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ABSTRACT

This technical report details a study to examine the retention of mathematical and reading comprehension skills for students enrolled in a learning-in-work environment (experience based career education) and a traditional classroom learning environment. (An executive summary is available as CE 027 942.) Chapter 1 introduces the problem, background, and research framework. Chapter 2 on design and methodology contains three sections describing (1) the research background characteristics, (2) major measured variables (instruments), and (3) the analysis questions and strategies. Chapter 3 presents findings for the five research questions described in Chapter 2: factor structure of the learning environment questionnaire, cross-lagged analysis of math scores based on predictions from Bloom's taxonomy, effects of placement experiences on performance, effects of summer activities on performance, and relationships between student's perceptions of learning environment and cognitive style on performance. Chapter 4 sets forth implications and recommendations for research, practice, and policy. Appendixes include a selected literature review, description of Learning-in-Work Program, cross-lagged panel correlations used in math score analyses, and three commissioned papers. (YLB)

LEARNING AND RETENTION OF BASIC SKILLS IN ALTERNATIVE ENVIRONMENTS

Preliminary Investigation
of the Learning and Retention of Selected Reading
and Mathematical Concepts Resulting from
Student Enrollment in a Traditional Learning Environment
and in a Learning-in-Work Environment

TECHNICAL INFORMATION
AND
APPENDICES

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FOREWORD

Learning-in-work is an integral part of Experienced-Based Career Education Programs, internships, cooperative and work-experience programs, and on-the-job components of vocational education. Since the early 1970's, there has been a movement in education to expand the education opportunities of all students to include "real world" learning experiences as part of the total educational experience. In an attempt to investigate the relationships of learning and work, the National Center for Research in Vocational Education has initiated a programmatic effort to conduct basic research of the phenomena. This study, supported by the National Institute of Education, reports the findings of an exploratory examination of student retention of mathematical and reading concepts resulting from student enrollment in a learning-in-work and in a traditional learning environment.

Appreciation is extended to the Anoka-Hennepin School District No. 11, Anoka, Minnesota, for their cooperation and participation in the study. Don Anderson, Director of the Experience-Based Career Education Program, and Roger Giroux, Director of Research and Evaluation, were instrumental in providing support for the research staff in their investigation.

Technical advice for the research effort was provided by Harold M. Schroder, Professor and Department Chairman of the College of Business Administration at the University of South Florida. His scholarly research in the area of complexity training and development of individuals was especially useful to the research staff. He is also recognized for his critique of the report.

Appreciation is extended to our reviewers for their recommendations and suggestions: to Joseph Grannis, Professor of Education, Teachers College, Columbia University and Stephen Franchak, Research Specialist, The National Center for Research in Vocational Education.

Suggestions and extension of the first year's results were provided by David P. Ausubel, Distinguished Professor Emeritus, Ph.D. Program in Educational Psychology, Graduate School, City University of New York; Henry C. Ellis, Chairman, Department

of Psychology, University of New Mexico; and Benton J. Underwood, a Stanley G. Harris Professor of Social Science, Northwestern University. These scholars were commissioned to provide a perspective for investigating the psychological and pedagogical implications of learning and forgetting patterns in learning-in-work and traditional environments through extensions of their research and learning theories.

Special appreciation is extended to Ronald Bucknam, National Institute of Education Project Officer, for his contributions to this report.

Recognition is due Richard Miguel, Program Director, for the support and guidance he provided the study; Michael Crowe, Project Director, for his overall direction of the project and the writing of the report; R. J. Harvey, Graduate Research Associate, for his assistance in conducting the analyses of the data and assisting with the preparation of the report; Jeanette McConaughy for her editorial services; and Jackie Masters for her secretarial support services.

