CHAPTER I

Design and Selection Factors

PAUL SAETTLER (1968)

This issue of the REVIEW is the first to include a discussion of design within the context of educational media and technology. Instructional design is still an unexplored theoretical and research frontier, and at this stage in the history of instructional technology the function of an "educational designer" has yet to be clarified, let alone implemented in instructional practice beyond the most rudimentary beginnings. There are no texts or guidelines appropriate for use in designing instructional media-messages, nor do we possess a sufficient body or experimental knowledge which can provide a basis for such design.

Cooney and Allen (1964), Gagne (1965), Glaser (1966), Taylor and Williams (1966), and others have offered suggestions concerning a whole class of experimental investigations which might be fruitful in providing some scientific underpinnings for instructional design. Since experimental foundations for such design are presently lacking, however, this review will focus on selected theoretical formulations and experimental investigations which appear to pinpoint relevant factors in design. The first section is essentially a historical prologue, different in purpose from the rest of the review, to provide the reader with a contextual background for assessing contemporary media research. Because of space limitations, the remaining sections will be confined to those theoretical views or experiments which deal specifically with instructional media. This review will not, therefore, consider whatever relevant data may be derived from other fields such as social psychology, neurophysiology, mathematical engineering, computer programming, linguistics and psycholinguistics, and developmental psychology. Also, since educational objectives and learner variables are specifically dealt with in other chapters of this issue, these topics will be set aside with the understanding that it is impossible to deal adequately with instructional media-message design apart from a consideration of the learning task and the modes of learner information processing.

Background of Media Research

Saettler's (1968) historical study of instructional technology revealed a long media research tradition extending back more than half a century. Yet, despite this long tradition, media research has had little relevance to instructional design. This section will, however, review those few studies which warrant rediscovery because of their value for future research.

Hoban and Van Grmer (1950) produced the most comprehensive review of media research undertaken during the 1918-50 period summarizing results of more than 200 experiments on instructional films. Few general reviews of this period have been written. McClusky (1949) analyzed the early media research, and Dale, Finn, and Hoban (1950) made selective review of the literature to 1948.

Freeman (1924) has reported on the classic, yet generally unknown, series of experiments conducted at the University of Chicago in the 1920's. This monumental study consisted of 13 individual experiments representing the first systematic experimental investigation instructional media variables and making the first use of experimentally designed media for this purpose. Since the Chicago experiments still suggest areas for further study, they warrant particular attention. A few of the major conclusions follow:

1. The relative effectiveness of verbal instruction as contrasted with various forms of concrete or realistic material in visual media depends on the nature of the instruction to be given and the character of the learners' previous experience with objective materials.
2. The comparison of the film with other visual media (slides, graphs, still pictures) as a means of instruction when the medium variable is motion (e.g., a film showing the motion of a steamboat was compared with a still picture of the same object) indicates that the film is superior within a restricted range and type of content, but that outside this study, the other media are as effective or more effective.
3. The peculiar value of a film lies not in its generally stimulating effect, but in its ability to furnish a particular type of experience.
4. **It** is inefficient to put into films actions which can be demonstrated readily by the teacher.
5. **In** teaching science and how to do or make something, demonstration is superior to the film.
6. Films should be so designed as to furnish to the teacher other inaccessible raw material for instruction but should leave the organization of the complete teaching unit largely to the teacher.
7. The teacher has been found superior to all visual media in gaining and sustaining attention.
8. Each of the so-called conventional forms of instruction which engage visual media has some advantage and some disadvantage, and there are circumstances under which each is the best form to use.

The University of Chicago experiments clearly laid the groundwork for media research by investigating relevant instructional design variables which still remain largely unexplored. In addition, these experiments anticipated current research centering on single-channel versus multiple-channel communication. Unfortunately, however, the promising research areas opened by the Chicago experiments were not developed further nor did research investigators adopted a limited experimental design which has persisted to the present time.

