DOCUMENT RESUME

ED 156 518 SE 024 502

AUTHOR Atwood, Jan R.; Dinham, Sarah M.
TITLE Instructional Theory for Teaching Statistics.
PUB DATE Mar 78
NOTE 26p.; Paper presented at the annual meeting of the American Educational Research Association (Toronto, Canada, March 27-31, 1978); Contains occasional light and broken type

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS Concept Formation; *Educational Research; *Graduate Students; Higher Education; Instruction; *Instructional Systems; Learning Theories; Problem Solving; *Statistics; Transfer of Training

ABSTRACT

Metatheoretical analysis of Ausubel's Theory of Meaningful Verbal Learning and Gagne's Theory of Instruction using the Dickoff and James paradigm produced two instructional systems for basic statistics. The systems were tested with a pretest-posttest control group design utilizing students enrolled in an introductory-level graduate statistics course. The ANCOVA model included gender, entering algebra skill, and entering statistics knowledge as covariates. The Gagne system facilitated ANCVA and correlation concept learning better than either the Ausubel system or neither system. Neither the Ausubel nor the Gagne system promoted learning of problem-solving skills or transfer of learning. (Author/MN)

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INSTRUCTIONAL THEORY FOR TEACHING STATISTICS

Jan R. Atwood, R.N., Ph.D.
Sarah M. Dinham, Ph.D.

The University of Arizona

Presented at the Annual Meetings of the
American Educational Research Association
March 27, 1978

Printed in the U.S.A.

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INSTRUCTIONAL THEORY FOR TEACHING STATISTICS

Jan R. Atwood, R.N., Ph.D.*
Sarah M. Dinham, Ph.D.
The University of Arizona

A firm theory base for learning and instruction is essential for sound education, according to both educators and psychologists (Snelbecker 1974, P. 133). As early as Aristotle's time, three laws of association were recognized: contiguity, similarity, and contrast (Hilgard and Bower 1966, P. 50). However, theories of education are primarily descriptive rather than prescriptive and, therefore, not readily useful to the classroom teacher (Glaser 1976, P.6). Instructional models based on theories either have not been specified or have not been tested, and conditions under which the theories obtain have not been thoroughly researched.

The purpose of this study was to devise instructional models based on two specific theories and to test whether or not materials based on those models helped statistics students learn. The specific area of interest was the basic knowledge of research analysis and design; the specific problem chosen was the learning of basic statistical analysis by graduate students who are striving to become intelligent consumers or consumers and doers of social science research.

Methatheoretical Assessment of Theory

The Approach of Dickoff and James

Many theories of teaching and learning are available to the typical classroom teacher, but few, if any, theories are practically useful because they do not speak specifically to classroom conditions. The teacher is left to deduce an instructional model from a limited theory requiring a great deal of interpolation and extrapolation.

Metatheorists Dickoff and James addressed this quandry as they proposed a four-level theory framework for practical disciplines such as education and nursing (Dickoff, James, and Wiedenbach 1968a, 1968b). The framework provides a means of analyzing theories to explicate the logic of the contents so that viewers of the theory may know its capabilities and limits as well as specific spots in need of development. The four levels of theory in the Dickoff and James framework are:

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*This paper was presented at the annual meetings of the American Educational Research Association, March 27, 1978. Inquiries concerning this research should be directed to the senior author, at the University of Arizona College of Nursing, Tucson, Arizona 85724. This research was supported in part by funds provided by USPHS Division of Nursing's Nurse Scientist Traineeship program.

I. Naming or Factor-Isolating: well-specified definitions of concepts.

II. Descriptive or Factor-Relating: complete description of relationships among variables, including correlational assertions.

III. Predictive or Situation-Relating: predictions which may be causal conditions under which assertions obtain.

IV. Prescriptive or Situation-Producing: causal propositions, directions for producing a desired situation, e.g., learning.

Level IV is the epitome for a practice discipline (Dickoff et al. 1968a, pp. 420-422). From another perspective, Glaser (1976, P. 23), an educational psychologist, more recently has called for production of prescriptive educational designs of immediate use to the classroom teacher.

Application To Ausubel's and Gagne's Theories

The two theories of interest in the present study were Ausubel's Theory of Meaningful Verbal Learning and Gagne's Theory of Instruction. Selected basic elements of both theories have been studied extensively, but the research has neither been definitive nor has it concerned the specific conditions under which each theory is useful. Clearly neither Ausubel's Theory of Meaningful Verbal Learning nor Gagne's Theory of Instruction is prescriptive (level IV) and ready for general use. Both theories have weaknesses at each level in the Dickoff and James taxonomy.

For example, the definitions of key concepts in Ausubel's theory are not clear. On the whole, his own writings and research reports tend to have several crucial omissions, e.g., definition of initial terms such as "transfer of training (Ausubel 1962b, p. 647)," or "affective factors" influencing learning and retention (Fitzgerald and Ausubel 1963, pp. 73-74). At the descriptive and correlational levels, the elements of cognitive organizers are vague. Unanswered questions include: Are all concepts amenable to structuring? What is it about a cognitive organizer that helps the student? At the prediction level, which kinds of learning are facilitated by cognitive organization? How many of what kinds of organizers does the learner need?

