the classroom.

Any human communicator may—at times or simultaneously—be a message form and a carrier. In the former instance, a learner may attribute value to the message conveyed by the other person in terms of the learner's attitude toward that person, thus affecting the acceptance and interpretation of the message being conveyed. At the same time, a person is a message carrier by being the physical means for transmitting the message. The crucial issue in separating message forms from their carriers is to focus on the uniqueness and appropriateness of the form and carrier for presenting different kinds of information—recognizing that sometimes it may be difficult to distinguish between the influences upon the learner of the message form and its carrier.

The effects of media upon processes of learning must take into account what each learner perceives as reality. It is this reality that is brought to bear on the interpretation of information. The theory of solipsism, for exam-

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ple, suggests that the self can be aware of nothing but its own experiences; that nothing exists or is real except the self. If this is the case, the reality that a symbol system (source of information) presents is thus real to the extent that the self gives it reality. Thus, any assumption of a teacher that information will be learned exactly—or even approximately—as presented, runs counter to the theory of solipsism. Media thus become information sources for learner interpretations of the world, suggesting the need for pedagogical techniques that probe student perceptions of information rather than assuming student performance is related solely to teacher presentation. This conceptualization underlines that any analysis of media effectiveness must include the two-fold process of determining the types of message forms best suited to given information and of determining what actually is perceived by each learner.

Popper and Eccles (1978) propose that reality consists of three worlds: World 1 is the physical reality, not of solid objects but of empty space inhabited in part by atoms and molecules which provide us with the illusion of solid objects; World 2, all of the experiences that fill human life; and World 3, the world of culture and ideas which exist independently of the world. World 3 influences Worlds 1 and 2. World 3 is the creation of Worlds 1 and 2.

Given the emphasis today upon cognitive psychology and upon new knowledge of the brain and its functions (Travers, 1982; Chall & Mirsky, **NSSE Yearbook**, 1978), it is apparent that the functions of media (message forms and coding systems) must be analyzed as information systems utilized by learners for interpreting their world. As each of us gathers and interprets various forms of information in our respective environments, there is no doubt that we filter information through a complex system of values, experiences, and capabilities peculiar to ourselves.

As research indicates, much of what we respond to in our external world has structure and that perception involves recognition of that structure. As we observe structure we also filter out irrelevancies and "pigeonhole" or categorize. It appears that the more exact and precise the information, the more the likelihood of "pigeonholing" or assigning of information to subcategories of one's repertoire. Some authors have described the learning process as a "stimulus sampling" for purposes of comparing new information with that already known. The "gatekeeper" concept of cognition suggests that persons respond to and take in information in terms of which gates they open and close, not in terms of accepting without qualification whatever the information form presents. Hart (1975), for example, describes the brain as a structuring mechanism which, in the normal course of events, strives to make sense of and give organization to incoming information. He contends that lessons structured by the teacher to aid learning may be incompatible with the inclination of the human to organize information on its own. This point of view raises questions about theories of instruction and evidence that argue for presenting learners with structures, methodologies, and conceptual Gestalts that are intended to accelerate and fix learning, such as the strategies for meta-processing or learning how to learn.

Part of the theoretical controversy, which also determines how one determines the relationships of information systems to information processing, relates to basic premises about research methodology. Of current interest is the reductionist versus the constructivist approaches to research. The former characterizes a good deal of early research in media where all variables were presumed to be held constant while experimental variables were tested. The reductionist approach has as its goal the confirmation or refutation of an a priori theoretical position.

The constructivist approach, on the other hand, is basically a process of theory generation (see Magoon, 1977). The researcher, such as an anthropologist, approaches the problem or situation with no a priori assumptions but argues that one must spend enough time on location to observe the conditions that affect outcomes.

In the reductionist approach, such as is characteristic of aptitude-treatment-interaction research, one always runs into the question of the validity and reliability of research instrumentation and the question of whether, in fact, a measurement of learner aptitudes is more a slice of a moment in the life of a learner than it is a measure for predicting the interaction of learners with given treatments over time.

While the constructionist approach seems more amenable to the documentation and verification of a wide variety of learner and environmental factors as they affect reactions to media, there are problems of insuring that data collection is unbiased.

Research methodology is introduced here very briefly only to alert researchers and teachers alike to the need to examine the reliability of methods for gathering information about the true interactive effects of information gathering systems employed by the teacher and learner and the effects of perception, memory and physiological and psychological capabilities of learners upon the gathering, processing, storing and retrieval of information.

In applying this brief discussion to the practicalities of instruction and research relating to media in particular, it is reasonable that the following areas of investigation would be most appropriate for advancing knowledge consistent with an information systems/information processing model of media and learning.

1. The uniqueness and appropriateness of coding systems and information forms for conveying different kinds of information;

2. Methodologies most appropriate for maximum interaction of learners with media;

3. Structures within media for focusing learner attention on criterial elements;

4. Methodologies for determining which learning processes and memory stores have the greatest effects upon the interpretation of information sources;

5. The structural elements and coding systems within information forms which may serve as systems for learners to gather and process information;

6. The influences of different kinds of information forms in shaping the cognitive and affective systems of learners;

7. The kinds of information forms most appropriate for developing the potential of each brain hemisphere.

8. The functions of iconic and propositional information systems in the processing, storage, and retrieval of information.

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A single learning theory which will function as an effective predictor of visual learning may never be possible.

The dilemma of visualized research: Lack of practioner involvement and implementation

by Francis M. Dwyer

The decade of the 1970s ended with expenditures for audio visual equipment and materials exceeding the $3 billion per year level. With the introduction and implementation of microcomputers, video disc, satellite and laser communications, cable television, etc., and the software to be developed for use in these electronic delivery systems, expenditures for audio visual equipment and software materials will reach astronomical proportions in the decade of the 1980s. Within the varied instructional strategies the use of the visual medium has been optimized, presumably to assist learners in acquiring, storing, transmitting and applying information.

Despite the widespread acceptance and use of visual materials for instructional purposes, surprisingly little is known relative to the instructional effectiveness of different types of visualized materials, both from the standpoint of how learners react to variations in the amount and kinds of stimulation contained within the various types of visual delivery systems and how visuals differing in amounts of realistic detail influence learner achievement of different educational objectives. Consequently, difficulty has been experienced in designing visualization that will function effectively in increasing learner information acquisition of designated eductional objectives. This fact is evidenced by the large number of experimental studies reviewed by Stickell (1963), Chu & Schramm (1967) and MacLennan & Reid (1967), which indicated that the use of visually mediated instruction in many cases resulted in no significant increases in student learning when compared with conventional types of instruction.

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Research on visualized instruction

Theorizing and philosophizing about the advantages of visualized instruction and how learners interact, process, store and retrieve visually acquired information are useful in establishing general structures which can be used to provide a focus for exploration; however, it is only through experimental research that actual cause and effect relationships can be established among variables. Why then is there a scarcity of guidelines for the design and use of visualized materials, since there is certainly no scarcity of experimental research associated with visualized instruction?

An inspection of the experimental research relating to visualized instruction reveals that much of the research, in addition to suffering from many of the threats to internal validity identified by Campbell and Stanley (1963), has additional problems. These problems tend further to complicate data interpretation and frustrate any attempts to derive broad generalizations useful to practitioners in the classroom. Following is a sampling of the types of complications found in many of the experimental studies: (a) lack of hypotheses or predictions based on theory, (b) the use of content material far removed from that which is commonly taught in the schools, (c) failure to identify specifically the type of educational objectives to be achieved by the learners, (d) failure to describe properly the type of visualization used in the study or how it was used—whether it was related or redundant to the verbal/oral information it was designed to complement and (e) failure to specify for how long learners were permitted to view or interact with the visualized instruction and how long of a time span existed between when learners received the instruction and when they were tested.

Program of Systematic Evaluation

In response to the apparent lack of information about how to design and/or use visual materials, the Program of Systematic Evaluation of variables associated with visual learning was initiated at The Pennsylvania State University in 1965. Since its inception over one hundred experimental studies involving over 40,000 students have been conducted by the author and his colleagues. Research in this program has focused specifically on the instructional effects of visualization in the teaching-learning process—where visualized instruction has been presented in a variety of formats: television, synchronized slide-audiotaped instruction, visualized programmed instruction, regular textbook type of instruction (visualized, etc.). The results from these studies indicate that the use of visual materials to complement oral/print instruction can be a powerful strategy to increase student information acquisition; however, if visuals are used inappropriately and for the wrong types of educational objectives, instruction with visuals is no more effective than the same instruction without visuals.

In general the research has indicated that effectiveness and efficiency in visualized instruction are primarily dependent upon (a) the amount of realistic detail contained in the visualization used, (b) the method by which the visualized instruction is presented to learners (externally paced vs. self-paced), (c) learner characteristics, i.e., intelligence, prior knowledge in the content area, reading and/or oral comprehension level, etc., (d) the type of educational objectives to be achieved by the learners, (e) the technique(s) used to focus learner attention on the essential instructional characteristics in the visualized materials, e.g., cues such as questions, arrows, motion, verbal/visual feedback, overt/covert responses, etc., and (f) the type of test format employed to assess learner information acquisition, e.g., for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information learners acquire from visualized instruction than verbal tests. In this respect effective visualized instruction (and learning) must be approached not as an isolated phenomena, but as an interrelated constituent process operating at varying levels of complexity—the elements of which acquire significance only in the context in which they are used.

Research Findings

Following is a sampling of specific conclusions obtained in the Program of Systematic Evaluation (Dwyer, 1978):

1. The use of visuals specifically designed to **complement** oral and printed instruction does not automatically improve student achievement. For example, when visualization is used to illustrate basic terminology (e.g., screwdriver, carburetor, baseball bat, etc.) for which students already possess meaningful examples, then the use of visualization is superfluous. Similarly, when visualization is used to complement already complicated material, very little additional learning is achieved. In general, a major portion of a student's learning results from either oral or printed instruction—both are sequential and orderly in nature. When visualization accompanies complicated content, students have a tendency to scan **all** of the visualization immediately. Since students are not adept in switching back and forth from the oral/printed to visual channel as the crucial cues are described in the respective channels, a certain amount of frustration occurs causing the student to block out the less familiar communication channel (the visual) and concentrate more intently on the more familiar (the oral or printed).

   However, when students are required to be able to demonstrate by identification or drawings: (a) a knowledge of the location and interrelationships among parts or positions inherent in the content, (b) a recollection of specific patterns or functions, (c) the ability to produce (via drawings) content relationships (e.g., drawing and positioning correctly the primary parts of an automobile engine, a carburetor, etc.), the use of visualized instruction has been found to be significantly more effective than instruction without visualization.

2. The type of visual illustrations most effective in transmitting information is dependent upon the type of information to be transmitted. For the types of educational objectives (identification and drawing) where visualization helps improve student achievement, simple line drawings have been found to be the most effective type of visualization. In general, the least effective type is the more realistic illustration. Apparently, the additional stimuli contained in the realistic drawings and photographs may, by distracting students' attention, interfere with the information being transmitted. It seems that realistic illustrations and photographs can be esthetically pleasing and very effective in acquainting a learner with reality but are limited for instructional purposes unless the learners are somewhat familiar with the material being presented or are experienced in learning from visual materials.

3. Identical visual illustrations are not equally effective when used for externally paced and self-paced instruction. The effectiveness of a particular type of visual in promoting student learning depends on the amount of time students are permitted to interact with the visualized instruction.

   In general, for students receiving externally paced instruction, the simple line drawings have been found to be most effective; for students receiving self-paced instruction, the more realistic detailed, shaded drawings are most effective.

   Students participating in externally paced instruction (slide/audiotape, television) view their respective instruction for equal amounts of time. The process of identification and discrimination is time consuming; the more intricate the visual stimuli, the longer it takes for the student to identify and absorb the information. The more realistic illustrations contain more information than the less realistic, but the students apparently do not have sufficient time to take full advantage of the additional information provided. It may be that realistic illustrations containing much information are not useful when students are not given adequate time to scan and interact with the information.

   The effectiveness of the more realistic presentations in self-paced instruction may be explained by the fact that students are permitted to spend as much time as they wish in absorbing as much information as necessary to complete their understanding. The less realistic illustrations possess less detail and are, therefore, limited in the amount of information they can transmit, regardless of how long the students are permitted to study them.