Near the end of the first decade of media research, Weber (1930) pointed out that no further experimentation on the comparative value of media was needed and recommended that future research should be conducted to determine the optimum length and content of instructional films and to discover whether a topic in biology may be taught with the aid of a hundred feet of film, a series of lantern slides, several colored charts, and a model or two, all in addition to the traditional microscopic slides. He further recommended that the researcher study the problem of individual differences and interrelationships between animation and other psychological factors.

Weber's research recommendations went unheeded, and the next 15 years reflected mainly additional media comparison studies which produced in most cases the same monotonous result of "no significant differences." This barren era of media research did not come to an end until Hovland, Lumsdaine, and Sheffield's (1949) *Experiments on Mass Communication.* Their research report is of great historical value, containing the most comprehensive discussions concerning instructional media variables and offering fruitful suggestions for media research which has yet to be undertaken. It was also during this period that Gibson (1947) undertook a series of investigations dealing with perceptual learning and the value of films for psychological testing.

Both the Instructional Film Research Program at Pennsylvania State University and the studies conducted by the U.S. Air Force in the 1950's manipulated instructional film variables by producing experimental versions of films incorporating defined variables and then comparing their effects on appropriate groups of learners under controlled conditions. These studies demonstrated that no effective

techniques had yet been discovered. Comparable studies of this type have declined appreciably in recent years.

The sheer volume of research on instructional television over the past decade has been unprecedented in the history of media research. Yet, the comprehensive report of Reid and MacLennan (1967) indicates that most of these were media comparison studies. Stickell (1963) analyzed some 250 media comparison studies of televised instruction and direct instruction and classified 217 as "uninterruptible," 23 as only "partially interpretable" because of defects in experimental design, and only 10 studies as "interpretable." All of these 10 showed no significant differences in learning at the .05 level between televised and direct instruction.

Media research reviews appeared in the April 1956 and April 1962 issues of the REVIEW. Other reviews have appeared periodically, e.g., Allen (1960), Lumsdaine (1963), Lumsdaine and May (1965), May (19658, b; 1966), Travers (1964). Two volumes of abstracts and indexes-*Office of Education Research Reports* 1956-1965, *Resumes* and *Office of Education Research Reports* 1956-1965, *Indexes* -- provide the most complete review of government-supported media research for the 1956-65 period ending in December 1965. Also, since January 1967, Educational Resource Information Center (ERIC) has published abstracts in monthly issue *Research in Education.*

The research literature reveals that the bulk of the experiments which have some relevance for media-message design were generally completed prior to the 1960's. Moreover, the total number of analytical experiments on theoretically relevant instructional variables has been small during past 50 years. Obviously media comparison studies have predominance. In a critical analysis of this latter type of research, Knowlton (19??) observed that in most of these studies it was the addition of a medium not the message variable, which was considered to be the variable under investigation. He noted that these studies failed to reveal any significant information about media because they were not, in fact, research on media since their experimental designs did not provide a satisfactory method analysis which separated the physical characteristics of the medium design vehicles of the message carried by the channel.

Theory and Technology of Instruction

It is obvious that a technology of machines exists, but it is also equally clear that an adequate theoretical and operational base for a science and technology of instruction does not presently exist. The curriculum reform movement and such instructional innovations as programmed instruction language laboratories, multimedia communication systems, and computer assisted instruction a\1 stress the need for a more systematic theory of instruction. But how, if at all, does a technology of instruction differ from a theory of instruction?

For Bruner (1966), a theory of instruction would be concerned with (a) the question of the kinds of prior experience that are most likely to predispose the learner to learn, (b) the way in which learners organize and structure knowledge for the most effective learning, and (c) a consideration of the sequence of encounters with the materials to be learned that is most likely to result in efficient learning. For Glaser (1965), on the other hand, the four aspects of a technology of instruction would involve (a) analyzing the characteristics of subject matter competence, (b) diagnosing preinstructional behavior, (c) carrying out the instructional process, and (d) measuring learning outcomes. These descriptions reflect converging concepts of a theory of instruction and a technology of instruction.