Ausubel recommends that advance organizers be used to form a cognitive framework skeleton on which to put the content or "meat" of meaningful school learning (as contrasted with rote memorization). However, the precise building blocks for meaningful learning are not specified (Ausubel 1962a, pp.213-224; 1968, pp. 107-109). Some research has shown that "learning consisted of activating the assimilative set quite early in learning and using it continuously throughout learning, rather than adding more and more different kinds of material to memory (Mayer 1975, p. 534)."

The results suggest the need for advance organizers as well as content and perceptual organizers. Additional research has shown that the organizers promote assimilation of information in a broad framework (Mayer 1975, P. 540), which tends to promote far rather than near transfer of learning.

On the other hand, a study of 72 bright university students showed that transfer of learning of number base concepts was not affected by using Ausubel-type advance organizers (Groteluesc hen and Sjogren 1968, p. 201). Biehler (1971, p. 303) reports that college students can be confused rather than helped by advance organizers if they are not developmentally able to handle formal operations. Clearly, research about cognitive organizers is conflicting.

At Level III in the Dickoff and James framework, the cognitive hierarchy in Ausubel's theory is not firmly established, and although evidence is severly limited, a few basic pieces of research were done to discover the specific conditions under which the theory operates. For example, when Ausubel, Robbins, and Blake (1957, p. 343) tested subsumption-dissociability assertions about retention and forgetting, they found that "proactive rather than retroactive inhibition is the determining factor in forgetting," and that identical repetition of material is just as useful as interpolated material for facilitating retention. The subsumption concept in Ausubel's theory has two important ramifications: initial learning can function to facilitate or inhibit subsequent learning, depending on the conditions of recency and type of previous learning (Ausubel et al. 1957, p. 343). It is important to note that the methodology in written accounts of the research is hardly replicable.

Glaser and his associates at the University of Pittsburg have adapted the Gagne model to the Individual Prescribed Instruction System (IPI). They claim that reinforcement in the form of immediate feedback is the key motivator for a student and that a Gagne-type of system enhances retention and transfer (Glaser and Cooley 1973, p. 842). The mechanisms of motivation, retention and transfer have not been thoroughly tested. Near transfer of learning has been tested at primarily the lower levels of learning rather than the levels necessary for college material. In addition, the learning material has been job-specific or narrow laboratory tasks rather than university subjects (Snelbecker 1974, pp. 458, 475). Suppes (in Gagne and Gephart 1968, p. 45) claims that Gagne-type stimulus-response instruction simply does not facilitate transfer. Evidently, the conditions under which the theory obtains have not been explicated. Larger questions of interest to the educator are left unanswered. For instance, does the same cognitive hierarchy apply to all kinds of subject matter? Nevertheless, the framework of the theory does exist.

Like Ausubel's, Gagne's Theory of Instruction has weaknesses at each level of theory. At the definitional level, Gagne has proposed that there are eight learning types. Unanswered questions include: Do all kinds of learning fit into one and only one of the eight types? Are there more types? Fewer? The hierarchy formed by the eight learning types is central to the theory and has been used in a variety of educational settings (Gagne 1970, p. 254), but it is yet unvalidated. Attempts at validiation have been frustrated by insufficient definitional theory. Once validation of the theory occurs at each level, meaningful correlational studies can be done. Currently, some of the assertions in Gagne's theory are correlational, and some are predictive. In addition, the instructional system devised by Briggs provides a useful prescriptive base.

In summary, practical application of both Ausubel's Theory of Meaningful Verbal Learning and Gagne's Theory of Instruction is limited primarily by weak definitional bases at the first level of theory and at the predictive level by unvalidated learning hierarchies and by poorly specified conditions. Ausubel's theory has a very weak prescriptive component (Lawton, 1977, pp. 25-27). However, use of the Gagne theory is facilitated by a relatively explicit instructional system developed by Briggs (Gagne and Briggs, 1974). In addition, each theory contains some assertions at each of the Dickoff and James four theoretical levels and, therefore, each has merit.

Focus of The Study

Intercept Point

This study concerned the point at which the theories come together to describe or predict learning. Both theories describe the way adult learners learn and therefore, both suggest ways in which teaching can facilitate learning. However, each theory explains adult learning from a different perspective. Ausubel's theory is perhaps the most fully developed cognitivist position; although the theory is not well specified, it is attractive because it has been designed and tested for college learners. And Gagne's paradigm is clearly and the most extensively developed Behavioral school theory of instruction for dealing with college-level complex material.