4. For students in differing grade levels, the same visuals are not always equally effective. A student's ability to profit from visualized instruction is related to his intelligence, reading comprehension level, and background knowledge in the area. This does not mean, however, that special or different types of visualized materials have to be used for each grade level. Fortunately, identical types of visualized materials often are effective for specific educational objectives across several grade levels.

5. For specific students and for specific educational objectives, the use of color in certain types of visuals appears to aid in improving student achievement. For other educational objectives, however, the effectiveness may not be enough to justify the added cost of color. Often the realistic detail in the visuals is accentuated by color; thus, the students are better able to make the appropriate distinctions to obtain the necessary information. Color may make the visuals more attractive to students, who might pay closer attention as a result.

6. Student perceptions of the value of different types of visual illustrations are not valid assessments of instructional effectiveness; that is, esthetically pleasing visuals may not be of great instructional value.

7. The realism continuum for visual illustrations is not always an effective predictor of learning. An increase in the amount of realistic detail contained in an illustration will not necessarily produce a corresponding increase in the amount of information assimilated.

8. Boys and girls in the same grade level (high school) learn equally well from identical types of visual illustra-

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tions when they are used to complement oral instruction.

9. Identical visual illustrations are not equally effective in facilitating the achievement of students possessing different levels of entering behavior (prior knowledge in a content area).
10. Merely increasing the size of instructional illustrations by projecting them on larger viewing areas does not automatically improve their effectiveness.

Summary & Conclusions

Results from studies conducted in the Program of Systematic Evaluation are making significant contributions to the development of a comprehensive understanding of the instructional potential inherent in different types of visualization. However, because there are so many variables associated with the learning process and because most of these variables are continuous rather than discrete in nature, it is doubtful whether the development of a single learning theory which will function as an effective predictor of visual learning will ever be possible. The results of experimental research are usually presented in the form of abstract theoretical statements, principles having varied ranges of generality or applicability and points of view. For the practitioner these "guidelines" may be conceptualized as a skeleton framework for guiding the operational management of instructional systems—including producing and selecting modes and media for presentation and/or distribution and finally assessing the effects.

The building of skeletal frameworks is the principal function of good research, but experimental research cannot alone clothe the skeleton with living tissue. This latter responsibility is the job of the practitioner—the writer, producer, instructional developer, etc. In the behavioral sciences research cannot be expected to yield precise and complete formulas or prescriptions for the effective use of visualization in the teaching-learning process, nor can research yield results which will apply directly and precisely to the enormous range of situations and requirements for all kinds of learning objectives, modes or formats and media.

Similarly, it is to be expected that research on the instructional effect of visualization will be an ongoing process. The skeletal framework of results grow and change. Sometimes results are additive; at other times they are conflictive. Problems are rarely solved completely, and for each one that is investigated, new ones are discovered for solution. We can hope that as intensive systematic research in the area of visualized instruction continues to make worthwhile contributions, the body of useable results will be systematically implemented by practitioners, in a variety of different circumstances so as to determine their areas of appropriateness and subsequent levels of generalizability.

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Despite increasing interest in non-verbal media, they are still less well understood than forms of verbal communication.

Processing spatial media

by William D. Winn

It is safe to say that, in spite of increasing interest in non-verbal media, they are still less well understood than forms of communication that use verbal languages. By and large, non-verbal media express meaning through codes and conventions that rely upon spatial relationships among elements in the visual displays which encompass them, (which is why I have called them "spatial media" rather than the less precise though more usual "visual media").

Any consideration, however, of learning from spatial media, within the current cognitive paradigm, must be based upon an analysis and understanding of internal cognitive processes and forms of representation which enable learners to construct knowledge (Neisser, 1976; Piaget, 1967; Papert, 1980). This article therefore picks up some of the ideas expressed in earlier reviews of research related to cognitive processes and spatial media (Winn, 1980a, 1982a) and pursues them with a more particular focus on processing the spatial codes of these media.

A theme, derived ultimately from the debate about imaginal and propositional representation (Kosslyn, 1980, 1981; Pylyshyn, 1981), that will recur in this paper is the fundamental distinction in spatial processing between serial and parallel, or better, successive and simultaneous processes. Finally, the importance of such considerations for instructional design will be discussed.

Basic principles

Certain results from research into learning from spatial media (and into learning in general) have recurred with sufficient frequency that they are accepted as axiomatic. The following are some of these basic principles.

1. Spatial media and the information they contain involve a) elements, and b) relationships among them, each of which can be varied in instruction. A thorough discussion of this aspect of spatial media can be found in Knowlton's (1966) article "On the Definition of 'Picture,' ". The elements in any visual display, as Knowlton points out, can vary from the highly realistic to the completely conventional. One thinks of maps where buildings are shown as little pictures or as black dots. Similarly, the relationships among elements can vary in realism, from isomorphic to reality, as in topographical maps, to arbitrary, as in block diagrams.

2. In perception, all information is encountered sequentially, element by element. We tend to think of reading language as a sequential process and looking at spatial media as somehow holistic. However, we see by means of a series of rapid ocular fixations which take in only one detail of a visual display at a time, as studies of eye movements have shown (Yarbus, 1967). So while the order in which the elements in spatial materials are "read" may not be as predetermined as the order in which words are read in a text, they are nonetheless apprehended one after the other.

3. It is through the way in which these sequentially encountered elements in a visual display are synthesized into a meaningful aggregate that differences in processing occur. Das, Kirby and Jarman (1975, 1979) have proposed that there are two ways in which this synthesis can happen—simultaneously or successively. When perceived elements are synthesized simultaneously, all of the accumulated information is surveyable by the learner at any one time. Each new element in the visual display is added to the aggregate in memory in the same way that a piece is added to a jigsaw puzzle. In the case of successive synthesis, the order in which the elements are encountered is meaningful. There is not the necessity for the learner to be able to survey all of the accumulated information at once. People tend to conclude from this that text is synthesized successively and that visual displays are synthesized simultaneously. However, it is not as simple as that. Reading involves both processes, and as the meaning of a text becomes more complex, simultaneous synthesis becomes more important (Kirby and Das, 1977; Cummins and Das, 1977). This is because in more complex sentences meaning is accessible only if learners are able to survey information given early in the sentence at the same time as the information given later which modifies it. On the other hand, in processing spatial media, the succession of elements is often meaningful, as we shall see.

4. Learning occurs when the information presented in spatial media interacts with existing knowledge schemata, learner ability, learning strategy, learner perception of the task, and a whole host of other things. This interactive nature of learning has been discussed frequently (Salomon, 1979; Neisser, 1976; Bransford, 1979; Rumelhart and Norman, 1981) and will not be pursued here. But an implication of this particular principle is that there is no magic link between the forms that spatial media are given and the way that they are processed and learned. Too many other variables interact with media form and learning for prescriptive links (or "media utilization principles") to be established with any certainty.

Spatial codes and processing

We will now look at research into certain "spatial codes" and cognitive processing that is built upon these basic principles. Specifically, studies concerning the meaningfulness of elements in spatial media, relationships among elements and learning strategies will be discussed.

The elements in a visual display are either meaningful on their own or become meaningful only when combined

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with other elements. Cognitive processing is influenced by which of these two categories the elements of a particular visual display belong to, as two recent experiments have shown (Winn, 1982b). Subjects were shown either random sequences of letters or random sequences of lines on a computer screen. (When put together, the lines formed complete geometric figures.) Subjects had either to remember and draw the sequences of lines or letters in the order in which they were shown or draw the patterns (or figures) that the letters or lines formed when synthesized into an aggregate. These are obviously successive and simultaneous tasks. Subjects who saw the lines were far more successful with the simultaneous task than with the successive, while the reverse was true for subjects who saw letters. Since letters of the alphabet are more meaningful on their own (more "nameable" if you like) than isolated line segments from a figure, this suggests that meaningful elements are generally processed successively, while less meaningful elements are processed simultaneously. However, the contiguity of one element with the next is also a factor in this, as a second experiment showed.

Two more treatments were added in the second experiment. A third group of subjects was shown letters and had to recall just the position of each and mark it with an X. A fourth group was simply shown X's, the positions of which they had to recall. Only the simultaneous task was used. Subjects seeing letters but recalling only positions and subjects seeing X's performed significantly better than subjects having to recall letters and their positions. But these two groups still did not perform as well as subjects constructing figures out of lines, suggesting that the contiguity of elements (lines) in a geometric figure makes it easier to synthesize through simultaneous processing. When low-meaningful elements like X's are not contiguous, they can still be synthesized into patterns, though not so easily. And when the nature of each element has to be remembered as well as its position, performance is relatively poor. Interestingly, when subjects from the letters group were re-scored so that they were given a point whenever a letter was in the correct position, regardless of whether it was the right letter, their scores improved significantly and were no different from the two groups who drew X's.

What these two experiments suggest is that the meaningfulness of individual elements in spatial media affects the way in which they will be processed. In addition, the relative positions of the elements can be recalled best if they are contiguous and if only their position, not their name, has to be remembered. If meaning is deriveable from the elements themselves, it will be more difficult for learners to derive meaning from the patterns that the elements form.

An important influence on the way students process information in spatial media is the fact that we read English left to right, top to bottom. Learners tend to "read" spatial materials in the same way with the result that if the materials do not conform to the traditional format, difficulties arise. In a study of learning from diagrams (Winn, 1982c), students learned about the evolution of dinosaurs from a flow diagram. The animals evolved from left to right, and a time scale showing geological periods and time in millions of years ran across the top. A second diagram was prepared in which the dinosaurs were shown evolving from right to left with the time scale at the bottom. On tests of their knowledge of evolutionary sequence and classification by period and type of dinosaur, subjects who saw the reversed diagram performed significantly less well than those who saw the normal diagram. (On two tests, they performed no better than a control group.) Subsequently, eye movements of other subjects viewing the same materials have been recorded. While the analysis of these data has not been completed at the time of writing, initial analysis seems to suggest that the difficulty with the reversed diagram stems from its countering normal scanning behavior.

An aptitude-treatment interaction was found. For classification of dinosaurs by type, subjects who were low verbal and high spatial performed better on the reversed diagram than subjects who were high verbal and low spatial, there being no difference for the normal diagram. This suggests that learners who are better at processing spatial materials as patterns are less affected by departures from the normal way of presenting information in spatial media than those who would be more likely to process that information as sequences. While it is unlikely that spatial materials as perverse as the reversed diagram used in this study would be prepared by instructional designers, these findings certainly suggest precepts of which instructional designers would do well to take heed.

Spatial media can also be used to convey information about conceptual distances among concepts. (We think of a cat as being "closer to" a dog than to an aardvark.) In an earlier study (Winn, 1980b), subjects learned about food chains from a short text. One group was also shown a diagram of a typical food chain that had been constructed to represent conceptual distances as physical distances on the page. For example, hawks were placed closer to mice than to plants because in a food chain they eat mice not plants. It was found that the addition of the diagram to the text helped high ability learners but did not help those of lower ability. One interpretation of these data is that high ability learners were able to employ the diagram in a spatial processing strategy, which enabled them to organize the material more effectively, while low ability learners were unable to see the connection between the diagram and a useful learning strategy they might employ to good effect.

This conclusion leads directly to the consideration of metacognition and learning from spatial media. Metacognition involves the processes whereby decisions are made by learners about which strategies to use (see Gagne, 1977; Lawson, 1980). In a study (Winn, 1982d) which used tasks similar to the sequence and pattern recall tasks described above (but using letters only), one group of subjects was given instruction in the use of simultaneous and successive learning strategies and was told which of the two tasks (recall pattern of letters or letter sequence) to perform before each trial. A second group was not given instruction in strategies, and a third group was not told which of the two tasks to perform until after the sets of stimuli had been presented. In this way, learning strategy and knowledge of the task were varied. It was found that subjects who had been taught learning strategies performed better than those who had simply been told which task to perform, while the latter in turn performed better than subjects who did not have knowledge of the task until after the materials had been presented. Aptitude-treatment interactions were found showing that for both simultaneous and successive tasks, knowledge of task improved the performance of high ability learners relative to their performance when knowledge of task was withheld until after the stimuli had been presented. However, unlike with high ability learners, knowledge of task alone was not sufficient to improve the performance of low ability learners. These performed significantly better only if they had been given instruction in an appropriate learning strategy.

These results suggest two things. First, simultaneous and successive learning strategies can be taught to learners with the result that their processing of information in spatial media improves. Second, provided they know what the task is, high ability learners are able to decide on an appropriate learning strategy for themselves, while low ability learners need to be taught the strategy and when to use it. This conclusion is consistent with Bovy's (1981) theory, which relates learning strategies and mental ability. Generally, high ability learners can make better metacognitive decisions than learners of low ability.

