INSTRUCTIONAL STRATEGIES:

Multivariable Studies of Psychological Processes Related to Instruction

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13. ABSTRACT

This report summarizes the activities conducted within a program of research aimed at investigations of instructional conditions that make for optimal learning, so as to improve and advance the efficiency of training. The specific directions of the research were defined in terms of: a) the characteristics of instruction ~~(i.e., what the instructor does)~~ and their effects on learning efficiency and outcomes; b) learner behaviors (i.e., processes employed by the learner) under specified instructional circumstances, and their consequences in learning outcomes and training efficiency; and c) the influence of ~~status variables~~ (i.e., individual differences) on learning with special emphasis on how individual differences in performance are important in instruction, and how these individual differences (or aptitudes) interact with instructional methods. The investigations included the following topics: the identification of individual differences; the influence of individual differences in imagery-ability and auditory-visual preferences on learning and recall; an analysis of the dynamics of note-taking and their influence on learning; instructional strategies for teaching concepts; the organization of instructional materials; social factors in instructional settings; and personality and motivational factors as variables in problem-solving. All studies were conducted within the conceptual framework of psychological principles that ~~were~~ believed to provide the foundation for the teaching learning process.

Instructional Strategies: Multivariable Studies of Psychological Processes Related to Instruction

Final Report

This final report is a summary of research completed under subject contract during the period from September 1, 1968 to June 30, 1971. It is based entirely on the outcomes of investigations conducted by personnel associated with the program. A complete listing of technical reports, dissertations, and other publications emanating from this program and to which references are made for statements in the summary is provided at the end of this report.

Personnel

The principal investigators on this program of research were Francis J. Di Vesta, Professor of Education and Psychology; Nicholas Sanders, Assistant Professor of Educational Psychology; and Paul Weener, Associate Professor of Educational Psychology. Charles B. Schultz was a full time research associate for the duration of the project. Donald Peters, Assistant Professor of Human Development was associated with the project for one year on a part-time basis. Graduate students who held research assistantships, for one or more years, on this program of research were: Carl Harris, Ovid Tzeng, Gary Ingersoll, Steven Ross, G. Susan Gray, Phyllis Sunshine, Samuel Rock, Marcia Rosenfeld, Eric Bell, Edwin Marlow, and Timothy Dangel.

Objectives of Program

The objectives of this program of research were aimed at investigations of instructional conditions that make for optimal learning, so as to improve and advance the efficiency of teaching. On the basis of results from these investigations and integration of these results with the findings obtained by other investigators, an attempt at a general theory of instruction was planned. This theory was intended to be employed as a guide for specifying some of the characteristics of an instructional system as well as for further systematic research investigations on instruction and training (see Instructional Strategies, Part I, July, 1971, Annual Report, for presentation of the theory).

All studies were conducted within the conceptual framework of psychological principles that provide the foundation for the teaching-learning process. Thus, the goal of the project was to provide empirical support for learning principles which could be employed in the design of instructional systems, rather than to produce instructional "hardware" or to design instructional systems, per se. In many cases variables or processes important to scientific psychological investigations were reexamined in terms of their implications for instruction. Conversely, there were processes which were believed, on an intuitive basis, to be important in instruction (e.g., note-taking and listening). These were redefined in terms of psychological variables and outcomes. It should be noted that this approach differs radically in both procedures and outcomes from one that might have been developed by specialists in curriculum and instruction, or even by specialists in measurement and individual differences.

It is now apparent, in retrospect, that the major foci of this program of research were coordinated with certain trends which now appear to be

major thrusts in research on instruction. The variables hypothesized to affect learning in educational settings were to be specified as intervening variables and were assumed to be amenable to control by an external agent such as an instructor. The specific directions of the research were defined in terms of:

a) The characteristics of instruction (i.e., what the instructor does) and their effects on learning efficiency and outcomes.

b) Learner behaviors (i.e., processes employed by the learner) under specified instructional circumstances, and their consequences in learning outcomes and training efficiency.

c) The influence of status variables (i.e., individual differences) on learning with special emphasis on how individual differences in performance are polarized, which individual differences in performance are important in instruction, and how these individual differences (or aptitudes) interact with instructional methods.

In large part, the research was designed to examine cognitive processes which appear to influence the amount and direction of learning. Analyses of individual differences included differentiations of learners according to auditory vs. visual ability; imaging vs. verbalizing ability; dogmatism vs. open-mindedness; conservative strategists vs. hypothesis-spewers (i.e., gambling strategies); high need for uncertainty vs. low need for uncertainty; high achievement anxiety vs. low achievement anxiety; high tolerance for ambiguity vs. low tolerance for ambiguity and the like. Our analyses of methods of presenting information examined: the effectiveness of pictorial vs. verbal presentations; auditory vs. visual presentations; blocking vs. mixing of concept instances; the presentation of materials so as to arouse conflict (curiosity) and so as not to arouse conflict; the teaching of a

lesson when learners were anxious (i.e., under threat of being called upon to answer) or non-anxious; and so on. Finally, to examine learner processes we measured how much the learner subjectively organized the material; i.e., we examined the extent of his organization during recall and asked such questions as these: "Did the learner organize a set of several concepts, each with many attributes, according to the concept-names or according to the concept-attributes?" "Or, did he form a more complex basis for organizing the material such as would be found in a matrix?" If the learner arrives at a matrix (rule) does he do so through a definable, perhaps standard, path?" In other studies we examined the effect of externally observable processes such as the influence of verbalization (articulation) on learning a concept or the influences of note-taking and test-taking on attentiveness or listening behavior.