Similarities and Differences in the Two Approaches

The two theories were chosen both for their similarity and for their differences. The two share several characteristics. For example, both are specifically designed to be useful in classroom learning and have been tested primarily with college students and other adult learners (Ausubel and Blake 1958; Snelbecker 1974, p. 476). Both are currently debated in education circles. Both identify entering knowledge as the most powerful influence on subsequent learning, both include higher-order concept learning, and both order learnings hierarchically.

There are several key differences between the two theories. They apply the learning hierarchy principle differently, each predicting different resultant learnings. The Ausubel paradigm specifies deductive progression, facilitated by cognitive organizers, through the hierarchy from abstract to specific concepts, while the Gagne paradigm specifies inductive progression from the highly specific, simplest learning to the most complex.

Research Hypotheses

In the present study, analysis of the propositions offered by each theorist (Gagne, 1977; Ausubel, 1968) led to the following hypotheses:

1. The Ausubel and Gagne paradigms both facilitate learning better than an instructional approach not purposely geared toward either one. Therefore, The Level of Statistics Learning Is Higher for Students Using an Ausubel or Gagne System Than for Students Using Neither System.

   $(\mu_G = \mu_A > \mu_N)$

2. Both systems are designed to facilitate near and far transfer of learning, but research provides conflicting testimony as to the validity of each design. Therefore, The Level of Near and Far Transfer of Learning is Not Different for Students Using Either A Gagne or An Ausubel System, and is Greater Than the Level for Students Using Neither System.

   $(\mu_{A_{NT}} = \mu_{G_{NT}} > \mu_{N_{NT}};$

   $\mu_{A_{FT}} = \mu_{G_{FT}} > \mu_{N_{FT}})$

3a. Both the Ausubel and Gagne systems are designed to facilitate concept learning and are more effective than neither system. Therefore, Level of Statistics Concept Learning by Students Using an Ausubel System is Not Different From The Level of Those Using a Gagne System; Both Levels Are Higher Than That of Students Using Another System.

   $(\mu_{A_C} = \mu_{G_C} > \mu_{N_C})$

3b. The Gagne system is specifically designed to facilitate learning up through the problem-solving level. Both the Gagne and Ausubel systems promote learning better than use of neither system. Therefore, The Level of Problem-Solving Ability of Studnets Using a Gagne System is Higher Than the Ability of Those Using an Ausubel System, Which is Higher Than the Ability of Those Using Neither System.

$(\mu_{G_{PS}} > \mu_{A_{PS}} > \mu_{N_{PS}})$

Research Design and Procedures

A pretest-post-test control group design was used to assess differences in student learning attributable to either the Ausubel or the Gagne instructional system. The pretest-post-test control group design was selected for its strength in controlling the main threats to internal validity even though generalization of results to an unpretested population is risky (Campbell and Stanley, 1963, p. 13-18).

The test of the two instructional systems involved multiple independent and dependent variables. The model proposed that a student's gender, prerequisite skills, and pre-instructional knowledge, together with the instruction the student receives, predict the knowledge with which the student leaves the learning experience. The model included three covariates: gender (self reported), prerequisite skills (Iowa algebra aptitude test), and pretest knowledge (pretests in ANOVA and correlation). The treatment was either use or nonuse of supplementary materials according to either Gagne's or Ausubel's theory. The dependent variable was post-test knowledge reflected by scores on ANOVA and correlation post-tests.

Treatments

The treatment variable was the instructional system based on either the Ausubel or the Gagne theory. The rationale for selection of the two theory bases has been discussed. Addition of supplementary instructional materials, used by the students independently, seemed to be the most practical way of assessing in what ways the theory-based instructional systems facilitated learnings for university students who do much of their work outside the classroom. In this study, all students received the statistics instruction typically given by the instructor. In addition, the students in experimental groups received supplemental instruction, group 1, of the Ausubel type, and group 2, of the Gagne type. The control group (group 3) received no supplemental instruction.

Treatment Materials

The supplementary materials were designed to illustrate each instructional system as it would be used for the two main statistics topics: analysis of variance (ANOVA) and correlation (Dinham 1976, Helmstadter 1972, Roscoe 1975). These two topics were selected because they are relatively complex, they are very important aspects of basic

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data analysis, and they are difficult for the average student to learn. The complexity of the topics in a learning hierarchy for the Ausubel and Gagne models is illustrated by the taxonomies for ANOVA and correlation (Illustrations 1 and 2). The two instructional topics are important also in that one or the other of the two is basic to nearly all education research analyses. Students typically have difficulty with ANOVA and correlation for several reasons: (1) The language of the content of the analysis types is new to most of them (2) The decisions about using one type of analysis or the other require familiarity with many aspects of the data at hand, and (3) most students in beginning statistics are not accustomed to thinking in that way.

Examples of Ausubel (group 1) and Gagne (group 2) treatment materials for both ANOVA and correlation are shown in Illustration 3. The supplementary instructional materials were carefully constructed to include specific organizers, feedback mechanisms, check quizzes, and other aides suggested by each learning system. The treatment materials were validated for theoretical integrity at several points throughout their development. The features of the Ausubel and Gagne instructional systems prominent in the treatment materials were derived from writings by Ausubel (1968) and Gagne (1971a, 1971d). Task analysis of the ANOVA and correlation content based on Gagne's theory were used for both treatments because Ausubel's theory does not specify a taxonomy (Gagne 1971b).