Robert E. Taylor
Executive Director
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in Vocational Education

ABSTRACT

The study examined the retention of mathematical and reading concepts for students enrolled in a learning-in-work environment (Experience-Based Career Education) and a traditional classroom learning environment on a measure of academic achievement in a twelve-month longitudinal design. Student performance in each environment (n=27) was evaluated using the Comprehensive Tests of Basic Skills, which was administered at the beginning and end of their junior year and at the beginning of the senior year. Thus, the learning interval was designated as the time between pre- and post-testing, and the retention interval, the time between post- and follow-up testing. The results indicated (1) differences in two areas--in reading skills vs. math skills and in traditional learning environments vs. learning-in-work environments; (2) math cognitive concepts causally related but not in the hierarchical order predicted by Bloom's taxonomy; (3) different causal processes in the acquisition of math concepts, depending upon placement in one of the two learning environments; (4) significant relationships between the students' cognitive style and their math performance; and (5) moderate relationships between the students' perceptions of the complexity of the learning environment and their math performance. An interference/assimilation model was proposed to interpret the findings.

CHAPTER I

THE PROBLEM

Introduction

This study is predicated on the belief that the learning environment affects the satisfaction, learning, and personal growth of young people to a considerable degree. The report represents the outcomes of the second year of investigation into the interaction of students and their learning environment and is focused on providing answers to questions raised in the preliminary first-year analyses (Crowe and Harvey, 1979). The study proposes to extend and examine the relationships between retention of mathematical concepts and the type of school environment in which instruction occurred. These concepts are measured by the Comprehensive Tests of Basic Skills (CTBS) that are administered to high school juniors at the beginning and close of the school year as well as to seniors at the beginning of their last year in high school. The instructional environments under investigation are a traditional school program and a learning-in-work program.

Background

Learning Environments: Historical Trends

Throughout the last decade, schools, in their attempt to be more responsive to the employment needs of students, were affected in the curriculum areas by the Career Education movement. This movement emphasized career information related to student developmental needs, job market trends, correlation between subject matter and the world of work, and plans for further education and eventual job selection. The early efforts of the career education movement were primarily concerned with restructuring the curriculum used by teachers and students in the classroom.

Later efforts, however, included the development of community employer-based programs providing students the additional option of spending time at the workplace for the purpose of career exploration or preparation. In addition to the resurgence of vocational and cooperative education, new programs such as the Experience Based Career Education Program of the National Institute of Education, the Career Intern Program of the Opportunities Industrialization Center, and a privately developed program called the Executive Internships Program were developed and implemented at the local school level. These programs emphasized new arrangements for student learning. An underlying belief was that the classroom had to be supplemented (and in some cases replaced) by experiences at worksites. Although students were supervised by certified teachers, worksite mentors were viewed as credible teachers and role models for students.

Concurrent developments, outside the public educational domain, were also taking place with regard to the "hard-core" unemployed youth. New CETA legislation was enacted requiring prime sponsors to provide training that would lead to employment for targeted groups of youth. Educational Work Councils were established by the Department of Labor to coordinate community resources for the purpose of training and placing youth in jobs. Organizations such as Youth Work were established to develop and pilot programs linking education and work. These efforts have led to new paradigms for instructional programs and have helped educators, employers, unions, and prime sponsors create educational or training programs with alternative learning environments to conform more closely with educational needs of youth.

The foregoing suggests that the educational outcomes have been expanded to include career exploration, work skills, positive attitudes, and personal growth, while simultaneously reinforcing basic skills; that the workplace is an appropriate environment for learning some or all of these outcomes; and that students are becoming increasingly responsible for selection of their educational environment. The cumulative effect of legislation and educational practice persuades us that one of the major results from these efforts has been legislative approval of alternative learning environments for students. Generally these environments combine school instructional components with involvement at the workplace. Current descriptions of programs that involve learning-in-work environments can be found in <u>The Current Status of Assessing Experiential Education Programs</u> (Crowe and Adams, 1979) and in Experiential Education: A Primer on Programs (Wasson, 1978). Both documents reveal the diversity of design for such programs and the increased number of youth who are participating.

