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ABSTRACT

This five-part document presents three approaches to research on instructional improvement, with the final two sections concentrating on problems and implications for diagnostic prescriptive instruction. Part 1 reviews comparative instructional effectiveness studies. Part 2 discusses the Trait-Treatment Interaction Approach (TTI) which is concerned with the effects of instruction as they interact with individual differences. Part 3 focuses on the Systems Approach--comprehensive in its analysis of the learning situation. A model of this approach is presented in detail. Part 4 presents implications for research in diagnostic-prescriptive instruction. This section discusses research dilemmas and offers possibilities for coping with difficulties. It also includes a matrix of components and variables serving as a selective identification of research studies. Part 5 concentrates on implications of instructional improvement. This section offers a variety of diagnostic data and collection techniques and instruments which have been developed. (JS)

A Systems Approach to Diagnostic Prescriptive Instruction [1] [2]

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Those educators charged with the task of improving instruction often have to make instructional prescriptions while lacking both sufficient diagnostic data and a history of research results which could aid in the processing of the data. The expediency of the situation often leads the instructional developer to make decisions based on no more than intuition. Unsurprisingly the results are typically less than spectacular; and faculty respond accordingly. As Popham (1974) points out:

> For too many years we found professors of education peddling vapid platitudes such as "meet learners where they are" or "teach students, not subject matter." Having encountered such educationist pap, what clear-thinking professor would not be revulsed? (p. 12)

The need for a research based approach to diagnostic-prescriptive instruction is obvious. That one does not exist is not due to the fact that the effort has not been made. There exists a long history of research on techniques and methods to improve instruction, but it is filled with no significant differences and inconsistent results.

It is the position of this paper that such findings are not due to inadequacies of present instructional technologies and strategies. Rather they reflect a basic weakness in the traditional approach to research on instructional improvement. This research is based on a simplistic notion of the learner and his interaction with the learning environment. An approach is needed which accounts for the complexities of the human learning situation.

This paper will present three approaches to research on instructional improvement. Problems and implications for diagnostic-prescriptive instruction will be discussed. A model for a systems approach to diagnostic-prescriptive instruction will be presented in detail.

The Search for Main Effects

The first attempts at improving instruction were not diagnostic and could hardly be considered prescriptive. The early approach consisted of trying to identify the "one best way" to teach all things to all students. It rested on the premise that learning is the same for all students and that the only thing that need be done to improve instruction is to find that technique or method which maximizes learning. Resulting prescriptions would amount to "always use television" or "programmed instruction is best," depending on whom one talked to.

The research which accompanied this approach to instructional improvement was essentially comparative. A typical study would hypothesize that some recently developed instructional method or technology would result in more learning than the old method (i.e., lecture). Each new method or technology that was developed would foster a surge of such experiments. Unfortunately more than two decades of this research has left us with no panaceas.

A review of comparative effectiveness studies by Briggs, Compeau, Cagne and May (1967) examined research on television, motion pictures, programmed instruction, pictorial presentations, radio and recordings, three-dimensional models and field trips. The review found no consistent results favoring one method over another. As far as prescriptions are concerned, Briggs et al. (1967) pointed out that "neither the learning psychologist nor the classroom teacher can justify such decisions (media selection) entirely on the basis of present research evidence (p. 138)."

A more recent study by Jamison, Suppes and Wells (1974) examined the research on the effectiveness of traditional instruction (TI), instructional television (ITV), programmed instruction (PI), instructional radio (IR), and

computer assisted instruction (CAI). Most of the studies reviewed compared one of the technologies to traditional instruction or to another technology. Consistent significant differences were not found. A sample of summary statements are:

> ITV can teach all grade levels and subject matters about as effectively as TI...(p. 38)
>
> These evaluations indicate that IR (supplemented with appropriate printed material can be used to teach most subjects as effectively as a live classroom instructor or ITV. (p. 33-34)
>
> ...it is reasonable to conclude that PI is generally as effective as TI... (p. 41)

Jamison et al. (1974) conclude their review by saying that, "students can learn effectively from all these media, and relatively few studies indicate a significant difference in one medium over another or of one variant of medium over another (p. 55)."