General Methodology

The principal and associate investigators, graduate students, and graduate assistants, typically met weekly to describe study plans with each other and to report findings as they were obtained. These meetings often took the form of seminars with students or faculty members taking the lead. In addition, these meetings were employed to coordinate efforts on individual projects.

The general methodology of all investigations followed the traditional experimental design implying factorial analysis of variance or a mixed analysis of variance. In addition, there were two factor analytic studies (Sanders, Weener, Di Vesta, & Schultz, January, 1970 ; Di Vesta, Ingersoll, & Sunshine, 1971, in press) and one reliability study (Sanders & Weener, July, 1970).

While one of the studies was conducted in a naturalistic instructional setting (Peters & Messier, 1970) the others were designed to parallel or simulate classroom situations. In many instances, the procedures were such that, if incorporated into an instructional setting, they would provide a means for adapting to individual differences. An investigation by Weener (July, 1970), for example, required learners first to view a movie. Then later some of these learners reported, verbally, to another of the subjects, something about the contents of the film while still other subjects provided a written report. The subjects in the different experimental treatments (who could be classified as reporters, writers, and listeners) were then tested for recall. In another study (Schultz, 1970) individuals in groups of subjects were asked either to recite, or to listen, to other members of the groups. Some of those who were to recite knew when they would be called upon; the remainder of the group did not know whether or when they would recite. Some of the latter group never recited; but of the remaining subjects, half recited fifteen percent of the time, and the others recited thirty percent of the time. Such studies provided a quasi-classroom or simulated instructional setting. Also to provide a parallel with classroom situations, studies were made of expectations for objective vs. essay tests and for delayed vs. immediate test. Similarly, the effects of such processes as listening, note-taking, and organization of lecture or written content on acquisition, recall, and transfer were made. In other words, the methodology was such that psychological constructs described processes relevant to classroom learning.

The majority of the subjects in these experiments were recruited from the introductory educational psychology course at The Pennsylvania State University, thereby making available about 1500 subjects per year. In

three of the studies (Ingersoll, 1970; Peters, January, 1971; Schultz, July, 1970) the subjects were recruited from high schools within the greater State College area.

The use of students from the introductory educational psychology course enabled the investigators to administer a battery of tests, as measures of individual differences, at the beginning of each term. These tests were selected on the basis of research plans and the hypotheses related to these plans. Accordingly, in nearly every study, results were either correlated with performance or analyses were performed for differences between groups in parallelism of regression lines to identify aptitude by treatment interactions if any.

A final approach was to create "extreme groups" by selecting only high and low scorers on a measure of a relevant individual difference variable. In such studies as those involving imagery-ability and modality preferences (auditory vs. visual) tests were administered to a potential group of subjects. Then, on the basis of their performance on these tests, groups of subjects with high and low ability (or preference) were selected. They were then assigned at random to the experimental treatments with the restriction that equal numbers of "high" and "low" subjects would be assigned to each treatment.

Results

The Identification of Individual Differences

Scores on aptitude measures, such as those frequently used in the study of aptitude-by-treatment interactions, are based on both the responses to content of the items and on the individual's general dispositional tendencies or response styles. When people respond to measures of ability the content is clearly the more dominant factor. When they respond to measures of

attitudes then response style tends to play a more influential role. This point was clearly emphasized in a study by Di Vesta, Ingersoll, and Sunshine (1971, in press). They showed that imagery ability, subjectively reported by the person was not the same as imagery ability measured in an objective (i.e., performance) measure. The first was influenced by the response style which suggests the individual seeks approval of others (i.e., social desirability); the latter was affected by what the person could do with the items.

Too often, investigators are prone to accept a scale as a measure of whatever is designated by its name. Thus, because a test is called a scale of imagery investigators often believe that it "really" measures imagery; or if it is called a test of dogmatism that it "really" measures dogmatism. Such interpretations can be highly misleading. Although the scale may measure a reliably testable trait (see., e.g., Sanders & Weener, July, 1970), it may not be the trait named in its title, i.e., it lacks validity. Often such titles represent little more than intuitive judgments or inferences made by an investigator. Furthermore, even if the trait is named "accurately" (this can never be true, in the literal sense, since all titles are conceptual in nature) the trait measured may be too general to be of value or it may be analyzable into sub-processes. In either case, the trait, as measured, would not be a fruitful way to test hypotheses regarding aptitude-treatment interactions (ATI). Again, the factor analysis of imagery tests (Di Vesta, Ingersoll, & Sunshine, 1971, in press) clearly showed that measures involving the labeling of figures or colors in percept-word interference tasks were more clearly related to automatization than to imagery. Alternatively, the analysis showed that imagery itself was probably a trait analyzable into further sub-processes. Even such analyses do not help us in identifying whether imagery is a dependent or independent variable. Perhaps, it is both

but our attention has concentrated on it as an independent variable. Our studies have implied that a great deal must yet be accomplished with the definition of the behavior measured by a given test and with the generality of that behavior. The least that can be done is to attempt an analysis of the processes measured by examining the items rather than blind-acceptance of whatever label was given the measure.

Theoretical fuzziness about what a test measures may be one of the major sources of difficulties in arriving at fruitful hypotheses about ATI. For example, it might be supposed, for whatever reason, that imagery and verbal ability are bi-polar. If this is a viable hypothesis, then factor analyses, where a number of verbal and imagery tests are employed, should yield a bi-polar factor. Yet, in Di Vesta, Ingersoll, & Sunshine's (1971, in press) study it was found that imagery and verbal ability were not bi-polar factors, as some authors had assumed, but were, in fact, orthogonal (i.e., different, separate, and unrelated) factors.