Independent Variables

The independent variables were the treatment variable just described plus three covariates. Students were assigned to treatments by block randomization. The three covariates were gender, level of prerequisite skills, and pre-instructional knowledge of ANOVA and correlation. Gender was used because several studies have demonstrated differences in mathematics-related learning between males and females.

The second and third covariates were the aspects of entering behavior deemed by both theorists to be the most important predictors of subsequent learning: prerequisite skills (algebra aptitude test) and pre-instructional knowledge (pretest). The algebra aptitude test was chosen to measure the mathematical logic and calculation ability needed for learning statistics. The Iowa Algebra Aptitude Test has four subsections: series, lessons, open phrases, and dependence and variation. The test is most commonly used to measure students' existing cognitive structure in order to predict success in mathematics courses requiring some algebra proficiency (e.g. statistics). Spearman-Brown split-half reliability for the total test is 94. The Kuder-Richardson coefficient of internal consistency for the total test is .93 (Greene and Sabers 1967, p. 5). Predictive validity for high school modern math and for algebra was .78 and .74, respectively, and .69 and .64 using teacher grades as the criterion (Greene and Sabers 1967, p.3).

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The third covariate, the statistics pretest, like the post-test, measured students' ANOVA and correlation knowledge (as described below).

Dependent Variables

The dependent variable was terminal skill with statistics, i.e. correlation and ANOVA, measured in a total score and several subscores. The two statistics topics were tested separately. Each test included items written to tap near-transfer and far-transfer processes and to assess concept knowledge and problem solving ability. The eight item types were combined in various statistically independent groupings appropriate to each hypothesis. For hypotheses 1 (concerning the main effect of the instructional systems on learning), all post-test items were used. For hypothesis 2 (near-transfer and far-transfer), near-transfer items composed one subscore and far-transfer items the other subscore. For hypothesis 3 (concept learning and problem solving), concept items were used to form one subscore and problem-solving items the other.

In the development of the pretests and post-tests, well over 100 items were tested in pilot studies. Several criteria were used for final selection of items for each test:

1. An average item mean of approximately 0.70.
2. Inclusion of some morale-boosting items in each test.
3. A change in a positive direction from pilot study pretest to post-test.
4. A greater number of concept items in pretests than in post-tests because entering knowledge is more likely to be concept knowledge than problem-solving ability.
5. A greater number of near transfer items in pretests than post-tests and the opposite for far transfer items because entering knowledge is more likely to be of the near transfer than the far transfer type.

For both pretest and post-test on ANOVA and correlation, hypothesis testing required including items to assess knowledge of each topic at both the concept and problem-solving levels and for both near and far transfer of learning, as previously described. Low pretest reliability is not unusual due to low variance (S for ANOVA was 1.5 points; S for correlation was 2.3). The average pretest item means for the field study were .44 and .61 for ANOVA and correlation respectively. The ANOVA and correlation pretests were successful because the means were low (3.3 out of 12 ANOVA points; 8.53 out of 14 correlation points), responses were well distributed among alternatives, and students spontaneously reported feeling uniformed about the topics. For the ANOVA and correlation post-tests, coefficient alpha was .90 and .89 respectively.

Population and Sample

The population to which the conceptual framework speaks consists of graduate students learning the rudiments of being research consumers, planners, and implementers. Research methodology, including statistical analysis, is a key element in basic learnings about research. Thus, the target population for the study consists of students entering introductory graduate level statistics courses such as the University of Arizona's Educational Psychology 240, Statistical Methods in Education. Most commonly the students are Master's and Doctoral students in Education; others may be in Nursing, Speech and Hearing Therapy, Child Development (Home Economics), and other Social Science and educationally related fields. The study was designed to generalize beyond students in this particular course to beginning research consumers and doers who have chosen graduate school as their place to learn statistics. Of particular note is the fact that generalization cannot be made beyond the statistics considered because research has shown that students for whom an inductive sequence is optimal for one subject matter achieved most from a deductive sequence with different content (Tobias 1976, p.65).

The original sample consisted of forty-one students who volunteered as subjects from an introductory-level graduate statistics course. The volunteer sample was considered to be representative of the class as a whole because their scores on the regular classroom exams prior to the experimental treatment were similar to scores of the whole class; mean z-scores for the sample were 0.05 on the first pre-experimental classroom test and 0.09 on the second. Twenty-one students did not complete the study; two dropped the course, seventeen did not complete both of the post-tests, and two reported that they did not use the experimental materials. In the final sample, there were six students in the Ausubel group, four in the Gagne group and ten in the control group. Thirteen of the twenty subjects were graduate students in education or related fields and eleven of the twenty were women.