The tone of several recent articles by McKeachie (1974a, 1974b) is suggested by the title of one of them, "The decline and fall of the laws of learning." In these articles McKeachie reviews research on a variety of instructional technologies and strategies. The technologies reviewed include the Keller Plan, programmed learning, computer-assisted instruction, simulation and games, and instructional strategies such as feedback, reinforcement, and questioning. Each section is summarized by such underwhelming statements as:

> Thus it appears that CAI has no special magic that will solve our instructional problems (1974b, p. 173).
>
> Despite the increasing popularity of simulation and educational games, little evidence on their instructional effectiveness has emerged (1974b, p. 174).
>
> Knowledge of results is not necessary for learning (1974b, p. 186).

One is left to conclude after reading McKeachie's (1974a, 1974b) work that, with the possible exception of the Keller Plan, no one medium has been

demonstrated to be better than any other. As for instructional strategies, "...what we psychologists took to be verities are principles that hold only under limited conditions (1974b, p. 186)."

Even a recent article by Moldstad (1974), which was intended to be upbeat, can hardly stem the tide of inconclusive results. Entitled, "Selective review of research studies showing media effectiveness," the purpose of the review is not to be comprehensive or to review the many non-significant difference media studies. Rather it is to call attention to selected studies that demonstrate media effectiveness and can therefore be used by media directors to justify their programs (p. 391). As a result Moldstad is left with a set of generally obscure articles, comparing traditional instruction to traditional instruction augmented by technology, and for which only supportive results within a study seemed to be reported.

Reviews such as those cited above leave the "one best way" approach to instructional improvement virtually indefensible. The reason for its failure is not some insensitivity of the research methodology or inadequacies of instructional technologies and strategies, but rather a basic insensitivity of the approach itself. With its simplistic view of the learning process the "one best way" approach ignores the individual differences and complexities of the learners.

Trait-Treatment Interaction Approach

The trait-treatment interaction approach (TTI) is a combination of two schools of psychology: psychometrics and experimental psychology (Glaser, 1972). This approach is concerned with the effects of instruction (experimental psychology) as they interact with individual learner differences (psychometrics) and is essentially a reaction to the simplistic

approach described above. The basic premise is that there are a number of characteristics that differ with different learners and which interact with instructional methods making one method of instruction effective for those learners who have more of a certain characteristic while a different method is effective for learners with less of the characteristic. This is termed a disordinal interaction. The possibility of disordinal interactions occuring is not dissonant with the lack of consistant results identified by the comparative studies of main effects. A significant disordinal interaction can "average out" in the examination of main effects and result in no significant differences between treatments.

An example of this effect is demonstrated in a study by Stanton (1974). Stanton compared the effect of lecture presentation versus independent study on learning. There was no significant difference between the two groups. However there was a significant interaction between treatment and the personality factor of anxiety. It was found that students with high anxiety learned more with guided reading and those with lower ability learned more through lecture. Such results emphasize the difference between the TTI approach and the less sensitive main effects approach which buries interactions in error variance.

The implications this approach has for instructional improvement is represented by an adaptive mode of instruction (Glaser, 1972; Cronbach, 1967). This mode of instruction assumes that different instructional treatments work with different learners. The match, or prescription, of method and student is based on data on individual students (the diagnosis) and knowledge about research on the interaction of these variables and the instructional methods.

Unfortunately little systematic TTI research has been conducted since the approach was first suggested some fifty years ago (Washburne, 1925)

or popularized in 1957 by Cronbach and Gleser. What research has been done has left instructional developers with little results but some optimism.

A report by Cronbach and Snow (1969) discussed the implications of individual differences for instruction. Although the authors found a few interactions, in their review of the literature they generally concluded that few or no TTI effects have been firmly established; the frequency of significant interactions is quite low, and the evidence is often not very convincing.

A review by Bracht (1970) carefully examined 90 studies for significant interactions between treatment and aptitude. In the 90 studies 108 interactions were identified, of which only five were significant disordinal interactions.

Berliner and Cahen (1973) conducted a thoughtful and comprehensive review of recent TTI research. Fifty-five studies were organized for the purpose of analysis into personality, ability and status trait classifications; and inductive vs. deductive, structured vs. unstructured, subject matter, concept learning, mathemagenic strategies and programed instruction treatment classifications. Trait (student)-trait (teacher) interaction studies were also examined.

Significant interactions were much more prevalent in this review than in the earlier ones. One possible explanation is that researchers are approaching TTI from a meaningful theoretical position rather than as an interesting side note to the study of main effects. Recent studies have been arranged specifically to test interactions suggested by learning theory. A second reason is that the type of traits examined in recent TTI research have shifted from the rather general aptitude traits used in early research on individual differences to those which more closely correspond to specific

cognitive processes.