If aptitude and personality measures are to be useful to instructors and to investigators, these measures should overlap with measures of achievement. In the words of the factor analyst, academic achievement should load on the same factor as the personality or aptitude test. In a factor analysis (Sanders, Weener, Di Vesta, & Schultz, January, 1970) of 23 measures, six stable factors were extracted. They were: high-school achievement; socio-economic class; verbal ability; mathematics orientation; externalized control or reliance on authority; and academic achievement in college. These factors were not unusual or unexpected in view of the constituent tests. The unexpected finding was that none of these measures related to a gross achievement measure represented by grade point averages, a necessary concern for precise theorizing. Nevertheless, the primary reason may be

that, as stated in the aforegoing paragraphs such traits are poorly measured at the present time.

Individual Differences in Imagery-Ability and Auditory-Visual Preferences as Variables in Learning and Recall

Despite its many interpretations and apparent ambiguity investigators have found operational definitions of imagery to be relatively straightforward either by inference from objective descriptions of experimental conditions or by reference to the subject's behavior on tests. Auditory and visual preference have created less of a problem since either modality can be defined in terms of the way stimuli are recieved by the learner.

Imagery and modality preferences are placed together in this section because our studies in these two areas were more systematic attempts to uncover aptitude by treatment interactions (ATI) than studies in other areas. Furthermore, both series of studies described in this section were relatively successful in obtaining what often seemed to use as the "elusive ATI." When viewed as a whole, these studies may provide a paradigm for further studies of ATI.

Each of these approaches employs an "aptitude" variable that can be represented in at least three ways: as a stimulus characteristic; as a process or strategy; or as an individual difference variable. These characteristics differentiate imagery and modality preference from other classes of individual difference variables such as personality and motivational variables. To illustrate: when investigators treat imagery as a stimulus variable they differentiate experimental conditions according to rated-imagery (i.e., concreteness and abstractness) of stimuli; when they treat it as a process or strategy they manipulate learners' experiences by inducing sets (e.g., through instructions) to employ imaginal processes in

encoding information; and when they treat it as an individual difference variable they obtain measures based on the learners' reports of how vivid his experiences are or on scores from objective tests in which the solution of problems requires manipulation of objects in space. Similarly, modality preferences can be defined in terms of their stimulus characteristics, that is, they can be visual stimuli or verbal stimuli; or they can be defined in terms of a processing strategy in which case the modality can be defined in terms of the way a given stimulus is received, used, or transformed (e.g., whether stimuli are processed individually or as a pattern, whether template-matching or feature analysis is used by the learner); or they can be defined as individual difference variables by measurement designed to determine relative ability or preference in using the two modalities.

Studies of imagery. The initial approach to the series of studies of imagery was to attempt a replication of a series of three studies conducted in 1965 as a doctoral dissertation by Joan Stewart at the University of Toronto. In each of our studies the stimuli and procedures employed in Stewart's study were replicated. In addition, we employed the same tests as she did for classifying individuals as high and low imagers (see Di Vesta, Ingersoll, & Sunshine, 1971, in press).

While our replications of the original studies were not entirely successful from the viewpoint of ATI, the main effects of manipulated variables were replicated, and in some cases, partial support was obtained for individual differences in imagery as a potentially influential variable in learning, transfer and recall.

Extensions of the replications which had been incorporated into the design yielded conclusions of interest to instructors. One of the main findings (Di Vesta, July, 1971a, b) from this series was that stimuli presented

either as words or as pictures were recalled better when seen as pictures on a recognition task. The sequence of pictures and words was also important. Thus, when a referent was presented as a picture and then on the recognition task as a picture, the object was easily recognized as having been seen before. However, the poorest recognition was obtained when words were presented on both the presentation and recall trials. In further support of these findings the picture-word sequence was better than the word-picture sequence.

In still another variation of the experiment described in the aforegoing paragraph, pictures and the words from the first presentation were presented again with instructions to memorize them. Then the learners were asked to write down (i.e., free recall was used rather than recognition) as many items as they could recall. The results indicated that from the standpoint of increasing retention, as measured by free recall, some combination of both pictorial presentation and verbal label for the object was a sounder procedure than repetitions by the same methods of presentation whether pictorial or verbal, although straight repetitions of verbal representations of objects were more poorly recalled than straight repetitions of pictorial representations.

Similar results (Di Vesta, July, 1971b) were obtained when pictures and words were varied in learning and transfer lists. The use of pictures in a learning list clearly facilitated transfer to subordinate categories (e.g., coin to circle) whether the transfer task employed verbal or pictorial representations. These results were replicated when, instead of comparing the effects of pictures and words, we compared free recall of subjects who learned lists comprised of words that were rated high, medium, or low on vividness and concreteness. This study indicated that degree of concreteness

was directly related to both recall and organization in recall (Di Vesta, Gray, Ingersoll, & Sunshine, July, 1971).

In summary, the replication studies provided evidence that pictures are learned more easily than words, that a picture word sequence facilitates recognition more than a word picture sequence, that a combination of pictorial presentation and verbal labeling is more effective than repetitions by the same manner of presentation, and that concreteness of words, as a variable, has similar effects on recall and organization as does pictorial representation.

In an extension (Di Vesta & Ross, 1971, in press) of these replications, learners differing in imagery ability learned a paired-associate list consisting of noun-adjective pairs in either the adjective-noun or noun-adjective order. Equal numbers of pairs in each list were high or low in rated imagery.