Relevance to educational technology

Educational technology is concerned with the application of knowledge to the practical tasks of education (AECT, 1977). One ramification of this is that educational technology is concerned with design in the precise sense that the term is used by Simon (1969) to indicate a "linking science" between theory and practice. The design and development of instruction are therefore both central to educational technology and involve procedure for applying theory to practical problems.

Much of the theory that enables instructional designers to make useful practical decisions has been derived from research into learning and instruction. In particular, a great deal of this research has had to do with the ways in which information is presented to learners, cognitive processes, learner ability and learning tasks (see Bransford, 1979, pp. 6-9). This is precisely where the research described fits in. In "optimizing alternatives" (Simon, 1969), instructional designers must consider all forms of media, learners of all levels of ability, and all types of potentially useful learning strategies. Spatial media, simultaneous and successive processes, and the learning strategies that have been described will all at some time or another become grist to the instructional designer's mill.

There are as well more specific ways in which this research is relevant to instructional designs. When preparing spatial media (diagrams, for instance), the designer should not use highly meaningful elements if the intention is to show how the elements are related to each other. In extracting meaning from the elements, learners will find it more difficult to synthesize all the elements into the intended aggregate. Making elements contiguous (by linking them with lines, perhaps) might improve learners' ability to discern how the elements are related to each other. Designers should not allow spatial media to violate the left to right, top to bottom convention, particularly with learners who are low spatial and linear processors. Designers can use spatial media to make conceptual relationships explicit. However, only high ability learners are likely to use such representations unprompted. But designers can build instruction in relevant learning strategies into instructional materials, particularly when they are going to be used by low ability learners. This plan will overcome low ability learners' difficulty in selecting appropriate strategies for themselves.

These are just a few "design principles" that emerge from this selection of research on spatial media. A list of principles specifically for the design of diagrams is provided by Winn and Holliday (1982), and other relevant principles are to be found among those given by Fleming and Levie (1978). It is to be hoped that future research will shed even more light on the interactions that exist among the codes of spatial media and cognition so that even more guidance can be furnished to instructional designers for their important task.

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Why not allow students to organize, design, draw, script, produce and present instructional materials for their peers?

Involving students in the instructional design process

by John A. Hortin

Instructional design is the process of analyzing learner needs and educational goals and developing a systematic approach to meet these needs and goals through teaching methods, facilities, instructional materials and evaluation techniques. Teachers and educational technologists in secondary and elementary schools have not embraced the instructional design concept as readily as people in training, business or higher education.

There are several reasons for this lack of enthusiasm: few library media specialists have instructional design expertise, little or no money for materials and staffing is available, little time is allotted to teachers for instructional development and there is little awareness or concern about the instructional design process by curriculum developers or administrators. Instructional design is very time consuming and generally requires full time commitment by someone on the educational technology staff. Most schools can not afford the luxury of hiring someone as a full time instructional designer. Ironically, it is the goal of instructional design to discover the most efficient and effective use of time, resources, staffing, funds and teaching necessary to bring the desired result of improved learning.

Instructional designers use models, diagrams, flow charts or graphic directions to educate and involve teachers in the instructional design process. There are many different models for instructional development available (see Gustafson, 1981). Though these models or flow charts vary in terms of how they represent the instructional design process, the goal is to improve learning for the intended audience.

Generally, the instructional design process starts with goals and objectives; then depending on the model used, it progresses to stages that include (1) discovering the characteristics of the learners or their entering behaviors, (2) gathering content, (3) determining the scope, sequence and structure of that content and (4) specifying competencies, learning events and activities. Some instructional designers might give pretests, develop prototypes or specify alternative methods at this stage. Later the instructional designers may construct and determine several teaching and learning activities, design the instructional materials, assign local production work, and have the teacher conduct a tryout. The process ends with evaluation of the results and possible revision of the system.

Obviously, this process on a sophisticated level requires expertise, cooperation, time, management, money and personnel to implement. Even without instructional designers, teachers incorporate some aspects of instructional design in their teaching. Teachers start with goals and write objectives for their courses, they are at least somewhat aware of the characteristics of their students, and they gather and know the content of what it is they wish to teach. Most teachers test their students and sometimes evaluate and change their teaching methods.

What teachers need most is help in the design of instructional materials; in some cases this can be accomplished by involving students in the design of instructional materials. Often students are better with the technologies of instruction (use of microcomputers and production of videotapes, slide/tape programs, overhead transparencies, graphs, charts, audiotapes, and films) than are some teachers.

Why not allow students to organize, design, draw, script, produce and present instructional materials for their peers? This means that students, as well as library media specialists or educational technologists and teachers, become directly involved in the following: (1) preparing and determining learning experiences; (2) developing, producing and presenting media; (3) discovering alternative learning preferences; (4) selecting methodologies and (5) learning how to organize, simplify and present information.

Asking students to become participants in the design of instructional materials allows them to learn how each thinks and thus share, develop and learn how to learn.

Involving students in the design and presentation of locally produced media or the presentation of commercially produced media is based on five principles, some of which are supported by research in the field of education and some of which are common sense principles that have worked for me.

Principle one: Student participation in the design of media works because all learners become involved and feel as if they are an important part of the process. If change in behavior is the goal, all people in the situation must help make decisions about that change. This approach has a theoretical base in the research work of Hall (1975) and Freire (1971). The decisions that affect students are made by students.

Principle two: People never really learn a topic until they teach it. Students in my classes who make their own instructional materials and teach their peers become highly motivated, enjoy the collaborative experience of learning how to learn and discover how to communicate that learning to others.

Principle three: Learning how to learn is as important as learning the content. As we have often heard, in our technological age, information changes so rapidly that

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many things we learn today are outdated tomorrow. Some advantages of involving a class in the design of instructional materials are (1) students learn where to find information; (2) students compare how different students learn information; (3) students organize the materials and (4) students learn the skills of communicating that information to others.

Principle four: Instructional design is a means that may be just as important as the end products of that process. Teaching students the need for collaboration, cooperation, and community activity may be more long lasting and beneficial than the information that the teacher wishes to impart. The process of taking a body of knowledge and organizing it into some presentable form is a learning experience in itself.

Principle five: Learning requires that information be simplified and organized in some fashion. This is true for our own personal understanding as well as communicating our thoughts to others. Gestalt psychologists believe that we seek simplicity and organization in the processing of information and they have expressed this need by learners in the concepts of proximity, closure, continuity, similarity, etc. Involving students in the design of instructional materials is a means to organizing and simplifying information for better understanding.

Instructional design is not for everybody. Some situations, people and topics would not benefit from this approach. Also, involving students in instructional design is not applicable in all situations. It may be difficult to implement in training situations of business and industry. However, teachers and students should learn the value of designing materials for the classroom that are a result of a cooperative effort. The transparencies, videotapes, flow charts, audiotapes, etc. that the students produce can be used to communicate to others in the class the insights each student experiences and can thus become effective instructional materials.

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Computers will not pass from the scene, either in society or in our schools. The microcomputer revolution is upon us!

Microcomputers: Where did they come from? What will we do with them?

by Fred A. Teague and Doug Rogers

"New information technologies—computers, microprocessors, video recording devices and inexpensive means of storing and transmitting information—are creating a revolution as important as the invention of printing" (Melmed, 1982). Throughout the history of education, several technologies have developed which have had potential for major changes in educational practice. With the possible exception of the printing press, technologically derived educational changes have been minimal. In recent decades both programmed instruction and television have been viewed frequently as technological systems with great educational promise; however, these and other exciting technologies have generally not yielded the often anticipated benefits.

As a result, many educators are leery of a new technology heralded as a panacea for educational ills. Some may tend to write off the new microcomputer technology as an instructional toy that will shortly lose its novelty or as a gimmick that students and teachers will soon reject in favor of the familiar approaches.

However, the newer electronic technologies, especially microcomputers, will not fall by the wayside in our schools. The United States has become an information society and computers are rapidly becoming the national lifeline. They are essential to sustaining the quality of life that Americans now enjoy. Computers will not pass from the scene, either in society or in our schools. The microcomputer revolution is upon us!

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The very first "kit" versions of the microcomputer appeared in the early 1970s (Evans, 1979) and sales of these devices are increasing at a rate of 50 percent to 60 percent a year (Taylor, 1981). The classroom has not escaped the revolution. In 1980, a scant nine years after the first microcomputers were available, it was estimated that 90 percent of U.S. secondary and elementary schools incorporated computers for instructional and/or administrative purposes (Chambers and Bork, 1980). The implications of the microcomputer revolution for educators are many (Splittgerber, 1979). An exploration of these implications requires reflection on the revolution's origin and infiltration into the school to provide a more secure vantage point.

Microcomputers are actually the third generation of computers (Blair, 1982). First generation computers (1943-46) were enormous webs of mechanical relays and vacuum tubes. The size of a small building, they generated tremendous amounts of heat, required enough electricity to run a small city and were primarily limited to advanced mathematical calculations only. For these very reasons, the first generration was doomed to early extinction (Evans, 1979).

By 1950, major corporations (IBM, Bell Telephone, Speery-Rand) were funding development of the computer. The impetus for the evolutionary step into the second generation of computers came from Bell Telephone laboratories through the invention of the transistor. Replacing the bulky mechanical relays and vacuum tubes, the transistor allowed for the incorporation of expanded computer memory and for a vast reduction in size. The electronic nature of the transistor, as opposed to the mechanical nature of relays and vacuum tubes, substantially increased the already remarkable speed of the computer while expanding its versatility. The transistor, in essence, became the seed of the third generation. Nurtured by the militaristic and space exploration demands of the 1960s, computer development flourished. Development concentrated on the organization and miniaturization of transistor circuits. The concepts of "integrated circuits" and "large scale integration" combined these processes and made it possible to place 100,000 switching units on a "chip" of silicon about a centimeter square. Creation of this "microchip" or "microprocessor" gave birth to the microcomputer, the third generation of computers ((Blair, 1982; Eadie, 1982; Poirot, 1980).

If the microcomputer is only 10 years old, how did it infiltrate the classroom so quickly? One must realize that schools were using computer technology before the rise of microcomputers. Through purchasing a "port" (a connection or access point for a computer) or through a "time-sharing" arrangement (payment based on amount of computer time used), public schools gained access to mainframe computers at larger institutions, usually colleges or universities. The first applications were primarily administrative. Student scheduling, grade reporting, attendance record-keeping, and even college selection and occupational "counseling" (such as SIGI-System of Interactive Guidance and Information) were provided on these systems (Joiner and others, 1980). But the decreasing cost and the increasing capabilities of the microcomputer soon lured the educational system away from this type of arrangement (Poirot, 1980).

The microcomputer first stormed the classroom in the mid to late 1970s. B.F. Skinner's theories about learning, very popular during the 60s, led to the development of

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programmed texts, which now seemed especially suited for computer application. Experimental programs were conducted using mainframe computers, but the introduction of the microcomputer placed the cost of computer technology at a level where virtually all school districts could afford its use (Poirot, 1980).

The capacity of the computer to present information, permit student response, record and evaluate that response, reward or remediate, and record the student's progress made it the most versatile and complete "teaching machine" to date. Programs of this type are generally referred to as CAI—Computer Assisted Instruction.

Three branches of CAI have developed (Hallworth and Brebner, 1980). "Drill and practice" programs were the initial step into the classroom. Still the most heavily used type of CAI programs, "drill and practice" programs present repetitious applications of previously learned information; the primary purpose is to provide monitored practice and reinforcement of such skills as multiplication and addition, verb conjugation, and word or shape recognition. The second branch incorporates more of the microcomputer's potential. "Tutorials" present new information previously unknown to the student. Programs of this type are designed to provide sufficient practice for mastering the new concept or skill (Joiner and others, 1982). The third branch of CAI developed later and will be discussed later in this article.

A concurrent theoretical concept developed but not extensively practiced is CMI—Computer Managed Instruction. As the name implies, CMI is primarily a management tool. The computer's management capabilities include but are not limited to test generation, student pretesting, evaluation of a student's in-course progress, analysis of student's personal data, assignment of study activities or resources based on student's personal records and performance on test instruments and maintenance of complete records (Joiner and others, 1982; Leiblum, 1982).