However Berliner and Cahen (1973) conclude their article by stating:

> Lest an overly optimistic view of the present status of TTI research be conveyed, we hasten to point out the many cases where hypotheses about interactions were not confirmed and where findings of interaction were contrary to the hypotheses that guided the study. In addition, most studies of interaction have not been replicated; when replicated, interactions have not been confirmed (p. 85).

Even though the TTI approach seems to be quite promising, it still suffers from a basic problem which is, ironically, the same problem which its proponents attribute to the main effects approach: a lack of sensitivity to the complexities of the learning situation.

Although the inclusion of a trait factor accounts for a systematic variance which would otherwise be considered error variance in the main effects approach, the examination of one trait can hardly be considered sufficient to handle a situation as complex as classroom learning. Berliner and Cahen (1973) allude to this when the recommend future research in the area of trait-treatment-task interactions. There remains a need for an approach to instructional improvement and instructional research which accounts for the wide variety of factors which influence learning.

A Systems Approach

The systems approach extends the logic of the TTI approach. Whereas TTI examines only two components of the learning situation (traits and treatments), the systems approach attempts to be comprehensive in its analysis.

A system is a collection of parts or components which can be conceptually separated from its surroundings (environment). The distinction

between components, the system, and the environment is relative and to some extent arbitrary, and is determined by its usefulness to a particular analysis. What is a component in one analysis may be a system in another analysis. In a systems approach the components of the system are identified and the interdependencies of the components ascertained.

The system pertinent to this paper is the classroom, and the environment is the school and the larger society. By assuming that classroom instruction is essentially a communication process, identification of the components of the classroom system can be facilitated by examining the work done in communication theory. Berlo (1960) identifies four critical components in a communications model: the source, the message, the medium and the receiver. Figure 1 depicts the application of this model to the classroom situation. Respective components are the teacher, the subject matter content the medium, and the learner.

Any model of learning must obviously include and focus on the learner. The learner is probably the most complex component of the system. There are many learner attributes which can interact with other components to influence learning. Gagne (1970) stresses the importance of what he calls internal conditions which must exist in order for learning to take place. Internal conditions include previous learning, or achievement of relevant prerequisite skills and factual information, as well as the presence of various cognitive strategies and attitudes. This aspect of the learner has generally been ignored by TTI research in favor of aptitude, which has had a history of interest in TTI research. Other attributes of potential import are status and personality.

Another important component in the classroom learning situation is the instructor. Very little work in TTI has concerned the interactive effect

of different types of teachers on different types of learners. What little that has been done was briefly discussed by Berliner and Cahen (1973) in a section titled trait-trait interactions and remains inconclusive. Attributes of personality, ability and status have been considered. Other attributes to be considered are specific abilities dealing with the instructor's subject matter competence and teaching competence, as well as teaching style and teacher attitudes.

A third component in the system is the content or the subject matter of the course. Much work has been done in an effort to classify course content in a way that would be amenable to research (Bloom, 1956; Krathwohl et al., 1964; Gagne, 1970; Merrill, 1973). Most of this work has dealt with the types of learning tasks required of the learner. Briggs (1968) also discussed content in terms of its hierarchical structure. Although there have been some studies which have expressed subject matter concerns as treatment factors, Berliner and Cahen (1973) did not identify any studies which examined content characteristics as an independent factor.

A final component in system is the medium. This term is used broadly to include presentation strategies as well as the mode of presentation. This factor has generally been included in TTI studies as the treatment factor. Although there has been a long history of concern for treatment interactions, little has been done until recently to systematically classify the various treatments. Merrill and Boutwell (1974) and Baker and Schutz (1972) have attempted to come up with a taxonomy of treatments.

Environment represents another factor which can affect learning. Although most environmental variables are likely to be represented in one of the four system components, there may be variables which are independent and should be considered as a fifth factor. Such characteristics may

include physical environment, school environment and society.

Table 1 details the components, variables and indicators. This list is intended to be suggestive rather than exhaustive.

Implications for Research

The systems approach has the potential for serving as a basis for a comprehensive approach to instructional research. The detailed list of components and variables in Table 1 forms a very complex complete factorial matrix. Although such research design would account for all conceivable main effects and interactions, it would be both unfeasible and undesirable to conduct such a massive study. Rather the matrix should serve as a check-list for a selective identification of research studies. Each cell of the matrix is a potential research treatment, and each cell should be considered for its compatibility with learning theory and the potential significance of its implications for instructional improvement.