The results showed that noun imagery is a more critical variable than adjective imagery, and that this effect is most pronounced in the stimulus than in the response element. High imagery-ability was shown in one interaction to be most influential, in comparison to low-imagery ability, for learning pairs that contained low-imagery stimuli. These findings implied that imagery is a strong determinant of learning performance whether manipulated as a stimulus attribute or as an individual difference variable and that both have similar functions in processing information. From a methodological standpoint this was the first study conducted within this program that had implications for the systematic investigation of ATI with imagery as the aptitude variable. It pointed toward an emphasis on processing and hinted at a two-stage model of associative learning in which the meaning of concrete words is said to be developed through direct (imaginal) experience and verbal

association whereas the meaning of abstract words is developed only through intraverbal associations.

The aforegoing study can be compared with another by Ross (1971) in which the assumption was that high imagers would be more receptive to processing of pictorial stimuli. Learners in that study learned pairs of words mediated by pictorial or by verbal contexts (see also Di Vesta & Ross, July, 1970). The contexts were not tested directly, hence any effects were attributed to differences in sensitivity to these stimuli, i.e., to the learner's biases or predispositions. The findings implied that modality (pictorial vs. verbal) of context and relatedness of contextual cues (i.e., the conceptual distinction defined, as for example, the word "cardinal" within a context of sparrow and eagle belongs to the category of birds, while within the context of nun and priest it belong to the category of clergy) provide constraints on the storage and transfer of incoming information. The results of this study also implied that, at least during the acquisition trials, high imagers are more receptive to and more able to effectively process information that is embedded within a pictorial context than are low imagers. This finding suggests that students who are characterized by ability to code via imagery might also prefer (be more receptive to) contexts involving concrete examples and graphic displays.

However, the notion that high imagers might be more receptive to imaginal stimuli is not necessarily related to the notion that they employ different processing strategies than do low imagers. The latter point was demonstrated in a study by Di Vesta & Sunshine (July, 1971). Their study showed that imagery-ability, as measured in these investigations, reflects the ability of the learner to process the information by verbal or by imaginal strategies. There was little or no evidence, in this study, that

reflected a sensitivity of the learner to profit from pictorial or verbally presented stimuli as so often implied in earlier studies by other investigators. The results of this study showed that when high imagers were forced to employ imaginal mediation their performance was superior to that of low imagers especially with abstract stimulus materials. On the other hand, low imagers always performed more poorly when they were required (forced) to use imaginal mediation than when they were required to use verbal mediation. These effects were emphasized when low imagers learned abstract lists or where they used abstract mnemonic aids; in each of these situations imaginal associations are less readily available as implied in the two-stage model of associative learning. In retrospect, there is no reason why low imagers should profit more from verbal than pictorial materials. The tests do not "say" that high imagers use imaginal processing better than verbal processing and that low imagers use verbal processing better than imaginal processing. Our measures of individual differences merely say that some people are able to "image" better than others, that is, that they can process learning materials by imagery better than others can. Our results parallel this conclusion.

A study of modality preferences. In an investigation for his dissertation Ingersoll (1970) studied the conditions under which learners who differentially prefer to have information presented over one sensory modality as opposed to another (i.e., visual vs. auditory), learn and recall stimulus materials presented over the two modalities. Thus, the emphasis in this study was related to preference or bias rather than ability as in the imagery studies described above. The performance of visualizers (i.e., those learners who prefer to have material presented visually) and listeners (i.e., those who prefer to have materials presented auditorially) was compared in a variety

of bi-sensory auditory-visual tasks. It was assumed that for tasks in which unfamiliar materials were presented simultaneously over two sensory modalities, the learner would be unable to attend to both modalities and therefore he would select one or the other according to his general dispositional tendencies (see also Ingersoll & Di Vesta, 1971, in press).

The results of Ingersoll's study yielded a disordinal interaction between modality preferences and presentation modes, at least for short-term memory. That is, listeners recalled more auditory than visual stimuli and visualizers recalled more visual than auditory stimuli. Not only did listeners recall more auditory stimuli, but those stimuli presented later in the series were recalled better than those presented earlier. Conversely, visualizers recalled the visual stimuli presented earlier in the list better than those presented later in the list. These latter two results offer support for separate sensory storage systems. On more complex tasks, the results were not as clearly defined.

These data suggest that in settings where information is received on more than one channel, learners differentially sort out or choose materials presented on one or the other channel and that the modality they choose is a stable disposition. It can be assumed that in areas where audio-visual materials are used as instructional aids and where the information coming over both channels is not congruent (i.e., it is somehow different) some of the material may be lost due to the nature of multichannel stimulation. This loss may be further increased by the nature of selective attention as employed by the individual learner: Learners who consistently attend to the visual component of the task will suffer most on demands for information from the auditory channel. Similarly, the performance of auralizers will suffer when recall based on visual information is demanded. In view of these

findings it would appear that additional research must be conducted in settings where material is presented concomitantly by auditory and visual means in order to learn how these effects can be minimized.

The Instrumental Activity of Note-taking

Note-taking is one of the most extensively employed aids to learning in the student's repertoire. Nevertheless, its use is guided more by the student lore, being passed down from one student to another, than by sound evidence regarding its functions in learning. If for no other reason, intensive examination of this technique is warranted because of its prevalence. However, upon such analyses as we have made, note-taking can be found to be a rich source of hypotheses related to learning, studying, and teaching. The use of notes can be seen to help the learner obtain a valuable store of knowledge to which he can refer at a later time, to provide a basis for encoding the material, and to help him to consolidate the knowledge he has obtained. On the instructor's side these same processes carry with them the suggestion for the ways in which material can be presented and organized. For example, if some opportunity for consolidation (maturing of learning) is desirable, a research question may be raised regarding the relative merits of the mechanics of presenting the material in a continuous, rapid-fire sequence versus a sequence interrupted by pauses, questions, and the like. If the latter is found to be desirable then there are further important questions to be asked regarding the timing of such interruptions. The questions regarding organizations are innumerable; they range from the degree to which continuity of themes is desirable, to the use of advance organizers and review periods, and to the effects of any expectancies that might be built into the organization of material.