The essential difficulty in the development of a scientific technology of instruction is the serious lack of

relevant theory and experimental evidence. Moreover, much of the data which may be relevant is either too fragmented or too widely dispersed throughout many disciplines. Although the task of integrating large bodies of empirical data about instruction has been started by such men as Ausubel (1967), Jahnke (1967), and Rogers (1967), nothing less than a concerted effort by behavioral scientists, teachers, media and communications specialists, and philosophers will bring the needed cross. fertilization to provide a science and technology of instruction.

Gagne (1965) proposed a taxonomy of behavioral objectives and a related taxonomy of types of learning which have implications for the selection of media for instruction. Gagne outlined eight types or categories of learning, each with its own rules, and arranged them in a hierarchy from simple to complex on the assumption that each higher order learning category depends on the mastery of the one below it. Although S/R conditioning is at the base of his hierarchy, Gagne rejects the sufficiency of conditioning. The Gagne taxonomy offers some interesting possibilities for future research.

An urgent need exists for a taxonomy of instructional media which can provide a systematic approach to the selection and use of media for educational purposes. Meredith (1965) has suggested that such a taxonomy can provide the basis for four sets of variables: (a) the physical variables in the material and form of the physical medium providing the stimulus, (b) the neuroanatomical variables in the sensory/motor structures involved in the responsive behavior of the learner, (c) the ecological variables which take account of architectural and other environmental factors responsible for the context of media, and (d) a collective set of variables which embody the time dimension, factors of memory, learning, growth, history from the past, attention, purpose, expectation, imagination, and anticipation. Fleming (1967) developed a taxonomy of instructional illustrations which included physical types (size, color, etc.), verbal modifier types (captions, etc.), educational objective types, and subject matter types.

Additional References: Bloom (1956); Gage (1963); Krathwohl, Bloom, and Masia (1964); Richmond (1967); Saettler (1967); Siegel (1967); Verduin (1967).

Design of Multimedia Instruction

A monograph by Briggs and others (1967) reviewed relevant research, dealt with shortcomings of media research, made recommendations for future research, and reported a six-step procedure for designing a media program. This procedure, which stemmed from Gagne's hierarchical model, involves a team approach in systematically matching behavioral objectives to media as well as analyzing behavior and types of learning. As a consequence, the resulting behavioral changes would generate research for the improvement of future media design and would provide some data about the nature of individual differences and learner interactions with each other and teachers.

With respect to selection of media, Briggs and others proposed ways "to use a single medium for the optimum length *of* time most appropriate set of objectives" and decide among the alternatives: group instruction, individualized instruction, teacher-conducted instruction, and automated instruction. The authors concluded that others expect a more complex method of analysis with the increasing computers in education, but that the final solution: media should be based on relevant research findings and that the familiar comparison study cannot result in improved instructional design.

Smith, Schagrin, and Poorman (1967) reported on a multimedia used in conjunction with the Harvard Project Physics which implied many of the objectives of the Briggs report. Answers were sought in designing, developing, field-testing, and evaluating a sequenced unit involving all media and consisting

of materials produced by Project Physics, and in addition to programmed texts and commercially available films, the experimenters reported that they designed their multimedia systems with the idea of changing the traditional role of the teacher toward a tutor and guide. They found evidence of increased instructional preparedness, particularly in individualized instruction. They concluded that research in multimedia systems should include investigation of student/medium interactions, use of multimedia systems in teaching and instruction, and the development of a self-instruction teaching system and multimedia system as a framework.

Multiple- Versus Single-Channel Research

A prevailing assumption of audiovisualists and many research instructors is that learning will be more complete as the number of cues in the learning situation increases. The most influential theoretical notion embodied within this view is that which posits a continuum of effectiveness extending from the real situation or the object to a series of abstractions through a photograph, a model, a film, to a verbal description. Thus this theory led to the practice of multiple transmission channels, especially the pictorial, with as much information as possible because almost all studies showed a combination of to be more effective than one channel alone.

In reviewing past experiments on the relative value of transmitting redundant information through two sensory channels rather than one, Travers (1964) could not find any study which did not exhibit methodological flaws, nor could he find conceptual support for that a combination of two channels is more efficient in commonly used information than a single channel. Moreover, he further questioned the bulk of evidence supporting multiple-channel efficiency Broadbent's (1957) model of the perceptual system and evidence which tended to favor single-channel efficiency.