The feasibility of research based on this model is increased by selecting one or a small number of cells for a research study. Although any given study would thus be simplified, it would still retain its sensitivity to the complexity of the learning situation by controlling for systematic variance. The coordinates of the cells would act as a set of qualifiers to the generalizability of the results (probably a good thing since the results of most studies are over generalized). Through a series of small independent studies more and more cells would be filled over time. As the matrix is filled more elaborate comparisons could be made.

Such an approach to instructional research abounds with problems. The most profound is of course the nearly infinite number of cells in the matrix. Several possibilities exist for coping with this problem. One possible

solution is to use factor analysis or multiple regression to statistically reduce the number of variables for each component and construct more parsimonious taxonomies. A second possibility is to reduce the number of variables through more subjective means. Practiced intuition or application of learning theory could be used to identify those variables which are conceptually the most powerful. A third possibility is to develop statistical analyses which can compare such a large number of variables, possibly by using profiles rather than single variables.

A second major problem is measurement. The comparison of cell values assumes that each is a measurement of the same thing. This is a dubious assumption when comparing measurements of learning across subject matter contents. Can one equate a mean of 80 on a Chemistry exam with a mean of 80 on an English exam? Psychometric or statistical standardization of measurements is required before this approach can be reliable across subject matter. There also exists a criterion problem. What should be the dependent variable? test scores? final grades? student attitudes? This question begs for a multivariate reply.

It appears that the methodological problems to this approach are immense. Whether the results would be worth the effort is difficult to answer. Pending the solution of these problems, an immediate application of the systems approach would be to expand the TTI approach to include at least one measure of each of the system components making it a trait-treatment-teacher-task-environment design.

Implications of Instructional Improvement

The implications this approach has for instructional improvement are similar to those of the TTI approach. As with TTI the treatment or prescription is based on the characteristics of a particular situation, however with

the systems approach the diagnosis is much more complex. Whereas with TTI the diagnosis involves analysis of the individual differences of the learners, the systems approach requires a description of each of the system's components. The appropriateness of the treatment may depend not only on the kind of students one has, but on the type of teacher, content, and environment as well. A much more sophisticated diagnostic process is needed.

Among the variety of diagnostic data and collection techniques and instruments which have been developed, are those described below.

Learner analysis (Gagne, 1970; Schwen, 1973) is used to describe the learner in terms of available prerequisite skills, cognative style, interests and aptitudes. Prerequisite skills can be measured by pre-course exams covering the contents of the course, grades achieved on prerequisite courses, or assessment of student ability of skills specified as necessary for the course.

Cognative mapping is an effective masure of cognative style; preferred learner modes or strategies for information reception can be determined. There are a variety of scales which measure learner interests and attitudes. One of the most simple is C. Robert Pace's (1971) inventory. A more complex instrument which measures student background, aspirations, and demographic information as well as attitudes towards learning is the College Student Questionnaire developed by the Princeton Educational Testing Service (1965). The Meyers-Briggs Type Indicator (1962) provides a measure of differences in student personality resulting from the way they perceive and judge. Data obtained through these and other measures imply prescriptive recommendations concerning appropriate media use, content to be learned, and teacher strategies.

Content analysis (Merrill, 1973) is used to describe the subject

matter in terms of concepts, relations, and operations which define it. Concepts can be categorized as abstract or concrete and the relation between them is hierarchical or non-hierarchical. The operations which define content can be measured in part by task analysis which specifies the types of learning required of the student. This analysis results in a hierarchy of interdependent learning tasks which must be compared to the learner's existing skills. Prescriptions indicate the sequencing of content the learner must follow.

Media analysis (Briggs et al., 1967) requires an examination of the content in order to determine the most important media for the learning situation. Media as it is used here includes software as well as hardware technologies and thus refers to simulations, role playing, and questioning techniques as well as overhead projectors, computer terminals, and other pieces of hardware.

Instructor analysis describes the dominant instructional style preferred by an individual teacher. Typologies of teaching styles developed by Richard Mann (1970) and Joseph Axelrod (1973) provide a measure of this dimension and allow for adjustment of prescriptions to meet individual instructor's attributes.

Interaction analysis (Flanders, 1970) characterizes the direction and affect of teacher-learner interactions. Direction two-way, affect positive, need exists to make direction and affect contingent on the value of component variables.