Two major problems have hindered the widespread application of CMI. Software capable of manipulating and integrating the data bases necessary for CMI applications was designed for larger capacity computers. Versions currently available, such as Comprehensive Achievement Monitoring (Apple II), are limited to one aspect of the overall system or are poorly designed (Osborne and Bunnell, 1982). The reciprocal problem is that the current popular arrangement of floppy disk drives is inadequate for such software. The necessary memory for fully integrated programs is more likely to be provided by the small hard disk units (Memorex-101 8"—10 megabytes), which are considerably more expensive (Joiner and others, 1982).

The potential of the microcomputer, through CAI and CMI, to deliver a variety of programs at a variety of levels to a variety of students, seemed to be the instructor's answer to individualized instruction. Several elements still impede progress in this area. Though the cost of microcomputers continues to decline, the initial capital outlay to provide enough computers for even a relatively small number of students is still prohibitive. Likewise, the incompatibility of various brands of both hardware and software forces the purchaser to limit program selection to what is available for a particular system, to purchase a number of different systems, or to develop his/her own software, all of which are "costly" alternatives. Criticism of the "quality" of available software still proliferates (Blascke, 1979) and resistant faculty attitudes (Joiner and others, 1982) prevent extensive use of CAI. In spite of these issues, where CAI is being utilized on a large scale, improvement in student achievement and attitude towards learning has been good (Chambers and Bork, 1980).

No longer can instruction be viewed as a teacher and a group of students working in isolation. Experiences with CAI stress the importance of team approaches to the development of teaching programs. Authoring teams provided the means by which the large volume of PLATO materials could be developed, tested and implemented on a major scale. Staff development activities that provide basic microcomputer competencies for teachers who return to a totally traditional educational environment will likely not yield significant change. Instructional leadership which coordinates meaningfully the expertise and contributions of teachers, curriculum specialists, instructional technologists and evaluation specialists is necessary to achieve the changes required to derive lasting benefit from the new microcomputer technology.

As mentioned earlier, the initial number of microcomputers was generally small; therefore, access to these units was generally limited to two specific audiences —special education students and gifted students. Through these applications, the microcomputer established another beachhead. Computer programs using micros have been developed to aid the hearing, speech, motor and visually impaired. Talking computers are already available for the blind, while computer recognition of speech is rapidly improving the environmental control of the severely handicapped person (Joiner and others, 1982). The single-user nature of the microcomputer adapts especially well to meeting the variety of needs presented by exceptional children.

The second audience, gifted and talented students, makes extensive use of the third branch of CAI. "Simulations," based on the computer's problem solving capabilities, present the learner with situations requiring decision making, the results of which are projected, analyzed and reported to the student for continued alteration and manipulation. Students can run programs that control environmental, economic, socio-political and industrial models (Joiner and others, 1982). "Lemonade-Stand" (Apple) allows students to manage a mini-business controlling overhead, production, sales, etc.; "Geology Search" (McGraw-Hill) allows students to search for oil in a new continent, simulating geological tests; "CIVILWAR" is based on the strategies of 14 Civil War battles (Frederick, 1980).

The next wave of the microcomputer invasion was based on these same problem solving capabilities of the microcomputer. If students were to use the computer to experiment with various problem solving techniques and strategies, they had to be able to manipulate the computer's "intelligence." The need for instruction in computer programming was created. As modules and courses in programming were being written and tested, it became clear that additional areas of the curriculum could be integrated into these courses and the concept of the computer as an independent curriculum area solidified (Joiner, Miller, Silverstein, 1980). Under this new umbrella, courses in various programming languages developed; vocational computer education courses were implemented to teach students the skills necessary for computer related jobs; business courses were redesigned to give students experience in word-processing, data-base management, and automated accounting (Bork, 1978-79); computer science emphases also developed, covering such issues as computer theory, design and analysis.

Out of all this, sprang the new "buzz-term" for the 80s—"Computer Literacy." As the number of computer applications in society grows and as more and more microcomputers are available to all students, the need for a well-informed, well-trained, computer oriented population increases (Molnar, 1978-79; Poole, 1982). This very day, symposiums, lectures, presentations and courses are being developed around this single issue of "computer literacy." These rapid advances created serious problems for the professional educator who received little, if any, training in these areas.

The appropriate application of microcomputer technology to instruction implies changes in American teacher education. Both "computer literacy" and uses of microcomputers as teaching tools must be integrated in meaningful ways into pre-service teacher education. Educational technologists who understand the wide impact of technology on education should provide leadership for this instruction. It is unlikely that appropriate microcomputer competencies can be developed in existing methodology courses. Courses or other major learning segments in educational technology taught by technology specialists are necessary to the development of the in-depth knowledge and competence required.

Likewise, in-service courses for teachers are mandatory if schools are to implement microcomputer technology. One-shot courses, conferences and workshops can generate interest and develop awareness; however, they must be followed with extensive coordination, consultation and guidance if microcomputers are to be integrated appropriately into classroom practice.

Educational technologists who have extensive competencies in microcomputers are required if meaningful leadership and direction are to be given to this revolution in American education. These technologists must know more than just microcomputers; they must be based broadly in educational technology. They must know how humans learn and how instruction should be developed to facilitate learning best. Unfortunately, few such technologists are being prepared today in our colleges and universities, and few school districts have such personnel in the numbers necessary to facilitate appropriate integration of microcomputer technology into instruction.

While educators were still trying to "spread the computers around" so that more students could gain "hands-on" experience, while they were still trying to find or develop appropriate software, while they were still engaged in curriculum design and implementation, and while they were still searching for qualified professionals to teach and manage the microcomputers, the revolution assaulted yet another flank. Advanced applications of the type previously limited to large mainframe computers were being adapted to the microcomputer. Tremendous strides were taken in the micros word-processing capabilities. "Mini-Authoring" programs were developed; educators with little or no experience could use "skeleton" programs to provide computer structure for their course content. Teacher designed and produced CAI programs, quizzes, worksheets, and a host of other paperwork-type tasks could now be relegated to the school microcomputer.

Electronic worksheets (Visicalc-Commodore), which automatically calculate and recalculate rows and columns of figures, presented immediate administrative applications. As the number of microcomputers in the school increased, the ability to "network" (use one unit as the central memory for several other terminals) developed. This allowed the teacher to monitor several students at separate terminals, working on different programs, at a single central unit. And the combination of computer technology and video technology has created "interactive video," which presents even greater demands on the instructor than the original "drill and practice" programs that baffled many (Bork, 1978-79).

Educational leaders must take a comprehensive approach also to the use of the various newer electronic technologies available today. Microcomputers cannot contribute maximally to instruction in isolation from other technologies. Cable television systems, satellite communications, digital telephone networks for linkages between computers, low-powered localized broadcast systems and especially videodisc technology must be integrated into functional instructional communications systems capable of implementing the complicated processes which comprise human learning. Thus, it is unlikely that dropping microcomputers into technologically barren classrooms will result in significant change and improvement. A unified, holistic approach must be taken to the technological upgrading of American education.

The revolution is not complete, but in less than a decade, the microcomputer has infiltrated the breadth and depth of the educational system. The Congressional Office of Technology Assessment in its 1982 publication, *Information Technology and Its Impact on American Education,* stressed that "a broad approach, which takes into account the changing needs for education and training, considerations of equity and changing institutional roles will be required." Microcomputers have arrived in force in American schools. With them have come both a host of opportunities for improvement and challenges for change.

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LOGO will force teachers to become more like master teachers who guide others on the path of teaching and learning.

On first encountering LOGO; some questions for further research*

by Michael J. Streibel

I am always amazed that I can still experience all the excitement and anxiety of a beginner when encountering a new computer language. So it was when I encountered LOGO. Here was a rigorous, interactive and yet forgiving computer language that allowed me to create "objects-to-think-with" (Papert, 1980). I quickly went through the examples in the manual and marvelled at the ease with which I could manipulate graphics (Abelson, 1981). My years of hard work programming graphics in BASIC and FORTRAN seemed to melt away. I also began to study Turtle Geometry and became excited about the possibility of portraying complex concepts from finite differential geometry in a visual form (Abelson and diSessa, 1980). Finally, I was impressed with how high-level concepts such as recursion and top-down logic could be represented so easily in a computer language. My initial wonder is over now and it is time to investigate the educational utility of LOGO.

Several questions come to mind when investigating the educational utility of LOGO: 1) What kind of learning experience does LOGO provide? 2) Can LOGO be used as an efficient learning tool within the school curriculum? and 3) What is the role of the teacher in a LOGO learning environment? These questions are important to consider. LOGO gives a user a sense of mastery before that user has developed a thorough understanding of the content area with which he or she is working. This aspect of LOGO is very attractive because it provides a built-in motivator for learning. LOGO also has a simplicity of syntactical and semantical structure which make LOGO very easy to learn. This feature of LOGO brings us to the first question.

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What kind of learning experience does LOGO provide?

The LOGO language has been designed so that, no matter what a person is doing with LOGO, that person is always solving problems in a "top-down" procedural manner (Papert, 1980). An example should make this clear. Suppose you were asked to describe a fish tank. How would you proceed? You could describe all the things that other people know about fish tanks. You could also describe your own experiences with fish tanks. The number of ways to describe fish tanks is immeasureable. Each type of description can then be organized into a top-down hierarchy. Let us say that a fish tank includes a container, blue water, brown pebbles, green plants and swimming fish. In LOGO, this description would become:

```
TO FISHTANK
   CONTAINER
   WATER
   PEBBLES
   PLANTS
   FISH
END
```

The LOGO procedure called "FISHTANK" constitutes a wholistic event which is made up of smaller component events. Each component of the description, such as the statement "CONTAINER," is broken down into yet smaller components until some "primitive" level of LOGO is reached. Primitive statements in LOGO include commands such as "FORWARD 100" or "RIGHT 90." The top-down approach results in a hierarchy of descriptions in which each statement refers to an entire entity or event on one logical level while also referring to a set of procedures for generating that entity on the next lower level. LOGO, in other words, encourages the user to look at all events in a top-down procedural manner.

There are many consequences of the top-down procedural approach: 1) objects are treated as events and described in terms of the processes that bring about those events, 2) events are broken down into a hierarchy of subevents, 3) events at any level are described in clear, natural and explicit terms, and 4) errors at any level of the description are easily found and corrected. Each of these aspects of the top-down approach helps a person break complex problems into more manageable ones. This is the case no matter what the subject matter. What are the drawbacks of this approach?

First of all, vague, fuzzy, intuitive and "tacit" ideas are banished in the top-down procedural approach. The fish tank described above could not contain a component which could not be broken down into the primitive statements of LOGO. Vague ideas that are embodied in the LOGO code are considered "bugs" that have to be "debugged." Debugging procedures are a central feature of LOGO and involve translating all the terms of a problem into syntactically and semantically correct statements. A vague idea such as "PRETTY FISH" has no place in LOGO unless "prettiness" can be defined. In real life, on the other hand, the word "pretty" is used quite often without specifying exactly what is meant. This, therefore, poses a problem with LOGO because human beings often think about and solve problems in a fuzzy manner. Furthermore, human beings do not always reach some final clarity of thought when they solve problems.

Second, LOGO encourages the use of "local" procedural descriptions. This feature has its advantages and its disadvantages. A circle, for example, is described from the perspective of a person who is part of, and creating, the circle. In LOGO, this translates into instructions such as "move forward one unit" and "turn right one degree until you get back to where you started." Ableson and diSessa describe how LOGO can be used to teach finite differential geometry—a very local procedure-oriented area of mathematics. The same area of mathematics, geometry, can also be expressed in more abstract terms. Hence, a circle can be defined by the formula $x^2 + y^2 = r^2$. The terms of this abstract equation refer to a Cartesian frame of reference that is external to the actual circle. A person who represents a circle with an abstract equation is undergoing a different kind of experience than a person who is drawing a circle. How can LOGO provide the experience of non-procedural kinds of knowledge? Mathematics was used as an example here but the same question can be asked for other subject areas.

Finally, LOGO offers a great temptation for a user to remain at lower experiential levels. LOGO is an excellent tool for portraying certain ideas in visual form. This may very well be attractive to a "visually literate" population that has grown up with television and other visual media. Geometry is certainly more engaging when one can see a graphic representation of certain ideas unfold before one's eyes. But when does one let go of the graphic representations? In the learning process, it is very important to know when to leave experiences behind and when to start dealing with abstractions. While LOGO also permits the non-visual construction of concepts, the temptation to remain at more immediate experiential levels is strong.