Weener (January, 1971) carried out a study which investigated the effects of anticipated recall mode (i.e., essay test, objective test, and verbal presentation) and expectancies about when recall was to occue (i.e., students were to prepare for an immediate test vs. a delayed test) on the kind of notes taken by students and recall. (For other studies of the effect of test expectancies on note-taking learning and performance, see also Sanders and Tzeng [July, 1971] and Weener & Rock [July, 1971]). The group which expected the immediate test took half as many notes as the group which expected the delayed test. On an essay test, the immediate test expectancy group performed better than the delayed test expectancy group. Thus, the groups which took more notes performed less well on the essay test than did the group which took fewer notes ... and they did so on both the immediate and delayed tests. An interesting explanation of these results is that the delayed test expectancy leads to note-taking being employed primarily as an external storage device, which can be referred to later, rather than as an active transformational mechanism, while an immediate test expectancy leads to less note-taking but more active internal transformational activities. Obviously, perhaps, but most important is the reasoning that external storage strategies, such as note-taking, are inefficient information processing mechanisms when the externally stored information will not be available or when it can not be referred to by the student at the time of recall.

Di Vesta and Gray (1971, in press; July, 1971) compared the performance of subjects who took notes versus that of subjects who did not take notes. The note-taking variable was completely crossed with rehearsal versus no rehearsal and test-taking versus no-test. The results of this study implied that the activities of note-taking, rehearsal, and periodic testing did more than serve as external storage or superficial learning aids. Presumably,

they play a role in the dynamics of processing the material for storage. They appear to be important devices for the facilitation of encoding material for storage and even more importantly, they result in consolidation and transformations that facilitate the retrieval of material once it has been learned. Testing after a brief presentation appeared to facilitate learning and recall by increasing the salience of certain ideas expressed in a communication and, simultaneously clarifying the kind of transformations required by the instructor.

The results of the Di Vesta and Gray (1971, in press) study were supported in a study by Peters and Harris (July, 1970) for the note-taking variable but not for review. However, inasmuch as Peters and Harris employed a full length classroom lecture it is probable that the review given after this material was presented contributed more to relearning than it did to transformation of the material for relearning; a distinction which is readily apparent at the time this report was written but was less apparent when the study was conducted. Nevertheless, questions following clearly identifiable learning units were found by Peters and Messier (1970) to facilitate performance on a later, subsequent test of the material learned, thereby increasing the generality of the finding by Di Vesta & Gray (1971, in press) that test-like events during or immediately after learning facilitates later recall.

In another study Di Vesta and Gray (July, 1971) crossed the note-taking and rehearsal variables with variations in thematic relatedness of material within a passage and the length of the listening-rehearsal intervals. The length of the listening period (i.e., whether it was five, fifteen, or thirty minutes) did not differentially influence the performance of the subjects. As in the previous study note-taking was found to have a significant effect

effect on recall as did the opportunity for rehearsing immediately after learning. (It should be noted here that in all of our studies only one by Peters [January, 1971] failed to support the notion that note-taking is important. His study suggests that, especially under circumstances where material is presented at a rapid rate, note-taking may interfere with information processing.)

An important finding in the latter study by Di Vesta & Gray (July, 1971) was that the subjects recalled fewer ideas when they listened to thirty minutes of material related to a continuous theme than when they listened to thirty minutes of material consisting of six five-minute passages on six different topics. This finding suggests a phenomenon which may be closely related to release from proactive inhibition. At the least, it clearly supports the contention that retention of meaningful prose learning is subject to the influence of interference.

That note-taking can act as an aid to subjective transformation (i.e., encoding) was shown in a study by Schultz & Di Vesta (1971b, in press). Their study demonstrated that a passage organized by concept name or by concept attribute resulted in recall of more ideas than a passage in which the ideas were organized at random. Of more interest, in the present context, was that passage organization at the time of presentation was most influential in the way ideas were organized at the time of retrieval by the subject when note-taking was not permitted. When note-taking was permitted the subject organized his recall of ideas on the basis of the more dominant strategy, that is, of organizing the material according to the concept-name. On the other hand, when note-taking was not permitted, the subject organized the material upon recall in the same manner it was presented to him.

These interesting studies indicate the need for further systematic research regarding a process which, on the surface, appears to be trivial but, upon analysis, can be seen to influence the learning process in complex ways. Note-taking may provide an indirect basis for consolidation (maturing) of material by the interruption of continual listening. It certainly facilitates encoding and it lends the learner an opportunity for innumerable transformations of the material to be learned. Nevertheless, when it is not used as an encoding device it may be used only as external storage by the student and then it interferes with his recall. It not only influences the way the material must be learned, but it interacts with such instructional variables as the rate of presentation and the way the material is organized by the instructor. Note-taking itself can be influenced by the expectancies implied by the instructor. For whatever reasons, this learner-aid has been neglected, as a topic for research, for too long a period of time. Its use (or misuse) can influence the degree to which the instructor does (or does not) achieve his objectives. Its potentiality for analytic studies of learning meaningful prose or connected discourse should appeal to investigators concerned with basic research in learning as well as those who are concerned with research on learning as it applies to instructional strategy.