Most of the above techniques were developed independent of the others, and deal with only one component of the learning process. Researchers at the Center for Research on Learning and Teaching at the University of Michigan are working to develop a synthesis of these techniques which will adequately diagnose the learning situation without becoming unwieldly. Data is being

gathered using many of the instruments described above and others which are still being developed. Initial attempts to gather diagnostic data will be accompanied by experiments designed to fill in a small number of selected cells in the system's matrix.

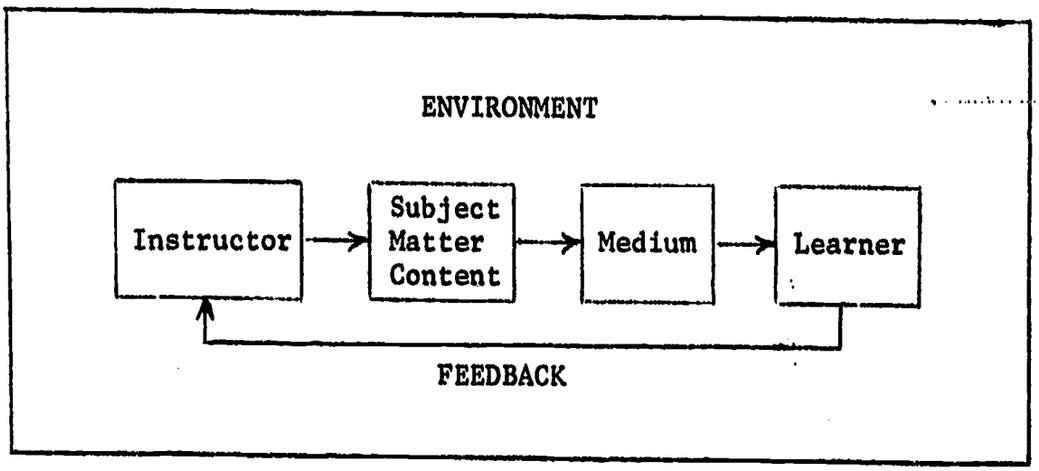

Figure 1. A systems view of the learning situation.

Table 1. A Systems Approach: Components, Variables and Indicators

- Learner
  - Previous Achievement
    - pretest
    - prerequisite skills test
    - assignment grade
    - test score
    - previous course grades
  - Aptitude
    - SAT Total
    - SAT Verbal
    - SAT Math
    - HS GPA/rank
  - Status
    - class
    - major
    - school
    - sex
    - age
    - race
    - SES
  - Cognative Strategies
    - auditory-visual
    - inductive-deductive
    - decoding skills
    - encoding skills
    - memory
  - Attitudes and Perceptions
    - attitude toward school environment
    - attitude toward instructor
    - attitudes about content
    - attitudes about instruction
  - Personality
    - anxiety
    - achievement motivation
    - open-closed mindedness
    - sociability
    - dependent-independent
    - introversion-extraversion

- Instructor
  - Status
    - age
    - sex
    - race
    - rank
    - tenure
    - length of time since degree
    - length of time at school
  - Subject Matter Competence
    - publications
    - matriculation
    - courses taught
    - awards and honors
    - research and grants
  - Teaching Competence
    - length of time taught
    - awards and honors
    - ratings
  - Teaching Style
    - learner centered
    - teacher centered
    - content centered
  - Attitudes
    - attitudes about students
    - attitudes about subject matter
    - attitudes about instruction
    - attitudes about instructional environment
  - Personality
    - anxiety
    - achievement motivation
    - openess-closed mindedness
    - sociability
    - dependent-independent
    - introversion-extraversion
- Content
  - Objectives
    - affective
    - cognative
    - psychomotor
  - Structure
    - hierarchical structure
    - lateral structure

- Environment
  - Physical
    - room size
    - temperature
    - seating arrangement
    - acoustics
  - Course
    - type of course
    - credit hours
    - course hours
    - enrollment
    - number of sections
    - interpersonal relations between students and teacher
    - interpersonal relations among students
    - homogeneity
  - School
    - department's support for teaching
    - departmentally sponsored functions
    - percentage of courses taught by teaching fellows
    - national ranking
    - size
  - Society
    - credentialing
    - economic conditions

- Media
  - Organization
    - pace
    - sequence
    - scheduling
    - goal setting
  - Mode
    - interactive
    - learner initiated-teacher initiated
    - audio
    - visual
    - emotive
    - kinesthetic
  - Strategy
    - feedback
    - practice
    - response con sequences
    - response mode

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