In answer to the first question, therefore, LOGO provides two very general learning experiences for a student: 1) a top-down problem-solving experience, and, 2) a local procedure mode of thinking and describing. LOGO also provides an immediate "mathing" experience of finite differential geometry. Top-down problem-solving is one of the best ways to tackle any complex problem, and local procedure modes of thinking emphasize the process nature of events (Higgins, 1979). These modes of thinking are very useful for creating "objects-to-think-with" (Papert, 1980). These modes of thinking also take a long time to develop. This problem leads us to the next question.

Can LOGO be used as an efficient learning tool within the school curriculum?

There are many ways of defining learning efficiency. Unfortunately, a whole generation of behaviorists, educational psychologists and instructional technologists have assumed that the concept of learning efficiency requires the fragmentation of the curriculum into behavioral bits and pieces (Callahan, 1962). In contrast to behavioral theorists, however, "top-down" theorists stress the importance of high-level goals. Hence, communication skills, problem-solving skills and evaluation skills are considered the long-term "basics" no matter what the cognitive or developmental level of the learner. From the top-down viewpoint, the integrated activity is always stressed and used as the criterion for evaluating learning gains. In the behavioral approach, on the other hand, mastery of the part is required and evaluated before moving on to mastery of the whole—a bottom-up approach to learning.

An example from language arts can clarify the difference between these two approaches. In the top-down approach, a teacher would encourage a grade-school child to communicate an idea or feeling in writing no matter how incorrect the spelling or grammar. The primary emphasis would be on the wholistic goal (the intended communication) with secondary emphasis on increasing precision. A written communication would be evaluated in terms of how well the child at his or her stage of development communicated an idea. In the behavioral or bottom-up approach, a teacher would insist that a child master the modules on letter drawing, spelling and grammar before attempting to communicate an idea in writing. The example here exaggerates the characteristics of the two approaches in order to highlight their differences. These two types of learning theories are nevertheless very much alive. LOGO embodies the top-down approach, whereas traditional computer-assisted-instruction (CAI) tends to embody the bottom-up approach.

The two types of learning theories described here embody very different notions of learning efficiency. Carter (1981), in his article "LOGO and the Great Debate," describes the parameters of the debate between the top-down and bottom-up theories. In a LOGO learning environment, learning efficiency seems to revolve around the issue of "learning how to learn," whereas in the drill-and-practice CAI environment, learning efficiency revolves around mastery of component facts, concepts and skills. Both types of learning efficiency are needed at different times in the learning process. For now, however, we will focus on the notion of learning efficiency in the LOGO top-down approach.

Seymour Papert (1980), one of the main developers of the LOGO computer language, believes that "debugging" procedures are the key to learning how to learn. Learning efficiency in LOGO must therefore deal with the efficiency of debugging procedures. How does one learn to debug a program (or an idea)? According to Papert, a person debugs a program (or an idea) by articulating the steps for reaching the intended goal—all well and good. Experience with debugging, however, has shown that debugging sessions last many hours. LOGO users report having lost all track of time when debugging a program. Is this process an efficient use of time? If these extended debugging sessions are absolutely essential for LOGO to be a successful learning tool in the school, then the K-12 curriculum will have to be radically restructured. The only other option would be to allow a teacher or even an advanced student to act as a kind of guide for the LOGO learner.

Using LOGO as an efficient learning tool also involves human beings in another way. Learning how to learn requires mastery of a wide range of heuristic strategies, such as problem-formulation techniques (Polya, 1945). How are these strategies acquired? Very often it takes group problem-solving sessions to generate and then evaluate these strategies (Johnson and Johnson, 1975). LOGO serves as the environment within which these strategies are tested. Learning efficiency in this case deals not so much with right and wrong answers as with better or worse strategies for solving particular problems. Since it is often hard to tell which strategy is most suitable until after a problem is solved, the experienced judgement of a teacher becomes a critical factor in the efficient use of LOGO. This factor brings us to our final question.

What is the role of the teacher in the LOGO environment?

This question boils down to asking what a teacher does when teaching a student how to learn. My own experience has led me to develop an analogy between a LOGO teacher and a master teacher. A master teacher in any field knows the particular subject matter very well and also knows how to learn that subject matter. With this knowledge, a master teacher guides students towards certain skills and values. A master teacher is as much concerned with a student's learning autonomy as with a student's mastery of the particular subject matter. Learning autonomy and subject-matter mastery are not quite the same thing, although they are interrelated. Master teachers, in other words, empower students with the ability to learn.

LOGO provides a very good environment for learning how to learn. Young children working with teachers and LOGO often take the lead while exploring a particular program idea. It seems especially important for teachers to "back off" in such situations even though the student's approach might not produce the desired results. The principle here seems to be to help students gain an increasing control over the learning process. Coping with potential failure seems to be more important in learning how to learn than marching towards mastery.

The LOGO teacher's interaction with students eventually takes on a guidance and co-learning aspect. These guidance and co-learning sessions are far more effective for the student's mastery of an idea than leaving the student totally alone with LOGO. Guidance and co-learning sessions need not be one-on-one but can involve a group of many students. Learning with LOGO, in other words, is most efficient when an experienced guide is part of the process—a guide who does not lead as much as point the way.

The LOGO teacher's interaction with students also forces the teacher to spend a lot of time learning the particular subject matter. This may very well be a result of the teacher's intimate guidance and co-learning role. Teachers who want to use LOGO in their classrooms can therefore look forward to intensive, life-long learning as part of their profession. This experience differs sharply from a teacher's experience in a CAI classroom. In the latter case, a teacher acts more like an "instructional manager" than a co-learner.

The difference between the teacher's role in LOGO and in traditional CAI has to be examined further. Baker, in his book on computer-managed instruction (CMI), discusses the managerial aspects of a teacher in a CAI/CMI environment (Baker, 1978, 1981). For example, in CAI/CMI, a teacher records, assigns, evaluates, arranges, reports, organizes and coordinates with the help of a computer. These functions are not really new because they are performed every day by teachers as part of their profession. However, these functions are highlighted in computer-assisted and computer-managed instruction. What happens in the LOGO environment? Does a teacher still spend as much time supervising instruction as in CAI/CMI? Not likely! In LOGO, a teacher spends more time on guiding and co-learning than on grading and report-writing.

LOGO also forces teachers to recognize potential learning problems and learning successes in students as part of the guidance and co-learning process. Since many problem-solving strategies pay off only at the end of a long and arduous process, teachers can not rely as much on objective tests of student performance. Rather, teachers are forced to rely on their experienced judgments. This situation contrasts sharply with the type of evaluation that takes place in mastery-based, individualized CAI lessons. In the latter case, student progress depends on an objective demonstration by the student of each component skill (Carter, 1981).

Several things can now be said about the teacher's role in the LOGO environment. Teachers who wish to use LOGO in their classrooms can look forward to a very active teaching/learning experience. This is the case because LOGO works best when the teacher acts as a guide and co-learner for the student. Teachers will also have to deal with a student's failures and turn them into occasions for further learning. Teachers, in effect, will have to become autonomous learners who guide others on the same path. Finally, teachers will have to rely on their experience and intuitive judgements as they guide novice learners.

Summary

In summary, we can now treat the three questions asked earlier as a unit. Learning to use LOGO to create "objects-to-think-with" in any subject area is a way of learning how to learn in that area. LOGO shifts the focus of learning from component facts and concepts to wholistic skills without sacrificing precision at the component level. It does this by providing a rigorous and well-defined environment where a learner can experience high level concepts, top-down problem-solving approaches, and local procedural thinking. It may not be as useful for creating vague, fuzzy, or even contradictory "objects-to-think-with." Finally, LOGO will force teachers to become more like master teachers who guide others on the path of teaching and learning.

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If a new technology does not fit comfortably in the scheme of things or seems powerful enough to pose a threat, it is resisted until it can be reshaped into a tool.

Instructional technology and decision making

by Robert Heinich

It is a cliche in education that it is easier to invent technology than it is to get it into general use. Certainly the major problem of technology is in marketing, but perhaps the opening statement should be modified by saying that **some** technology is easier to invent than to get into general use. The extent to which any technology is welcomed into an economy or an economic subculture depends on whom it affects, how it affects them and whether potential beneficiaries are in a decision-making position. Because the larger system within which we function encourages the development and use of technology, we assume that all its sub-systems do.

The peculiar nature of the educational sub-system is that decisions to use or not to use technology are most frequently made by those who are potentially threatened by the technology and not by those who potentially benefit from the introduction of technology. Because of potential threats to job security, teachers tend to reduce all technology to the status of aids—to the status of tools used at their discretion. If a new or improved technology fits comfortably within the role of tool, then its adoption is much more readily assured. If a new technology does not fit comfortably in the current scheme of things as an aid—a tool (e.g. television)—but rather seems to be powerful enough to pose a threat, the new technology is resisted until it can be reshaped into a tool.

In education we tend to think that the natural client for all instructional technology is the teacher or professor. We tend to see no difference between, for example, the overhead projector and a television system. In reality, introduction of the overhead projector does not change or threaten the power relationships in the classroom. A television system on the other hand has the potential to change power relationships among faculty, students, administrators and public (as represented by legislatures, school boards, etc). Because of this difference, decisions to use overhead projectors are best made at the classroom level; but decisions to install and, more importantly, **use** television systems cannot be left solely with the faculty.

Decisions to **install** television systems **are** generally made at administrative levels, but decisions to use ultimately face faculty veto. We do not fully appreciate the importance of examining innovations in terms of their potential impact on power relationships.

Let me illustrate with an example from industry that is based in the history of technology. Suppose a sales representative from a machine tool maker demonstrates to the manager of a plant that manufactures machine screws a new tool to cut threads. The new tool permits a faster cut, doesn't wear out as quickly and is easier to mount in the lathe. The foreman wastes no time in showing the new tool to the lathe operators who are delighted to try it out. Here is obviously an innovation that has high probability of being accepted by the work force—and the manager is wise to consult them.

Next year the sales representative demonstrates to the manager of the plant a new lathe that **automatically** fashions machine screws. Fewer operators are needed to produce the same volume of screws. The plant manager immediately recognizes an innovation that will have an impact drastically different from the tool he adopted a year ago. Here now is a device that will appeal to the owner of the plant because it will make his company more cost effective. The consumer benefits also because the unit price of machine screws will drop. In the long run, the workers also benefit from the expanded job markets that result. But in the short run the manager knows the lathe operators will not look kindly on a machine that will do their job.

I am **not** suggesting by this analogy that children can be treated like machine screws. The point is that it is important to look at technology from the point of view of how it affects the system and the relationships between and among those working within the system.

Many media delivery systems are inherently capable of assuming the major burden of instruction: television, programmed instruction, computer administered instruction, audio-tutorial techniques, etc. The main question is whether our current instructional management systems encourage their use as mainline sources of instruction or reduce them to supplementary aids. Given the present fiscal problems facing the schools, this is a critical distinction. Any technology reduced to supplementary status becomes an add-on cost that is regarded as a dispensable luxury. A very revealing study would be to give teachers a comprehensive array of technology in a hypothetical situation and observe how they would peel away technologies as budgets are progressively cut. It will never occur to teachers to increase productivity through the technology available to them (that is, reduce the labor intensiveness of instruction, which in the long run is the best approach to making real salary gains). And the most durable technology, the last to go, will be the textbook.

The textbook is worth examining because it has been around so long, has become so much a part of the system, that we tend not to think of it as a product of technology. The textbook endures for two main reasons: cost efficiency and the symbiotic relationship that has developed over a long period of time between teacher and textbook.

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Publishers, who make their money through large scale adoptions and who, therefore, must be considered the most successful diffusion specialists, are sensitive to both. When money was in good supply, production values such as pictures, graphs and color were generously incorporated. As money started to dry up, textbooks became leaner, monochromatic and less lavishly illustrated.

Publishers also found out that the symbiotic relationship is disturbed if the book takes over too much of the instructional burden. A text is essentially a course of study between hard covers. It requires the teacher to translate it into effective instruction. If the text translates itself into instruction, as in a programmed text, the symbiotic relationship is disturbed, and the text is rejected. During my brief tenure in the publishing business, I learned that the hard way. The more "pedagogical aids" (in publisher's parlance) provided with the text the better, but there is a very important difference between "pedagogical aids" and self-instruction: the former underscores the need for the teacher. The point is that the adopters are telling publishers that they want something that is supportive, not threatening.