Instructional Strategies for Teaching Concepts

The study of concept learning, whether concept-formation or concept-identification, has been and continues to be an important one for understanding the higher mental processes. In the past these studies involved the investigation of the effects of such processes as perception, abstraction, discrimination, and generalization. More recently, however, information processing approaches have been added to the list. In the main, these new approaches have tended to emphasize the use of strategies. By

observations of learners performing concept-learning tasks such strategies as focusing, gambling, and scanning have been identified. Computer-simulation studies have led to theories based on template-matching and feature analysis strategies. From the viewpoint of application to instructional strategies, sequencing of course material, methods of presentation of concept-instances, organization of material, and study requirements continue to remain important as relevant variables affecting the use of strategies by the learner. The latter has been the emphasis in the studies of concept-formation conducted within the framework of the present program.

In one study of the sequencing of materials (Sanders, Di Vesta & Gray, 1971, in press) learners were to acquire four concepts. In one treatment the instances were presented in blocked form; that is, all exemplars (instances or examples) of one concept were presented, then the instances of another concept were presented next, and so on. In the other treatment exemplars (instances of examples) of all concepts were represented in each block of four instances, and within each block the instances of the four concepts occurred randomly. The method of presentation, in which instances were blocked, led to faster acquisition than where instances were intermixed. However, learners who tend to formulate hypotheses randomly were not influenced greatly by these variations in presentation conditions. On the other hand, learners who prefer a systematic strategy do benefit from the blocked presentation.

It must be apparent to most instructors that contextual cues are present whenever concepts are learned in classroom situations. Nor is this point neglected by investigators inasmuch as recommendations for application of their work always includes making provision for presenting the concept-rule in a variety of contextual arrangements. Our studies in this area were

related to both the effect of the form (pictorial vs. verbal) of the contextual cues on acquisition and of the effect of the context on the conceptual quality abstracted by the learner.

A study by Di Vesta and Ross (July, 1970) on contextual influence indicated that learners presented with contextual arrangements may actually learn more slowly than when contextual arrangements are absent. The primary reason appears to be that learners proceed through active search to identify meanings even without directions to do so. In the absence of contextual cues learners acquire the material to be learned more quickly because there are no extraneous stimuli. Nevertheless, it was clearly the case that contextual features, though incidentally learned, did favorably influence both retention and transfer. Furthermore, because the context is learned incidentally, there is also more material learned when a context is provided. The disadvantage in providing a context is that a set or expectancy can be developed for applying the material in a limited way, thereby delimiting breadth of transfer. Accordingly, it is recommended that a concept be placed in as many contexts as possible if maximum transfer is to be achieved.

The method by which contextual cues are presented, i.e., either verbally or visually, was also found to affect high and low imagers differentially (Ross, 1971). At least during the acquisition phase, high imagers, more than low imagers, are receptive to and are more able to process effectively the concept embedded in a pictorial context. These results suggest that students who manifest a preference for coding via imagery, might best benefit from a context of concrete examples and graphic displays.

Closely related to contextual arrangements is the act of labeling a given concept (Di Vesta & Rickards, 1971). In effect, the label places the

concept within a given category, i.e., context. Highly specific labels call the learner's attention to specific details while highly generalized labels call attention to superordinate categories that diminish discriminability. In either case performance is detrimentally affected while labels which represent conceptual categories (intermediate between designations representing specific objects and those representing superordinate categories) facilitate acquisition. These effects (both detrimental and facilitative) are enhanced when the learner is required to actively engage in the learning process by overt articulation of the categorizing label. Such active participation, through searching material to identify a given concept, was also found to enhance acquisition of a concept-attitude, i.e., a concept with favorable or unfavorable connotations (Gray & Di Vesta, January, 1971).

In terms of the growth of concepts we have hypothesized that rote learning may necessarily precede concept learning. Preliminary evidence (Sanders & Tzeng, January, 1971; Sanders, January, 1970) suggests that learners may initially attempt to categorize all learning elements. That is, they try to find a rule for making the material meaningful. If successful, the learner will be able to learn a concept but may have an inaccurate memory of the specific concept-irrelevant characteristics of the materials studied and may tend to overgeneralize the concept. If unsuccessful, that is, if concept learning is found to be inappropriate, the learner tends to employ rote processes. Finally, where tasks have no underlying rule, rote learning may be the only appropriate strategy. In such tasks, attempting to use a conceptual learning strategy may actually impair learning.

The Organization of Instructional Materials

Communications which are directed toward helping students acquire concepts can be organized by concepts or by attributes. In a study by Schultz & Di Vesta (1971b, in press) learners were administered materials organized by concept-name, concept-attributes or in a random order. This variable was crossed with note-taking. The two organized passages resulted in significantly more recall than the randomly ordered passages and, in particular, influenced the selection of clustering strategies when note-taking was prohibited.

A most interesting feature of the results of this study was that, during recall, concept name was found to be the dominant clustering strategy employed by most people and, accordingly, was quickly adopted by the learner who read the communication organized by name. However, learners who read the communication organized by attribute adopted the attribute clustering strategy only gradually, presumably because they had to relinquish the more dominant name-clustering strategy.