Two types of control were used in this study: randomization of subjects to treatment groups of the manipulated independent variables, as discussed earlier, and constancy among control variables (Leonard 1971, p.4). The control variables were constant across all conditions or treatments for all hypotheses.

a. All students had the same instructor (style, course outline, lecture content, tests).

b. All students had identical assignments and handouts.

c. Both sections were daytime students in degree programs.

d. Class environment was similar for all students.

The class sessions were virtually identical; in fact, occasionally some students went to whichever class meeting suited their schedules for the day.

Pilot Studies

The treatment material for ANOVA and for correlation were pilot tested using a design similar to the one used in the main study. As a result of pilot testing, selected materials and exam questions were revised based on reliability figures and feedback forms completed by students. Also, the pre-test procedure was revised to enhance student anonymity and clarity of instruction.

Field Experiment Procedure

Students were randomly assigned to the control group and the two treatment groups. After the study was presented to students on the first day of class, the volunteer sample took the algebra test. On the second day of class individual feedback about the test was given to any student who requested it. Prior to the first lecture on each topic, pre-tests were administered, individual feedback on test performance was given to students who requested it, and experimental materials were distributed. Following the last lecture on each topic, post-tests were administered along with the regular class exams and the usual option to receive feedback was also offered.

Data Analysis

Because no causal ordering was posited among the several independent variables, they were considered simultaneously in the analysis model. A multivariate model assessed the relationships among all of the independent and dependent variables in a least squares solution to the linear model (Fennessey, 1968, Woodward and Overall, 1975). The hypotheses predicted the relative magnitudes of the effects of the treatment on each set of dependent variables; in addition bivariate analyses between each set of independent and dependent variables were expected to show that entering knowledge is the strongest single predictor of terminal ability. The alpha level used for rejection of null hypotheses was $p \leq .05$.

The logical analysis choice for multiple independent variables including covariates and multiple dependent variables is either analysis of covariance (ANACOVA) or multivariate analysis of covariance (MANACOVA), depending on the statistical independence among the independent and the dependent variables. In this case, after assessment of the number of unique independent and dependent variables and formation of new statistically independent variables, a series of independent ANOVA analyses was performed.

Results and Discussion

Hypothesis Tests

Tests of Hypotheses 1, 3b, and the far transfer portion of Hypothesis 2, revealed that the treatments made no difference in total learning in problem solving or in far transfer of learning. Analysis of Hypothesis 3a showed that the aspects of the concept post-test items which were due to topic (ANOVA or correlation) were relatively unaffected by the independent variables. However, regression of the concept factor variable on the independent variable showed that students in the Gagne treatment group had higher concept scores ($p \leq .02$).

Effects of the Covariates

Among the covariates (gender, algebra aptitude and pretest knowledge), only gender was meaningful. Being a woman was an important advantage in two circumstances: learning ANOVA in general ($p \leq .002$) and learning concepts in particular ($p \leq .001$) except for women in the Gagne group ($p \leq .01$). There were three women and one man in the Gagne group.

Both Gagne and Ausubel propose that entering skills and ability are the strongest determinates of terminal behavior. However, a student's entering skills and knowledge of algebra do not seem crucial to terminal performance in ANOVA or correlation, according to this study. In no cases were the pretest scores statistically significant influences on post-test scores. Consistent with the spectrum of current literature, this study showed inconsistent gender effects on learning outcomes.

Conclusions and Implications

The treatments and the three covariates accounted for an average of 79% of the variance in the post-test scores; further research concerning these theories is warranted. Additional research is needed at all levels of both theories; the great gaps seem to be at the definitional level. Further, validation of Gagne's learning hierarchy would greatly facilitate use of his theory in the classroom, as would specifications of prescriptive theory for Ausubel's.

Conclusions for Learning Theory

Ausubel's theory has been said to be weak at Level I, Naming Theory, because it contains unclear conceptual and operational definitions of key concepts such as cognitive organizers: During the development of the treatment materials for this study, it was very difficult to be sure precisely what were content organizers and what were not. At Level II, Factor-Relating Theory, the literature was not at all helpful in delineating how much of a cognitive organizer is enough, and at Level III, the causal level, how many different kinds of organizers suffice to help learners of a given type with a given subject matter. In confirmation of Grotelueschen and Sjogren's (1968) results, the Ausubel experimental materials did not facilitate transfer of learning any better than did the regular classroom instruction. It is difficult to assess whether or not the experimental treatments were strong enough because little, if any, Prescriptive Theory (Level IV) exists as a criterion.