Other delivery systems can be looked at the same way. It is easier to sell and adopt individual film titles than it is a course taught by film—and not just because of cost or research evidence of the lack of effectiveness of the filmed course. (Of course, we should know by now that decisions to adopt technology, or any innovation, are not made on the basis of research evidence.) When the Agency for Instructional Television produces a series of programs for schools, it knows it will sell more programs if each program stands alone rather than articulates closely with the one before and the one after. And so on.

We must become more sophisticated in how we assess the relationship of technological innovations to levels of decision making and then we must pursue adoption at the appropriate level. The adoption process for a programmed text should not follow the process of adopting a textbook. Adoption of a televised course must be handled differently than reception of individual television programs. A complete course on film requires different adoption procedures than purchase of individual titles. Our experience in television and filmed courses teaches us that it is easier to adopt complete courses in subject areas **not** currently taught at all. For example, a course in physics delivered by film can more easily be introduced into a high school that does not have a course in physics.

We are currently going through a shortage of qualified teachers in science and mathematics. Will this mean that our high schools will be more receptive to courses delivered by technological means? Are the administrators in our schools prepared to handle technologically delivered instruction, or will they repeat our experience of the late 1950s and 1960s when televised and filmed courses and programmed textbooks were undermined by the traditional adoption process? We will soon be offered complete courses delivered through computers. How will we handle the decision making process implied by instruction available to the fingertips of students sitting at computer terminals? In order to answer that question we must have a better understanding of how levels of decision making are affected by the nature of the technology involved.

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Technology has been a two-edged sword. Educational technology is no exception. We can use it wisely and well or take the other path. The choice is ours.

Educational technology in the near-term future

by Kent L. Gustafson

Introduction

Despite profound improvements in our understanding of many technologies, the technology of crystal ball gazing has not shared in that happy trend. Gazing into the crystal ball, or technology forecasting as some prefer to call it, remains a hazardous occupation. While there is an element of chance in all forecasts (even tide charts are stated as forecasts), technological forecasters have a particularly poor record. However, believing any forecast is better than none, I offer a number of near-term prognostications for your consideration.

There is some evidence to suggest that near-term (3-7 years) technological futures can best be predicted by examining current trends. Beyond that time, as yet unforeseen, scientific and engineering breakthroughs could dramatically alter the scenario. With that caveat, this article projects probable near-term developments in educational technology.

A Definition

First, what is educational technology? Educational technology is much more than the glittering pieces of hardware we have become accustomed to in our daily lives. Rather, it includes a variety of people (learners, instructors, designers, managers, etc.), materials (sometimes called software), knowledge and information and their accompanying communication channels and lastly the hardware. Advanced technology also assumes specialization of labor, division of work and rapid accurate flow of information to and from all parts of a system. By this definition a computer is not technology. It is **part** of a technology which also requires people, knowledge, materials, and information if it is to perform any useful tasks. Further, educational technology is not limited to schools. Industry is now spending three times as much on education and training as is spent on **all** of public education. Having less tradition and fewer existing instructional practices in place, business and industry and the military are very much in the forefront of applying "educational" technology. Almost without exception they will be among the first to adopt the technology described herein.

Why, you may be asking, is such emphasis being placed on a definition of educational technology? The reason is that many of the most important events of the near-term future will focus on improving the **interfaces** among these components of technology in order to reap their potential benefit. By interface, we mean the interconnection and interaction among the parts. Technology simply doesn't work if the components don't interact as specified. In the near future, I believe the greatest impact on education and training will occur as a result of improving these interfaces rather than as a result of spectacular hardware breakthroughs. Let's now examine several existing types of hardware to see how developments in the area of interfaces will likely occur.

Computers

Consider the increasingly popular small computer. As a piece of hardware it has a number of useful applications,—paper weight, boat anchor, conversation piece, child's toy, etc. However, coupling it with appropriate applications programs and people who know how to use it opens a vast array of options. The key new element is not the computer—it has been around for some time. Unlocking its potential are its lower cost and relative ease of use. The biggest news about computers in education and training in the near future is that they will continue to become more readily available and much easier to use.

Easier use will result from software that is more friendly to users. That is, users will be able to interact with computers in common English language rather than the esoteric languages so popular with computer freaks. For example, until now, administrators who wished to use data based management systems had to rely on computer specialists to obtain output from a computer. Any variation in the format of requested data required incantations from the programmer and often a long wait. New data based management systems are on the horizon which will make it possible for managers to examine and manipulate large data bases, analyze data and prepare reports quickly and directly without knowing any significant amount of programming. This development has greater near-term implications for administrators than the fact that "x" company is about to announce a new super chip capable of storing one megabyte of information, etc., etc. The key development will be computer application programs structured to correspond to how people think and communicate. This contrasts sharply with current programs which force people to think like computers and learn to speak their language.

Other significant news about computers is that most of them will not be used to "compute." Word processing, data management and instruction (in that order of acceptance) will become the principal applications of computers in education and training. Word processing holds enormous potential for improving the quality and effi-

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ciency of both instruction and administration. Preparation of instructional materials such as handouts, worksheets, curriculum guides, etc., can be greatly enhanced by use of word processing. Similarly, administrative correspondence, record keeping and reporting can be made more efficient by using word processing. Word processing packages are becoming available which require virtually no knowledge of computers or programming and will run on multi-purpose computing machines. Further, these packages will have built-in dictionaries to check spelling and grammar programs to analyze sentence structure and length, subject-verb agreement and incorrect or poor use of vocabulary. (No more embarrassment due to misspelled words in flyers sent home to parents or to potential business clients.)

When computer-based instruction is mentioned, most educators think of students sitting at a computer engaged in drill and practice or question and answer exercises. While these are legitimate uses of computers and will continue, the future will see rapid expansion of other increased uses of computers. First, computers will be used more for managing rather than delivering instruction. Record keeping, test generation, machine test scoring, and on-line testing will be more acceptable to teachers than sending students to engage in drill and practice on a computer. Secondly, students will use the computer much more as tool than a tutor. For example, it will be used as a word processor for reports, calculator for arithmetic operations, simulator for case studies and processor for self-generated experiments. It will also be the object of instruction at all levels of education as we examine its operation, applications and very importantly, its impact on society. Personally, I just don't see it being used much as an ordinary tutor for drill and practice or programmed instructional materials. Students don't like them for these uses and neither do instructors.

How will all this new generation of case studies, simulations, etc. be created? Three sources will become important. It is my opinion that individual teachers will **not** become the primary source of computer-based materials. Why not? Teachers don't know enough about designing varied forms of instruction. The computer and its programs will not be the problem but rather teachers' lack of knowledge and experience in planning interactive learning experiences. Hence, there is a critical role to be played by commercial producers, school districts, consortia of institutions, professional associations and government agencies in producing and distributing materials. Commercial producers, educational agencies, teachers and students will all contribute to development of the necessary instructional packages. So-called "driver" programs will become available to facilitate local preparation of rather complex materials. Libraries of high quality graphics will be available as will large data bases for manipulation and experimentation.

Cable

The TV cables being installed in most urban and suburban areas also have major educational implications in the near future. Obviously, educational programs can be sent to homes as has been done over the airwaves for years. But the big news will be interactive cable. With the proper equipment on both ends, the cable can be used to request specific programming (a two-minute message on treating insect bites from the local hospital), interact with a simulation (assignment from the biology teacher on genetics) or take a test (home-bound student). Interactive cable systems capable of carrying large numbers of messages in both directions can link the school, library, museum, local college and home to provide a variety of educational alternatives to users.

Extended learning opportunities for adults will be increased by reducing travel time and cost and permitting study/interaction 24 hours a day. Home-bound students, working or part-time student interns and others who may just not want to go to school will have a vehicle for keeping involved in their studies. Electronic mail and message systems will provide necessary personal communication and general announcements for students not in the school. Administrators should note that messages for parents can also be distributed electronically to specified individuals or everyone via cable. Individually addressable TV sets make it possible to tailor messages or delete portions of communication not relevant to specific individuals.

All the physical technology for interactive cable has been available for several years. Recent developments make it likely that phone companies can also offer comparable services via their lines. Any delay in utilizing this hardware is based on cost and human factors. Since much of the cable is already being laid and most homes and offices have phones, the cost factor should decrease in significance. However, human factors such as school attendance requirements, funding procedures based on "school-age" children, labor intensive, teacher-oriented educational environments and tradition will remain obstacles.

Satellites

Satellite communication will also play an increased role in education and training. In particular, companies are beginning to use satellites to transmit training programs to numerous sites. Present cost figures make satellite communication feasible only under some conditions. However, substantial cost reductions in the near future are expected to accelerate its use. Relatively inexpensive receiver antennae will contribute to this cost reduction along with increased satellite capacity and greater competition among vendors. Educational conferences and meetings will make increasing use of satellite communication to reduce cost associated with travel and accommodations. Business and multiple-campus universities will increase their use of satellites to offer courses in several locations. However, other educational institutions will likely offer little educational programming via satellite.

Data transmission via satellite will greatly increase as educational institutions realize the benefit of accessing existing data bases and sharing data among themselves. Likewise, state and federal educational agencies will make greater use of satellites for collecting and disseminating information.

Video-Imaging

Integration of sound, simulated motion and very high quality graphics opens a variety of options never before available. For example, how about a 1,000 live resolution TV image (about 2 1/2 times as sharp as current images) which can be rotated or examined from any perspective. (Did I forget to mention it is a 3-D perspective?) This means in anatomy you can go **inside** the heart and look around or in architecture you can first look at the building from above and at ground level and then take a visual stroll

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inside. Computer-generated visuals which until now have been dismally poor in quality are about to make a quantum leap in improvement. Lasers will be employed to a greater extent to provide more realistic 3-D images which you can walk around or rotate. Reduction in cost, size and complexity of lasers is almost certain to bring about increased use, especially in training programs or other instruction which focuses on real objects.

Interactive Video

Learner-controlled interactive video will also become more common. Video disk and video tape will both be used to provide a vast array of still and motion images to learners. When learners are provided a computer and appropriate programming, they can be allowed to explore the contents of a video tape or disk as they desire or be carefully scheduled through its contents. Still and motion sequences, as well as sound and verbal material, can all be integrated into a single program. As of today, the principal limitation on use of interactive video is lack of well-designed sequences. There is a wealth of existing visual material and it seems likely that some portion of it will be tapped when knowledge of how to arrange it into interactive packages becomes known. As mentioned earlier, computer programs will become available which will make it very easy for non-programmers to prepare instructional programs around existing video materials once the psychological principles of effective interactive instruction become widely known.

Synthesized Speech

Synthesized speech is certain to play a role in education and training within a few years. Talking toys, elevators and shuttle buses are only the beginning. High quality human-like speech is already possible and its cost will drop rapidly in the near future. How about "talking" with a chip in a southern dialect or in Chinese? Language instruction (English and foreign) will change greatly as voice recognition devices improve. Carrying on a verbal conversation with your computer is closer than most of us think. Voice recognition and synthesis have enormous potential for conventional classrooms but may see their first wide use in special education where their applications are more obvious. However, it would be a gross error to assume that use by students with special needs is their primary application. Neither should voice recognition and synthesis be thought of solely as classroom devices. How about automated voice systems permitting you to register for college courses via the phone or to schedule parent/teacher conferences?

Instructional Design/Development

What can we expect in the area of designing instruction? Unfortunately, I see little of profound importance occurring in the next few years. It would appear we are continuing to plow the same worn ground in learning theory. While research on lateral specialization of the brain holds some promise, I personally doubt it will have a major near-term influence on how we design instruction. We already know more about teaching and learning than we apply. Like the proverbial farmer, "We don't farm now as well as we know how." This is a people interface which will be extremely difficult to modify in most educational settings. I am less than sanguine about rapid advances on this front in the near future.

Similarly, our models of the instructional development process show little prospect of soon leading us to any brave new world. Almost no significant conceptual advances have occurred in these models in the last few years and I predict none in the near future. Like a biological chain of organisms, our present approaches may have reached their maximum extent of development and be headed for extinction. We can hope this extinction would be due to replacement by conceptually more powerful models of how to modify institutional environments as well as instructional settings. Only when we can change the organization can we change how we "farm." As an aside, my hunch is that new significant contributions to the technology of instructional development will come from the fields of management, economics and evaluation rather than psychology.