These results were supported in still another study by Di Vesta, Schultz, & Dangel (July, 1971). In addition, the way the student was to organize the material was manipulated in relation to the way the material was organized for him in the communication. Thus, some students were asked to organize the material by name when it was so organized in the passage itself or to organize by attribute when the passage was so organized. This was called the congruent condition. In other conditions the student was asked to organize the material on a basis (e.g., name) opposite to that by which it actually was organized (e.g., attribute) in the communication. This was called the incongruent condition. It was found that incongruency between passage organization and clustering strategy resulted in better

recall than congruency. These results are extremely interesting but on retrospect can be explained readily by the fact that in the higher mental processes the selection of an appropriate strategy for integrating materials is an important process.

The learner confronted with an organizational or other problem must search the alternatives and decide which is appropriate. In this case, however, there is still another variable: the materials will be most efficiently organized when they form a matrix. If this is accomplished all instances are adequately covered, a rule can be formed, and new instances can be generated in accordance with the rule. Now it can be reasoned that in the incongruent condition the learner is made aware of the dimensions by which the material can be organized into a matrix. In the congruent condition, he is given one of the dimensions but whether he identifies the other relevant dimension is left to the influence of other variables such as his history of experience. These results suggest the importance of providing learners with the means for identifying the bases on which rules may be formed, and showing them how simple matrices may be employed in organizing material for storage in memory and for later retrieval.

A study by Weener and Tzeng (July, 1971) showed that an instructional condition (free organization) which permitted unrestricted subjective organization of word lists resulted in better learning than a condition (constrained organization) which required the learners to use the categories formed by another learner. The constrained organization group, however, recalled more than a group of learner's who had to organize the words into random, meaningless categories (random organization). These three different organizational strategies which were imposed on the learner's activities accounted for much more of the variability in recall performance than did

the nature of the word lists. Subjects who were given word lists with "built-in" word categories recalled only a small, and insignificant, number of words more than those subjects who learned randomly selected word lists. The effects of the required organizational strategy was stronger than, and seemed to cancel out, the effects of the built-in organizational features of the stimulus materials.

An interesting aptitude-treatment interaction emerged from this study. The recall performance of subjects who used random word groupings correlated positively with a measure of verbal creativity, but this same correlation was negative and significantly different for the subjects in the two groups which used meaningful word groupings. This implies that the detrimental effects of working with unstructured stimulus materials was less for those subjects who were high in verbal creativity. Conversely, the instructions which imposed random organizational strategies tended to "penalize" subjects with low verbal creativity more than it penalized subjects with high verbal creativity.

Social Factors in Instructional Settings

There are few learning situations that do not involve social interaction at some point. Even though the person may spend considerable time studying alone, most traditional educational and training situations involve contact with a teacher. Such situations may range from a one-to-one relationship as in a tutorial setting to a one-to-one hundred or even one-to-a thousand, as in large classes. The student's attitudes may in any of these situations be affected by the personality of the teacher or by the kind of learning situation the instructor devises, to name but a few influences (Rock, July, 1971). Furthermore, what the student learns may be affected by the nature of his participation, whether it is that of a silent observer or active

participant. Recitation itself can be productive of anxiety and as a consequence can indirectly affect what is learned. But, in addition, the classroom by the very nature of recitation, interaction, and evaluation that comprise every instructional system, provides competitive and cooperative demands in conjunction with other individuals or with a normative standard.

Although social factors were considered as highly important ones in instruction they were not given as high priority as other variables and processes in the investigations conducted under [illegible]'s program. Nevertheless, there were three studies that provided some insight into the effects of social interaction on learning.

Sanders (July, 1970) examined the relative efficiency of studying with a partner versus studying alone under social competitive (competition with a study partner), social-cooperative (cooperation with a study partner), and normative-competitive (competition against a norm) conditions. An interaction between the two variables (amount of social-interaction and levels of competition) was significant. Direct competition resulted in the highest recall when learners studied together but resulted in lower recall when the learners studied alone. In the cooperative settings learners studying together recalled less than did those who studied alone. There were no differences between studying with a partner and studying alone when learners competed against a norm. Thus, this study demonstrated that grading conditions affect the learner's perception of his chances of success, influence his perceptions of his opportunity for gaining information from his classmate, and provide different levels of motivation.

While recitation is generally considered to have a facilitative effect on learning, educators have tended to neglect the detrimental aspects. Schultz (July, 1970) assumed that required recitation might be stressful

and would thereby have a debilitating effect on learning. Interestingly, his findings showed that learners who were "called upon" frequently retained less material than did those who recited less often. Moderate rates of recitation appear to result in optimal levels of motivation and consequently are more efficient than excessive recitation requirements which may create stress. In addition, stress producing instructional strategies, such as recitation, depresses the retention of learners characterized by debilitating anxiety compared to that of learners with facilitating anxiety. These results provide support, too, for the theoretical notion that debilitators elicit more task-irrelevant responses to stressful situations, which interfere with learning, than do facilitators.

In a follow-up study, Schultz and Dangel (July, 1971) found that the maintenance of a learner-sustaining climate (minimizing the evaluative aspect of recitation) facilitates learning for all learners but is particularly effective for improving the learning of debilitators.

Another study of the effect of anxiety on social interaction was conducted by Weener (July, 1970) who also hypothesized that the effects of student verbal presentations can be explained in terms of the arousal effects resulting from this activity. Accordingly, optimal learning occurs if the level of arousal is low during the early stages of learning new material and then is increased in the later stages as the material becomes better learned. Although the study resulted only in trends, if the results are replicated a case could be made for advocating the use of verbal presentation techniques during the later stages of study.

Personality and Motivational Factors as Variables in Problem-Solving

There are at least two major ways or approaching investigations about problem-solving: one emphasizes the descriptions of systematic strategies

typically employed by problem-solvers; the other emphasizes the factors which facilitate or are detrimental to the solution of problems. The former are illustrated by the approaches used in computer stimulation studies of problem-solving; the latter are illustrated by those in which the learning psychologist investigates the effects of the interaction between motivational or personality variables and instructional treatments on effective solution to problems.