Like Ausubel's theory, Gagne's contains some theory at the definitional, factor-relating, and correlational levels (I, II, and III), and unlike Ausubel's, Gagne's contains Prescriptive Theory (Level IV) for use by classroom teachers. Two chief problems are the incomplete operational definitions of various kinds of learning in the learning hierarchy and lack of validation of the hierarchy itself. The Gagne experimental materials were specifically designed to facilitate discrimination, concept-formation, rule learning, and problem-solving skills; correspondingly, pretest and post-test items were designed to test each capability. However, one limit of this study is that there is room for debate about whether or not each item in each test properly assessed the level of learning for which it was designed. Of particular interest is the fact that learning of concepts was facilitated in ANOVA, but the results of the data analysis do not indicate how important the mastery of concepts was for learning rules or solving problems. A second limit of the study is the relatively small and uneven number of items used to assess each type of learning as well as transfer of learning. Even though Gagne claims that transfer of learning is definitely facilitated by his system of instruction, the results of this study do not confirm the claim.

A key feature of the Correlational, Level II, Theory here is the reinforcing quality of immediate feedback which facilitates learning. Even though the treatment materials contained numerous and frequent self-tests with answers, and prompt feedback was offered for all classroom tests that were part of the study, the Gagne group of students excelled in learning ANOVA concepts only. From the Prescriptive Theory, it is difficult to guess how much feedback is enough, and it is entirely possible that the treatment materials were not strong enough in the other substantive area.

The fact that the Gagne type of materials helped most with ANOVA may be explained by Tobias' (1976, p. 72) comment:

> . . . students with high prior familiarity in a given area may be assigned to an instructional treatment, with minimal instructional support, or to a forward-branching sequence. On the other hand, students with low prior achievement may require maximal instructional support each step of the way.

This study suggests the following questions for Ausubel's theory: Exactly what are the conceptual and operational definitions of key concepts such as transfer of training (Ausubel, 1962b, p. 647)? How much cognitive organization is enough? How many kinds of organizers are required for given subject matter?

For Gagne's Theory, other questions may be raised: What are the complete operational definitions for the various kinds of learning in the hierarchy? Can the learning hierarchy be validated? How can it be determined that test items properly test the level of learning for which they are designed? How much feedback is enough to facilitate learning?

Conclusions for Teaching Statistics

Both Gagne and Ausubel propose that entering skills and ability are the strongest determinants of terminal behavior. In this study the influence of entering ability was assessed in terms of both prerequisite skills (Iowa algebra aptitude test) and pre-instructional knowledge (ANOVA and correlation pretests). The bivariate correlations between algebra aptitude and each pretest, and also the results of the ANACOVA, indicate that algebra aptitude did not influence any of the post-test scores in an important way. Therefore, a student's entering prerequisite mathematical logic and calculation ability do not seem crucial to his terminal performance in ANOCA or correlation. This news could offer comfort to student and professor alike..

In no cases were the pretest scores statistically significant ($p \leq .05$) influences on post-test scores. However, concepts and near transfer entering ability with both statistical topics showed promise of being substantively important influences upon post-test concepts and near transfer, respectively. The coefficients of determination (R^2) were 18% ($p \leq .18$) for concepts and 25% ($p \leq .08$) for near transfer. Faculty who are teaching statistics to educators may wish to consider pretesting students and then focusing their teaching on areas identified as weak.

In this study, men and women generally learned equally well, except that the women learned ANOVA, and especially concepts, better than the men. Consistent with the spectrum of current literature, the results of this study show inconsistent gender effects on learning outcomes, and it is unclear how gender operates as a variable. Because gender effects are unpredictable, they are worth further attention by classroom teacher and researcher alike.

In summary, it would clearly be wiser to base statistics instruction upon a theoretically-based learning hierarchy than not. Just as Murphy's law tells us "If something can go wrong, it will," Woodward's law warns us that "a theory is better than its explanation;" indeed there remain some substantial needs for further specification of the Ausubel and Gagne theoretical approaches. Until such research is done, classroom teachers of graduate students in basic statistics could look to Gagne's instructional system to help them teach ANOVA and similar concepts.