Pharmaceuticals

Chemically modified learning along with retention is probably the most frightening technology to contemplate. Almost no one wants to even talk about it, but it is not going to go away. One of the great moral and ethical dilemmas we are certain to face in the near future is the role of chemicals in altering learning and memory. The scandal over use of depressants and other drugs to sedate "hyperactive" children provides only a glimmer of the magnitude of the issue. What about a pill to increase attention (an "upper") or another to calm noisy kids (a "downer") or one to enhance memory—or block it? When we learn how to stimulate the brain to recall more of what is known to be there, who will decide the when and how and why?

If you feel more than a little uneasy about chemical educational technology, welcome to the club. Although I am a supporter of educational technology, I have grave concerns about how we will approach pharmaceuticals. We can start the discussion now, or we can wait until they are already in wide use. I fear we will take the latter route.

Conclusion

The technologies described here **already exist.** They are not of the next decade, they are now and tomorrow. They are the educational technology we must wrestle with immediately. This article was written and rewritten on a personal computer. That same computer can "talk" via cable and satellites and central video tape and disk and lasers. It can synthesize speech, provide instruction, and structure simulation and gaming lessons if I want to create them. If this article disappointed you because it failed to alert you to some "gee-whizzy" technology, my goal is accomplished. The message is that the near-term future is now! I end on a cautionary note lest you think I am an educational technology Pollyanna. Technology can help but also harm, it can free but can also enslave. It can make us more human, but it can also dehumanize. Throughout recorded history, technology has been a two-edged sword. Educational technology is no exception. Make no mistake about it, **we will use more technology in education and training.** We can use it wisely and well or take the other path. The choice is ours.

We can no longer ignore the fact that a picture is not neutral.

Picture as visual text

by Ann DeVaney Becker

A picture is not neutral. The image within it has been organized by another human being, framed, shot through a lens, printed and presented within a border. It is an image "upon which meaning has already been conferred." (Nichols, 1981) Individual interpretation is embedded in each step of the photographic process, so a picture, paradoxically, may bring viewers a glimpse of an unknown image while distancing them from that real world image. In this complex process, interpretation continues after the making of a picture. Layered with meaning, the end product, the picture, is presented to viewers who read it and bring interpretation to what might now be called the visual text (Barthes, 1977a).

The hidden process of layering interpretation upon interpretation is apparent in the case of an advertisement. A viewer who drives past a billboard advertising toothpaste is acutely aware of the fact that the larger-than-life, sparkling white, capped teeth are there to persuade viewers to buy a particular brand of toothpaste. The absent graphic designer is not present but the verbal message, limited to the name of the toothpaste, is aimed at persuading the viewer to buy the product. Properties or characteristics inherent in the picture have accomplished the job. What was included in and excluded from the frame has meaning. Size and position of the focal point of interest are an interpretation, as are focal distance, angle and lighting of the picture. The graphic designer relies on structural units to communicate meaning. Viewers, or at least drivers, are accustomed to such visual assaults and are keenly aware of the intent of billboards.

Billboards are pictures which have the same properties as textbook images, or pictures used in instructional materials, or visual media used as stimulus materials in instructional technology research. In fact, the billboard image has the same properties as images defined and discussed in theories of learning from pictures. Yet instructional media designers, researchers, teachers and students often ignore inherent visual messages when using texts or instructional materials, when using pictures as stimuli in research designs, or when discussing the manner in which viewers process, store and recall information from a picture.

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Problem

In the past 20 years efforts have been made by instructional media researchers to employ differentiated stimulus materials in research designs. Significant growth in this direction can be assessed by the trend away from a comparison of undifferentiated stimuli, i.e., still vs. motion pictures, to comparison of characteristics within a medium, i.e., zooming vs. no zooming in a television lesson (Salomon, 1979), yet few people have been willing to approach a pictorial stimulus as a text which is read. Layers of interpretation are difficult to identify and investigators are often reluctant to grapple with the structural units of a picture. The task of interpretation, then, has been left to communication researchers and art and film critics; yet it is evident that not only museum photographs and films but instructional pictures are layered with meaning. That the task of decoding instructional pictures is difficult or that the task is hard to fit within the current research paradigm does not vitiate the fact that a picture is not neutral. If a picture is used as an undifferentiated stimulus in instructional technology research, layers of interpretation already present will confound the results of an experimental study unless these layers are accounted for. Explanations of learning from pictures also need to address the claim of picture as visual text.

Early research

World War II research forms a base for investigation in the field of instructional technology as it is known today. Instructional media researchers during and after World War II were in the thrall of operant conditioning as a model of behavior. Programmatic research (WWII) under a behavioral model brought some rigor to a field which previously had engaged in non-rigorous case studies. Pre-World War II film research, however, was conducted and sponsored by film makers, administrators, librarians, artists, photographers, as well as educators. These were the people who represented the emerging instructional media field in the early Department of Audiovisual Instruction. Not intrigued with the new directions in instructional media research and application, artists, filmmakers, librarians and others broke away to join their own areas of concern.

Certainly the post-World War II decades can be called the age of specialization in most fields, not only that of instructional technology. Specialization did encourage a rigorous pursuit of instructional media and learning issues, yet the growing insights of scholars in art, film and photography were generally excluded from that pursuit. Specialization within the respective fields has also introduced rigor to the exploration of interpretation of images. If instructional media researchers study and employ the same class of images as those used in photography, art and film, they might examine some techniques for interpretation of visual text with an eye toward incorporation and accommodation within their own field of study.

Identification of structural units

If the toothpaste advertisement and the textbook illustration can both be classified as pictures, what are the characteristics of pictures which might allow researchers to differentiate a visual stimulus within a research design? Which parts will allow the investigator to unpack the layers of interpretation inherent in a picture? This issue has been addressed in literature for decades. Rudolf Arnheim

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(1969) lists ten parts of a picture which yield meaning within a frame. John Kennedy (1974) lists seven methods of line representation which interpret surface within a frame. Artists may speak of border, line, color and shape as structural units which give meaning to a painting while photographers speak of frame, focal point, focal distance, angle and light as structural units. The divergent names of these units do not suggest confusion as much as they suggest the use of borrowed structures. Film borrowed some of its structure from photography, and photography borrowed some of its structure from painting. All the visual arts share some structural units and apply these units in a similar manner. Such application is a code, so visual arts have some similar infrastructures and borrow codes from one another. Each visual art, however, does have some unique codes. The search, therefore, for the proper name of a structural unit may not be as important as its frequency of use and necessity in the construction of the work.

Eleanor Gibson (1969) in her seminal work on perception suggests frame, focal point, proximity, angle of approach and depth perception as key units of a photograph. If motion is added to the picture, additional units present themselves for interpretation, such as the plane of the image, the plane of the space photographed, and the plane of depth perception (Monaco, 1977). Structural units of motion, such as panning, tilting, and zooming and switches, such as cuts, fades, dissolves and wipes, are familiar.

Use of structural units

Beyond the mere description of structural units within a picture lies the more engaging issue of how these structures yield meaning. Like words in a sentence, they yield meaning because of their pattern of usage. Like words in a sentence, they yield primarily contextual meaning. And surprisingly enough, like words, these units are connotative as well as denotive, for example, space included within a frame may be defined by what is imagined to lie outside the frame.[1] The unit of frame, then, is highly connotative.

The word *code* has been used to describe the pattern of usage of these structural units. Calls for the study of codes in visual media have come from Wilbur Schramm (1977), Gavriel Salomon (1979) and Howard Levie (1978) among others. In his work on symbolic codes Levie (1978) discussed the relationship between pictorial codes and mental operations and suggested that visual literacy study focus on this relationship. A team from the University of Iowa's Visual Scholar's Program (Cochran et al. 1980) addressed the issue of meaning, especially social meaning, in the relationship between visual media and mental operations. Codes or usage patterns of structural units of the TV frame have also been recently addressed by Mettalinos (1979).

Outside the field of instructional technology, codes are often considered within the domain of semiotics, a general science of treating "sign systems" (de Saussure, 1966). Visual media, such as photographs, film, filmstrips and television, communicate through the use of visual signs and symbols and are ripe for semiotic analysis. One analyst, Roland Barthes (1982), has most recently addressed the question posed earlier, namely, "How do structural units yield their meaning in a study of photography?" These analysts attempt to describe the parameters of a sign system, such as photography, by close observation of the existing medium. Basic objectives of this type of analysis call for a logical description of the codes and signs that give meaning to the system. These codes and signs must be observed from the inside of an existing medium. One must understand how they are used and what they contribute to the whole system.

Although semiotic analysis[2] is diverse, that body of literature does yield some answers to questions posed previously about the description and patterns of usage (codes) of structural units within visual media. In other words, the semiotic literature might yield analytic techniques for interpretation of visual text which could be incorporated in instructional technology research. Which structural units and which codes have been insightfully described in the semiotics of visual media? Roland Barthes describes structural units and their relation to the culture in which they are found. Not only does his analysis include visual systems, i.e., photographs, street signs, and film, but music and writing as well. His sweep is broader than some other analysts, with emphasis on orders of signification. Since he deals primarily with order of signification, that is, levels of meaning in the work presented, his techniques lend themselves to the investigation of the social, cultural and ideological meanings embedded in visual media.

That is not to say he ignores basic units. His first level of signification is the representation of the image. He moves swiftly through it to second and third order significations where his contribution is strong. Units of meaning addressed in the second order are immediately social, i.e., myth or shared cultural meaning and connotation. His third order addresses the manner in which shared cultural meaning is organized into a belief or ideology.

Barthes has contributed an awareness of the social and inherently ideological meaning of any visual text. His contribution should not be and has not been ignored. Many current literary and media analyses are indebted to Barthes, but two outstanding treatments which owe a partial debt to Barthes are **Reading Television** (Fiske and Hartley, 1978) and **Ideology and The Image** (Nichols, 1981). Fiske and Hartley describe structural units of British television, their patterns of usage and social meaning. These authors tend to address smaller units than does Barthes, but their analyses are social. **Reading Television** unveils the "myths" or shared cultural meanings embedded in video images, describes television "reality" and compares the manner in which television interacts with the culture itself. The book is a fine antidote to the consideration of television as a undifferentiated treatment in an instructional media experiment, and it also argues clearly for the teaching of television reading or the interpretation of video in the classroom.

A more complex treatment of social meaning and visual media can be found in **Ideology and Image** (1981), which draws upon perception theory and psychoanalysis as well as Barthes' principles of semiotics to complete its task. Working quickly through communication signs, perception theory, and essentially the Lacanian perception of self, Nichols (1981) carefully relates this discussion to advertisements and then leaps to a analysis of many forms of cinema. His strokes are broad, but his message is clear. Prescriptive ideological values are embedded in all visual media.

Christian Metz (1974) may be cited for semiotic analysis of film that is more detailed and concerned with aesthetic as well as social meaning. Unlike Barthes, Metz consistently addresses small units of filmic structure, such as shot. In fact, he describes patterns of shot and scene usage in a hierarchy. The description lies along two axes, syntagmatic, which considers the sign selected in the shot or scene, and paradigmatic, which considers the set of signs from which the shot or scene was drawn. Besides providing a rigorous model for analysis of film, which he calls his Grand Syntagmatic, Metz mounts compelling arguments for the language of film. After Metz, one cannot claim that visual media do not have their own communication system. That system may be called a language.

Relying on Barthes, Gianfranco Bettetini (1973) presents a detailed social, aesthetic and technical analysis of the language of film. He contrasts this film language with some television techniques.

The most thorough linguistic analysis of film has been made by John Carroll in **Toward a Structural Psychology of Cinema** (1980). Carroll leans heavily on transformational grammar and argues that film language is generative.

Codes and visual media

The description of visual codes is the domain not only of semiotics. Social scientists have concerned themselves with such description for some time. Erving Goffman (1979) uses the concept of "frame" to explore an ethnographic analysis of advertisements.

Worth and Adair (1972) in a famous study with Navajo Indians asked questions about which compositional style novices would use when asked to tell a story with film. They found that native narrative styles used to tell existing Navajo myths and stories emerged in film composition. In fact, certain grammatical structures were transferred intact to film composition. In other words, narrative codes embedded in Navajo myth dominated the new medium or supplied a borrowed infrastructure for their film.