Travers and others (1966) completed a series of experiments using nonsense syllables as stimuli and concluded that there is little or no advantage to completely redundant materials in two channels, except at very high speeds when the multichannel message does not show as great an increase in errors as a single-channel message. This channel is hypothesized to contain a filter to prevent information from entering the system at a rate beyond its capacity and also a temporary short-term as well as a long-term storage system.

Severin (1967) observed that the Travers conclusion was specific to the redundant situation and stressed the use of the cue summation and the stimulus generalization principles in a method for comparative testing of multiple-channel presentations with single-channel presentations. In essence, the cue summation principle of learning theory predicts that learning is increased as the number of available cues or stimuli is increased. The other principle, stimulus generalization, would predict that information gain increases as a testing situation becomes more similar to the media presentation situation.

Conway (1967) questioned the assumptions underlying the Travers studies as well as earlier media experiments (see Hartman, 1961; Hoban and Van Grmer, 1950) and indicated that an enormous disparity has existed between experimental settings and relevant situations, that serious methodological flaws have been manifest, and that an underlying conceptual framework has been generally lacking in media research.

Additional Reference: Norberg (1966).

Approaches to a Psycholinguistics of Media

Knowlton (1964) developed a theory of pictorial communication and provided a critical analysis of media research. In an effort to develop "a metalanguage for talking about pictures," he assumed that further theoretical and experimental development required a pictorial or iconic unit of analysis as the formal basis for a taxonomy of visual-iconic signs. Knowlton's taxonomy is independent of the physical attributes of the sign vehicles categorized and requires that a visual-iconic sign "be analyzed in a way that takes account of the verbal context in which it is embedded."

Pryluck and Snow (1967) provided a conceptual analysis as the theoretical basis for the development of a psycholinguistics of cinematic communication. Since no vocabulary or syntax can presently be elaborated, they suggested that conceptual and terminological problems inherent in cine-language be partially resolved before the initiation of empirical investigation. Pryluck and Snow's analysis included the consideration of the multiple information channels available for cinematic communication, the nature of interactions between separate channels, the unique functional roles of the production features of each channel and combinations of channels, selection of appropriate units for the analysis of cinematic communication in each channel, and the specification of the syntactic structure of each channel, with particular attention to the nonverbal content of cinema. This conceptual analysis was concluded with a statement of some preliminary assumptions drawn from the field of psycholinguistics an originally presented by Miller (1965) as admonitions to psycholinguist researchers.

McLuhan's (1964) contention, "the medium is the message," has been widely quoted and analyzed in recent years. If this statement is intended as a metaphor, then it seems clear that it expresses a fundamental truth that the medium per se is important in that different media place different restrictions on the kinds of messages they can mediate. It is important to recognize, however, that the message cannot be confused with the medium in an instructional context and that there is, at best, only a low-order correlation between message and medium. McLuhan has produced a classic lineal argument in *Understanding Media* that a medium is any item of technology (e.g., clothes, money, roads, cars, houses, weapons) which either does not communicate information or communicates information only as a peripheral function. Moreover, he exaggerates a truth about the causal relevance of media into an unqualified theory of historical change

Additional References: Langer (1967); McLuhan (1967).

A Symbolic Interactionist Model of Human Communication

Hulett (l966a, b) provided a model of the message-generating process and described some symbolic interactionist principles which could be applied to the analysis and description of some theoretical and empiric issues in the field of human communication. This general approach was based on the view that an analysis of communication begins with what the human individual is actually doing when he encodes and transmits messages and when he receives and decodes them in a particular situation. The greatest error or deficiency in communication occurs when the intended receiver is ignored or when the communicator has wrong information on or makes wrong assumptions about him. The communicator’s degree of success depends on the accuracy and completeness of the information stored in his cognitive map of the environment, on his awareness of his need and ability to take the role of the receiver, and on his general efficiency and accuracy in assessing the interpersonal feedback loop so as to control the entire

communication transaction.

Additional References: De Fleur (1966); Hall (1966); Smith (1966); Thayer (1967); Watzlawick, Beavin, and Jackson (1967).