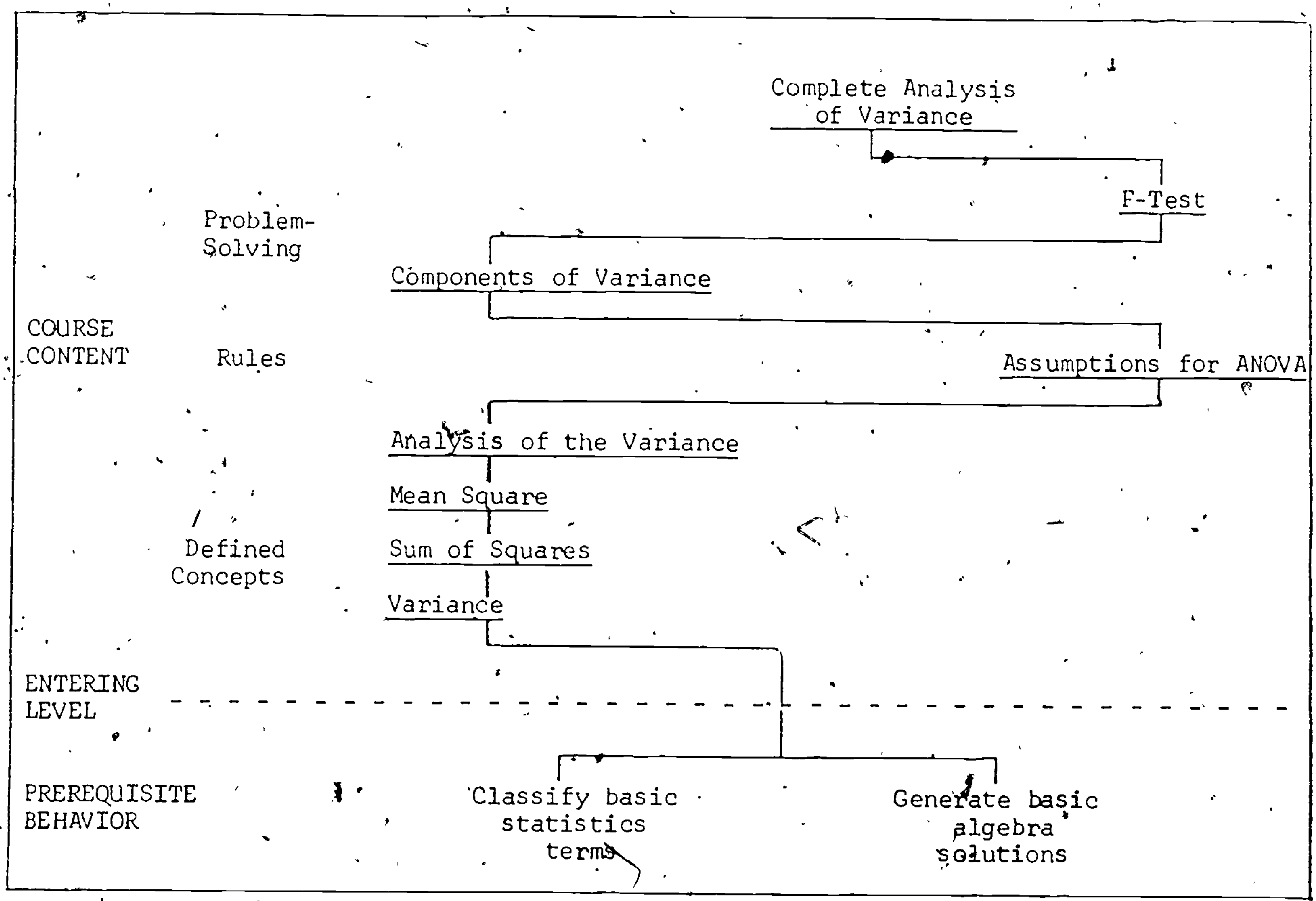

Illustration 1

Task Analysis for ANOVA

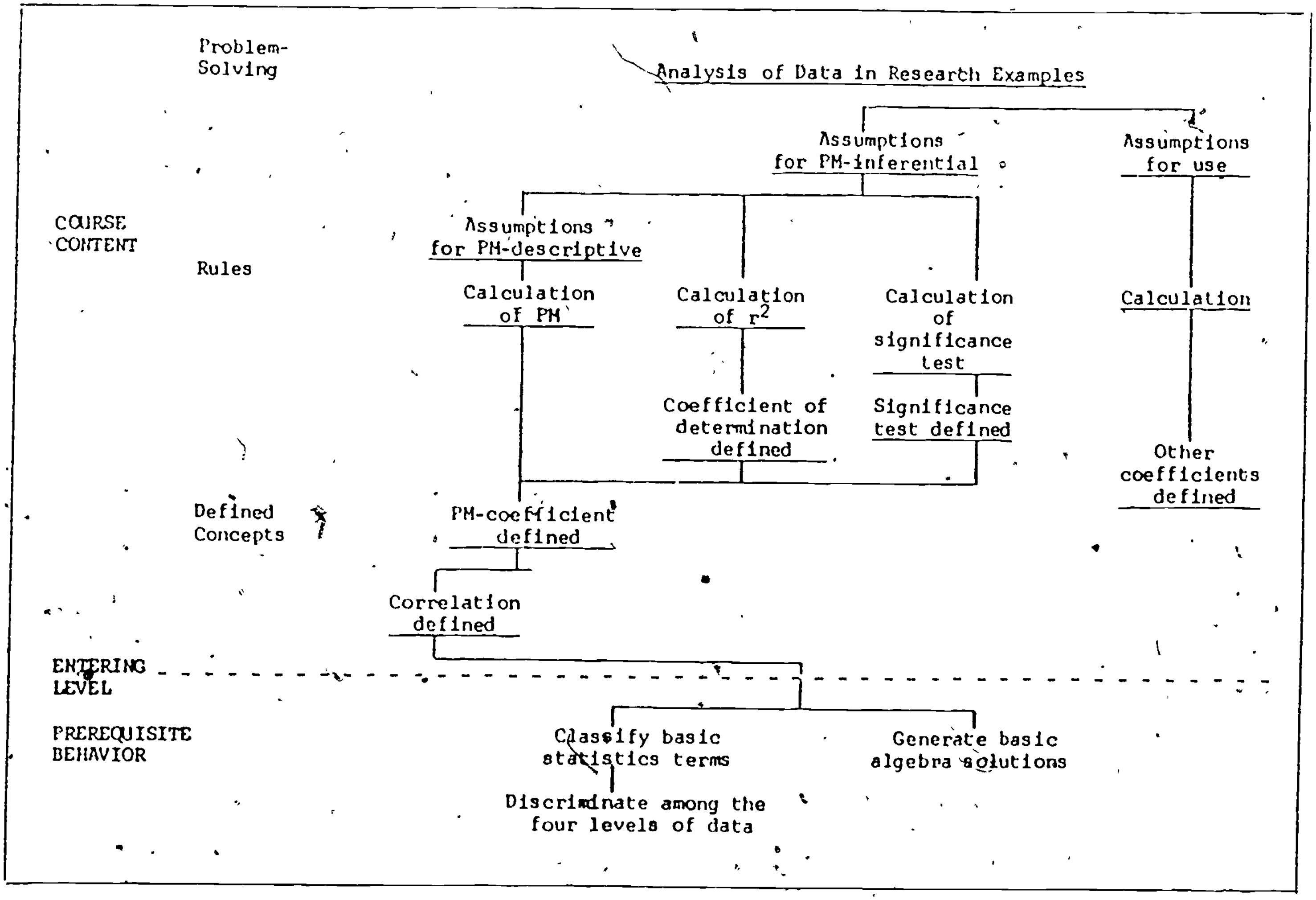

Illustration 2

Task Analysis for Correlation

Illustration 3

Group I

ANALYSIS OF VARIANCE

I. PRELIMINARY CONCEPTS

Analysis of variance is based on several concepts. It is important to understand these concepts before delving into the analysis of variance material. The numbers in parentheses refer to pages in the text (Fundamental Research Statistics for the Behavioral Sciences by John T. Roscoe, 1975) on which the terms are found. All except the last one have been part of the course prior to this unit.

population (p. 20)
sample (p. 20)
variable (p. 5)
criterion (p. 198)
parameter (p. 21)
statistic (p. 21)
random sample (pp. 155-157)
independent samples (p. 164)
dependent or related samples (p. 165)
normal distribution (pp. 45-46; p. 73-83)
central limit theorem (p. 163)
sum of squares (pp. 67-69)
variance (pp. 69-70)

III. WHAT IS CORRELATION?

All of the descriptive statistics you have used so far in the course (e.g., mean, median, mode, range, standard deviation, variance) have used one variable. Now we turn to correlation, a statistical technique which can be used for descriptive purposes but, in contrast to the earlier statistics, describes the relationship between two or more variables. Only the bivariate case (using two variables) will be considered here.

The descriptive statistics you used served to describe characteristics of distributions of scores. In addition, some of these statistics were indicators used in hypothesis testing procedures so that population inferences could be made. For example, means were used in t-tests. Variances were used in F-tests in the analysis of variance procedure. Correlation is another indicator that can be used for inference.

In previous hypothesis testing procedures, two or more variables were used. One variable was designated as a dependent variable, and the others were independent variables. Bivariate correlation uses two variables, as well. However, neither variable is designated as the independent or the dependent variable. Therefore, correlation coefficients by themselves cannot tell us anything about cause and effect, that is, which variable "caused" the other to vary.