The studies conducted in this area, under the current program of research, were all within the latter framework (see Marlow, 1971; Schultz, 1970; Silvestro, 1970, for typical studies). Schultz's (1970) study implied that for most educational settings student learning will be facilitated when it follows the generation of uncertainty and so suggests a source of motivation for problem-solving. Accordingly, it appears that when constructing curricular materials the instructor should incorporate open-ended questions, content containing conflicting interpretations, controversial subject-matter, and descriptions of phenomena which violate the learner's expectations. Typically, those student projects which stimulate discovery, inquiry, or reflective thought tend to utilize uncertainty as a motivational device.

The importance of uncertainty in problem-solving is that it goads the learner to search for alternative paths to the solution. He searches for other information, new or other ways of structuring the problem, or syntheses of information that permit him to arrive at new rules or generalizations for arriving at the solution.

Schultz also hypothesized that closed-minded (dogmatics) persons would be less prone to develop uncertainty or to relinquish old, often incorrect, beliefs, However, the evidence from his study did not support this hypothesis.

Silvestro (1970) investigated the influence of conditions which would create a need for novelty. He thereby attempted to investigate a condition resembling that described by Schultz. Silvestro's study was directed at the possibility that satiation with divergent thinking activities would create a lack of interest in novelty; conversely, he assumed that satiation with convergent thinking activities would result in a search for novelty. In general, these hypotheses were supported. On the basis of findings from this study Silvestro suggested that an emphasis on divergent thinking can be overdone. If the instructor overemphasizes tasks requiring creative effort he may hamper the need for novelty, since too much familiarity with the once novel experience results in habituation. The learner then turns to the activity which is less familiar. This reasoning suggests that motivation based on novelty is relative to some base or adaptation level. The need for novelty in Silvestro's study was related to the antecedent conditions but was not related to high and low creativity as measured by the Remote Associates Test. Nor did high and low creativity interact with the antecedent conditions (satiation) to influence differentially the need for novelty.

Weener (January, 1970) employed scores on the Remote Associates Test as a dependent variable to investigate the hypothesis that as situationally-induced anxiety is increased, achievement anxiety (a personality characteristic) becomes increasingly correlated with performance on tasks requiring non-dominant responses such as are found in creative thinking. Success and failure were successfully employed to include situational (i.e., state) anxiety. Contrary to his hypothesis, however, Weener demonstrated that change (measured as the difference between scores before and after the induction of anxiety) in performance on the Remote Associates Test was

negatively correlated with debilitating achievement anxiety in the success condition and positively correlated with performance in the failure condition. The opposite relationships were found between the changes in scores for the Remote Associates Test and level of facilitating anxiety. There remains the question of whether the effects of situational anxiety will generalize to other learning tasks.

A particularly interesting interaction between dogmatism and expert endorsement of beliefs on problem-solving was identified by Schultz and Di Vesta (1971a, in press). The problem, as in most problems requiring creative solutions, necessitated the rejection of initial problem-solving tendencies that were inappropriate for the problem-solution and replacement with a new set of responses. Furthermore, the problem was such that the learner was required to integrate (synthesize) the new set of responses into a sequence that would yield the desired outcome. During the course of problem-solving the learner was provided with "expert" advice. In one experimental treatment the advice consisted of endorsement of old beliefs (which were inappropriate for the problem) while in the other treatment it consisted of endorsement of new responses (which were important to the solution of the problem). The dogmatic (i.e., closed-minded) learners, with their ready acceptance of authority and expertise as their primary guides, were hampered in their problem-solving activities when the experts endorsed old beliefs but were facilitated when the experts endorsed new beliefs. On the other hand, the open-minded learners, who tend to evaluate the reliability of content (and, accordingly, of the source) before acting on new information had more difficulty than closed-minded learners when solving the problem under conditions where experts endorsed the new beliefs. Thus, the open-minded learners looked skeptically on the authority endorsement

and took time to test the validity of this endorsement in action. The extra time taken was, in a sense, wasted. Their skepticism paid off when the expert endorsed old-beliefs. Upon testing the validity of the expert's recommendations they were found to be incorrect and alternatives could then be sought.

The study by Schultz and Di Vesta suggested that the provision of frequent cues as to the direction of activity in problem-solving for creative solutions is relatively unimportant for low dogmatics. On the other hand, the "devil's advocate" strategy of teaching, i.e., where the instructor may take an incorrect stance in attempts to raise the student's interest, may seriously impair the problem-solving ability of high-dogmatic students.

Summary

This program of research has culminated in an overview of what we believe is a unique approach to instructional strategies. In a separate volume (Annual Report, July, 1971, Part I) we have consolidated the findings from our own research and that of others into a cognitive approach to training and education. This view appears to be especially cogent for educational settings in which adults are involved, as opposed to a view emphasizing principles of behavior modification that may be more appropriate to the education of children and special groups of people than to normal adults. Accordingly, in the aforementioned volume we have spelled out an overall model of instruction (Di Vesta, July, 1971, Part I) and treated in detail such notions as cognitive stimulation (Schultz, July, 1971, Part I) as an approach to motivation; student expectancies as they relate to instructional goals and objectives (Sanders, July, 1971, Part I); transformational processes during learning and their effects on what the teacher does and what

the student learns (Di Vesta, July, 1971, Part I); and the students' instrumental activities (Weener, July, 1971, Part I).

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