Word-Picture Relationships in Media-Messages

May (1965b) reported on experiments which suggest that prefilm verbal instructions and other verbal procedures are more effective for directing and sustaining attention than built-in devices and that visual devices are more effective for cue identification. In the section of his report on perceptual responses and perceptual learning, he noted that misunderstanding of the intended meanings of spoken words and of the visuals could result in failure to learn. In other portions of this report, a large number of experiments were cited which indicated that significant differences between experimental and control groups on tests of immediate recall disappear on tests of delayed recall. In a very few experiments the reverse was reported to be true. May pointed out that a problem basic to understanding picture-word relationships in learning from audiovisual presentations is that of sensory dominance. In addition, more laboratory experiments are needed to explore the relations among sensory dominance, learning, and retention as well as the relative merits of words and pictures for attracting and holding attention. There also is a need for more analytical studies of the roles of visual and verbal symbols in media messages.
Additional Reference: Melton (1964).

A Search for Instructional Film Design

Wagner (1966) made an approach to the design of instructional films by producing a series of four experimental films on communication theory and the new educational media. Out of this effort came a design which Wagner called "a galaxy of films" a concept calling for the production of predesigned clips or "film-links" which would make it possible for an instructor to put together his own film without destroying either picture or sound track. Thus this film design allows the instructional message to be restructured to provide for individual instructor and student needs.

Cooney and Allen (1964) reported an exploratory study that used the film medium to examine the relative effects on learning of visual images presented nonlinearly or simultaneously and visual images presented linearly or sequentially. These experiments were conducted with sixth and eighth grade children, and such variables as sex, language. IQ, ability in arithmetic reasoning, and environmental conditions were considered. The results showed that the difference between the nonlinear and linear formats for the sixth grade groups barely missed significance and that this difference held up well in the delayed test. Also, the mean scores for these groups favored the nonlinear format in both immediate and delayed tests.
Additional References: Miller (1967); Smith and Smith (1966).

Relevant Research in Computer-Assisted Instruction

Few experiments have been undertaken in computer-assisted instruction which appear to be relevant to design. It is obvious that the technology of programmed instruction is in disequilibrium with the technology machines. Although the first linear models of programming were largely influenced by the theory of operant conditioning during the first stage of the contemporary programmed instruction movement, it is apparent there is much uncertainty as to what constitutes an effective program, and it is even less certain that programmed instruction or computer-based instruction must inevitably be interpreted as individualized instruction

Suppes and Groen (1967) and others at Stanford University have offered some fruitful approaches to computer-assisted instructional des Lewis and Pask (1965) have developed a system of instruction based on the notions of cybernetics and artificially intelligent adaptive behavior. Needed are parametric studies of theoretically important variables on effectiveness of programs.

Additional References: Briggs and Angell (1964); Briggs and Rami (1964); Bushnell and Allen (1967); De Cecco (1964); Holland (1965); National Society for the Study of Education (1967); Schramm (1964).

Summary and Conclusions

This review has provided a historical perspective by describing pattern of media research during the past half century and has shown the prevailing experimental design to be the media comparison type of study. Apart from the serious methodological problems associated with much of this research, as a whole it has had only peripheral relevance to media-message design. Comprehensive theoretical and experimental bases are lacking for such design. In view of these limitations, only those theories, models, and experimental investigations which appear to suggest some basis for a technology and science of instructional message design and analysis have been selected for review.

The period under review has been distinguished by an increasing recognition of the need for a systematic, scientific approach to instructional design. What we need are criteria and procedures whereby we may match a medium to the requirements of a learner. To do this we must change the nature of our research on media-message design and develop adequate models of communication before we can hope to provide a scientific framework for the instructional designer. In the reviewer's opinion, what is needed is systematic research on the relative effectiveness of analogical and digital modes of representation as these relate to the content of the instructional message, to communicator and learner characteristics, and to the physical and psychological aspects of a particular medium or combination of media. It also is suggested that the cognitive approach (e.g., Neisser, 1967) to problems of design may offer a fruitful avenue to future research.

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