A study similar to the Worth and Adair study was conducted by ethnomethodologists Beryl Bellman and Bennetta Jules-Rosette (1977) in Africa. They asked approximately the same questions of natives selected from two African communities in Liberia and Zambia. Questions about compositional style of novices were posed. Video cameras were given to the selected participants who then created their own stories on tape. Traditional narrative codes which appear in the oral literature of both of these tribes were transferred to the composition of videotape. As with the Navajos, the Africans' compositional style was narrative. When Bellman and Jules-Rosette conducted this same study with American TV production novices, it was found that their dominant compositional style was dramatic, not narrative. Bellman and Jules-Rosette gave a detailed reading of the units of motion contained in the narrative style of videotaping. Patterns which emerged on the tapes were extensive use of panning for establishing shots, slow panning throughout, an absence of zooms (whereas Americans used the zoom), use of dollying and use of hesitations. What they described for the first time were codes of narration in documentary videotape.

This paper has presented an argument for the consideration of any picture as a visual text. It has presented applicable descriptive analysis and research from investigators who have approached pictures as visual text and suggested that instructional technology research address itself to this "state of the art" analysis in visual media. The accommodation of visual text in instructional technology need not require a paradigm shift. Even through semiotic analysts use the time honored method of individual interpretation in their investigation, instructional media researchers could use existing observational methods. Precise observation is a social science method which provides verification and generalizability. The task is enormous but workable, and one can no longer ignore the fact that a picture is not neutral.

Reference Notes

1. For a thorough description of the meaning of a frame read Noel Burch's discussion of space within the cinema frame and imagined space outside this frame in **Theory of Film Practice.**
2. The scope of this paper does not include a basic explanation of semiotics, only examples of its application. For a basic discussion read Terrace Hawkes' **Structuralism and Semiotics.**

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In the next few years we should be able to reflect and build careful models of technology.

The next decade of instructional technology research

by Richard E. Clark

I've always thought that writers who try to predict the state of a field beyond a few months are guilty of projecting their wishes onto supposedly objective forecasts of the future. For that reason I tend to set aside unread all manuscripts which begin—"By the year 2,000 . . . ."

Even presumably objective methods of future forecasting such as Q-sort and other summaries of "expert opinion" are suspicious because they tend to be highly subjective individual goal statements in summary form. With this bias in mind then, I am going to try to make some limited projections concerning the direction of research for the next few years while attempting to separate my wishes from what I perceive the "reality" of things will be. With your forbearance, I'll begin with my view of the realities of research in our field during the next 10 years.

Realistic Trends in Instructional Technology Research

I generally find four crucial realities confronting research in instructional technology, and three of them are mildly alarming:

1. Graduate programs in instructional technology will continue to deemphasize research and research training and focus instead on design and development.
2. Research questions will become increasingly distant from the most popular design and development models.
3. Media research will continue to dominate the field in spite of evidence that media variables do not contribute to learning, achievement or performance.
4. Our knowledge of prescriptive theories and research strategies will increase with a parallel increase in the potential of research to solve immediate and practical problems in instruction.

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I. Research Deemphasized

There is no indication that the trend has diminished. We can hope that this is a temporary problem. It has been partly caused by the difficult economic times which have led to greatly diminished financial support for both research and research training. Other possible contributors are the increasing concern with jobs on the part of prospective graduate students and the reluctance of faculty to insist on rigorous training. Students assume that research training is preparing them for jobs in research laboratories and correctly assess that there are few of those types of jobs available. Of course, they tend to forget that indepth knowledge of research is required to acquire "consumer" skills which allow technologists to advance their profession. Faculty contribute to the trend through a fear that the diminishing pool of graduate students will select programs which deemphasize research in favor of instructional design or media production. Programs without students tend to be eliminated by cost conscious universities.

Of course, it is research which leads most directly and consistently to successful technology. When research is deemphasized by our graduate training institutions, the young people enter the profession with little training or inclination to advance knowledge. This may lead to a situation in which there is increasing distance between the types of questions asked in our limited research programs and the instructional design models currently being utilized.

II. Increasing Distance Between Research Questions and Design Models

Our most successful and popular instructional design models are the "mastery" approaches which have been derived from behavioral research and "learning rate" studies. On the other hand, our most popular research questions deal with cognitive processes, individual differences in learning and trait-treatment interaction hypotheses. Researchers, having established that different learners profit from different types of instruction, are in the process of refining that insight and producing specific generalizations. Instructional designers continue to employ models of instruction which ignore individual differences and attempt to find the best instructional method for all students. Evidence that individual differences influence achievement even in the behaviorally based mastery approaches such as the Keller Plan (e.g. Reiser, 1981) is generally ignored by developers.

This is a less serious problem than it appears to be. Part of the problem is that individual differences are very difficult to accommodate in instruction given the current economic and political climate in most instructional settings. Another mitigating factor is that research has not progressed to the point where findings can be utilized to solve instructional problems more efficiently or effectively at this time.

III. Invalid Media Research Persists

It is likely that the next few years will see a continuation of our tendency to repeat a very popular but very invalid type of research question. Since one of the main historical origins of instructional technology was the media and audio-visual movement, it is understandable that media questions would dominate research. However, many decades of research have failed to yield adequate media selection guidelines or a clear specification of how different media might enhance learning or performance. As radio and movies were replaced by television and television is slowly being replaced by minicomputers as the hot topic in research, both the research questions and the results of the studies remain typically disappointing.

The reason for the disappointment is that we simply have failed to learn from the results of past research what Keith Mielke warned us about nearly two decades ago (Mielke, 1964). That is that there is no reason to expect a difference in learning when we contrast the relative merits of two or more media since media are generally the "inert" carriers of instructional messages rather than the "active ingredient" in learning. The many surveys and meta-analyses of media research studies which have been conducted since the Mielke article bear his assertion out. When there are learning benefits to be found in a media study, they are inevitably attributable to the instructional methods employed or the content of different programs plus the types of students participating in the studies. This is a highly counterintutitive finding and as such it rubs deeply against our prejudices.

To suggest that different media or forms of media have no direct influence on learning also runs counter to the claims and pressures of a multimillion dollar industry which exists to sell media to educators. All of us have been guilty of being persuaded more by our desires and slick advertising than by the overwhelming evidence from research. If we were to pile up all media comparison studies on a continuum with one end representing studies which have shown extreme learning benefits from media and the other end representing failures, the resulting pile would look very much like a normal curve. There would be very few complete failures and successes but a huge number of equivocal results that are largely uninterpretable.

Even the successful studies would be susceptible to very plausible rival hypotheses due to design errors. Of course, there are valid questions in regard to and a critical need for media in education. Media make the delivery of instruction possible in different forms and to diverse audiences at potentially lower costs than our currently labor intensive delivery system. However, it is very likely that we will continue the very wasteful practice of researching the question of media effects on learning. The alternative is to place more emphasis on instructional methods, content and learners.

Prescriptive Research and Theory Trends

One encouraging trend in instructional technology has been and will continue to be the development of prescriptive instructional theory (e.g. Shuell, 1980). Prescriptive research differs from traditional research in the types of questions it addresses and the ways it draws on prior theory to develop generalizations useful in design and development. One of the main reasons why research has not been more influential in practice has been our nearly total reliance on the descriptive research and theory which characterize the "pure" and predominantly physical sciences. Recently we have begun to understand that additional research and theory must be developed to extend the work of the more basic sciences. A basic theory of learning, for example, does not seem to have any direct utility in the design of instructional methods because it is a description of one version of how people learn. Prescriptive theory, on the other hand, attempts to provide generalizations about how people **might** learn, given realistic constraints and goals. Descriptive theories of learning involving individual differences, for example, have found that there is a strong, positive relationship between intelligence and learning. The higher our general ability, the more we will learn in typical instructional settings. This knowledge does not necessarily help the instructional designer who wishes to enhance the learning of the lower ability student.

Prescriptive research and theory depend on the more basic variety of science for their existence but they **extend** basic research into more utilitarian forms and generalizations. As an activity it precedes design and development which are very complicated problems in themselves. Space limitations preclude a thorough discussion of this very large issue but readers may be interested in consulting articles by Clark (1982), Shuell (1981) and Glaser (1978) for additional information. It is sufficient here to notice that this trend to prescriptive research and theory is one of the more robust and positive forces in instructional technology research and the trend will probably continue to grow over the next decade.

Desirable Research Trends: A Personal View

In a more subjective vein, I have a great fear that our graduate programs will fall victim to short sightedness. Even though we may attract more students by advertising training in design and in popular new media such as minicomputers, the more secure long term contribution is to be found in demanding depth skills in a variety of areas, including research. I have found that it is necessary for professional technologists to have a great deal of knowledge about research in order to understand the problems they confront well enough to generate and understand novel solutions. Giving graduates prejudiced models and solutions enormously decreases the half-life they enjoy as contributing professionals and similarly affects the entire profession they represent. There must be a more positive middle ground between our current curriculums, the often fickle and limited goals of prospective students and the demanding and well rounded programs which will insure our continuing ability to contribute successfully to education and training.

Next, there is great promise in certain recent research directions and less certain promise in others. While we should be reluctant to discourage inquiry of any kind, we simply cannot rationalize the sheer amount of certain kinds of research when compared with the benefits we have derived from them in the past. The media and learning question described earlier heads this list, of course. More fruitful areas deal with the blending of new advances in cognitive psychology with existing technologies which have derived from behavioral research.

I have been impressed with the work of David Rumelhart and Donald Norman on the use of analogies to teach complex procedures (Rumelhart & Norman, 1981); with Henry Levins' extension of the use of keyword mnemonics to teach foreign language vocabulary and facts in sequence (Levin, 1981); with Pelligrino and Glaser's (1980) highly creative studies of the mental processes that underlie inductive reasoning; with the work of Dick Snow (1981) on general ability and Robert Sternberg (1980) on specific abilities which influence learning under different conditions; and with Joseph Rigney's model of the function of external instruction in influencing internal processes (Rigney, 1980). These researchers (and many others) are gradually providing a map of the mental processes which we engage, modify or buttress with external

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instruction. These maps or cognitive models of learning will eventually be compatible with the behavioral technology we currently employ and should blend nicely with existing instructional methods.

Another problem being addressed in research at the present is advance in our knowledge about techniques which promote the transfer of learning. To date we have mixed information about the effectiveness of transfer technologies such as the "identical elements" technique (Clark, 1980). However, work by Royer (1979) has added some coherence to the area and promises to increase greatly our knowledge of technologies which promote the transfer of learning from the training environment to the application setting. One expected byproduct of this advance is more knowledge about how to transfer instructional technologies between nations and cultures.

Limited space prevents listing more than the most outstanding directions which we might take. The problem which confronts us at the moment is that we have many useful directions possible in research and a continuing development of research technology at a time when the activity is out of favor in universities and in the profession. The next few years will probably find research with lower levels of support but with the opportunity to reflect and build careful models rather than act under pressure.

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ROBERT E. SCOTT

Robert E. Scott, professor of adult and occupational education in the Kansas State University College of Education, died May 1 in Manhattan. Scott had been a member of the Educational Considerations editorial board.

Scott was found to have cancer in the spring of 1982 and although he had been in and out of hospitals since, he had continued to work at least part time until the middle of last April.

Scott is survived by his widow, the former Charlotte Bowman, of the home at 1405 Westwind in Manhattan; by a daughter, Janice Marie Scott of Overland Park; and by two sons, Paul Robert and Larry Eugene, both of the home. Also surviving are his parents, Leo and Frances Scott of Independence; a sister, Shirley Amend, Council Bluffs, Iowa; and a brother, Lloyd Scott, Pawhuska, Okla.

Born Dec. 13, 1931, at Independence, Scott was graduated from Independence High School in 1949 and from Independence Junior College in 1951. He earned B.S. (1953) and M.S. (1956) degrees from Pittsburg State University before receiving his Ed.D. from the University of Missouri in 1965.

From 1953-1955 Scott was in the army at Fort Riley; from 1956 to 1963 he taught industrial arts at Pawhuska, Okla.; and from 1965-1970 was on the faculty of Pittsburg State University.

Scott joined the KSU faculty in 1970 as coordinator of industrial education and had held the rank of professor since 1973. He was a frequent consultant to such organizations as the U.S. Army, Catholic Hospital Association, American Institute of Baking, and vocational schools in Kansas, and had been cited for outstanding service by the American Nursing Home Association.

He was a past president of the Kansas Vocational Association and a member of numerous professional and honorary organizations. He was author of two books and more than 50 other publications.

Two memorials have been established in Scott's memory: a Robert E. Scott Cancer Research Fund through the KSU Department of Adult and Occupational Education and the KSU Foundation and a memorial through the First United Methodist Church, Manhattan.

Scott has been replaced on the editorial board by Gerald Bailey, professor of curriculum and instruction at Kansas State University.

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