For a description of correlation, read Section 12.1, pages 93-94 in the text.

Group II

ANALYSIS OF VARIANCE

I. OBJECTIVES

By the end of this segment of the course, students who have knowledge of most of the key concepts in One-Way Analysis of Variance should be able to:

1. Define Analysis of Variance.
2. Identify what its uses are.
3. Tell what assumptions are made in using the technique.
4. Compute One-Way Analysis of Variance.
5. Give the rationale for doing the computations.
6. Perform the F test for significance and state the outcome of the hypothesis test.

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II. PRELIMINARY CONCEPTS

Correlation is based on several concepts which have been part of the course to date. It is important to understand these concepts before delving in the correlation material. There are two options at this point.

A. To see whether or not you understand the concepts listed in SELF TEST 1* on the next page, briefly define each one in the space provided. Then answer the accompanying questions. AFTER you have completed as many as you can, refer to the pages in parentheses beside each concept. They are found in the course text: <u>Fundamental Research Statistics for the Behavioral Sciences</u> by John T. Roscoe. The answers to the questions are found in pages 141-142.

B. Look up the concepts and answers first and then see if you can define the concepts and complete the questions.

Either way, the important thing is to understand the concepts before going on.

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*NOTE: The Self Tests are designed to give you a chance to practice using each concept and to give you immediate feedback on your performance. When you come to a Self Test, read it over and do all of the items you think you need practice doing. On some tests you may elect to do all of the items, while on others, you may choose one problem of each type. In most tests more than one problem of each type is available.

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