Learning Environments: Descriptions

The basic problem under investigation includes the further examination and description of student retention of reading and mathematical concepts as a function of their instructional or learning environments, in this study a traditional school environment and a learning-in-work environment. Because traditional learning environments are as diverse as learning-in-work environments, a comprehensive description is not attempted for this study. Nevertheless, our perspective of a traditional learning environment includes specific structural features:

- One teacher for approximately twenty-five students
- Subject matter organized according to the major discipline areas--math, English, sociology
- Instruction for a subject matter course limited to fifty- to sixty-minute intervals (periods) each day
- Schedule of five to six instructional periods per day
- Instruction confined to a classroom, under the supervision of a teacher who uses curriculum guides and/or textbooks as major instructional tools

By way of a general comparison, the learning-in-work environments studied for this research includes the following structural features:

- One learning coordinator for approximately twenty-five students
- A resource person (worksite mentor or supervisor) identified for each worksite who provides opportunities and assistance for students
- Subject matter organized according to curricular areas, thereby cutting across major disciplines (Algebra is defined not only as traditional mathematical concepts but also is related to the natural science concepts of atomic structure, to electricity, and to the English/communications concepts of research and reporting skills.)
- Course instruction integrated with the worksite experiences and not confined to fixed intervals of time

- An instructional cycle defined for the student as four days a week spent at the worksite and one day at the learning center

- Instruction guided by an activity sheet negotiated by the student and the learning coordinator, relating subject matter concepts to learning activities and providing evaluative criteria for determining successful participation in activities

Students in the two learning environments are exposed to different instructional processes and environments related to learning. For example, students in the traditional environments are likely to be presented information from textbooks, films, and lectures. The information is often pre-packaged, the outcomes are specified in measurable terms, and there are agreed-upon cognitive structures for teaching the discipline-oriented subject matter.

From the perspective of the traditional learning environment, students in the learning-in-work environments may be thought to be provided a series of random experiences, since the instructional experiences cannot easily be categorized in a prescribed curricular fashion. Information is acquired from stimuli in this environment that many times cannot be well specified, arranged, or measured. The worksite learning environment can be viewed as complex, temporary, and transitory. Student outcomes vary depending upon the unique relationships established among the student, learning coordinator, and worksite resource persons and within the parameters of the program goals.

Retention of Knowledge

Generally, studies indicate that the retention of knowledge rapidly decreases after it has been learned. For example, Ebbinghaus studied his own retention of lists of nonsense syllables at differential time intervals after he had learned them. His results became known as the "forgetting curve." Analysis of forgetting curves suggests that immediately after learning, individuals forget information rather rapidly, but that with the passage of time, the rate of forgetting decreases. An explanation of this phenomenon has been postulated suggesting that two different memory systems determine an individual's capacity for short-term and long-term memory. According to this view, recently learned materials will be quickly forgotten (less likely to be retained) unless they are practiced, whereas older, better-consolidated memories (experiences) may be maintained without the benefit of additional practice or rehearsal.

The research literatuare is replete with studies dealing with various aspects of retention. Much of the research details specific methods and paradigms designed to measure retention in short-term memory (STM), which generally refers to time intervals of several seconds. Some researchers have introduced the notation of intermediate-term memory (ITM) to refer to time intervals of several minutes to perhaps an hour. Long-term memory (LTM) is, therefore, used to designate time intervals of more than one hour. The research usually occurs in a laboratory setting where there is control over the variables thought to be related to retention such as the length of time between exposure and test, the presence or absence of cues, the degree of overtraining, the length of exposure to the stimulus, the number and nature of intervening rehearsals, and events occurring between exposure and test.

For purposes of this study, our interest is in retention as it relates to long-term memory and as it occurs in naturalistic settings. Our intention is to examine further and to describe the relationships between the learning environments of students and their retention of subject-matter concepts.

Summary of Related Research

The learning-in-work approach would seem to offer the benefits of frequent, meaningful, and speedy feedback on task performance for students. Research in academic learning and retention (Ausubel, 1968; Boker, 1974; La Porte and Voss, 1975) would predict increased performance as a function of the above variables. Ausubel (1968) reported increased learning and retention of meaningful vs. rote memorized material. Anderson and Biddle (1975) and Boker (1974) found a strong relationship between increased application (practice) of material and subsequent retention. Similarly, La Porte and Voss (1975) demonstrated superior retention performance as a function of usage of the information and response-contingent performance feedback.

As stated, the learning environment an individual chooses (learning-in-work vs. traditional classroom instruction) is important with respect to academic learning and retention; however, research has indicated person-related variables, (i.e., cognitive style), interact with the environment, suggesting the difference in environment alone is not able to account for all differences in learning and retention. Davey (1976) concluded that the match of students' cognitive style, defined as stable preferences in individuals with respect to conceptual categorization and perceptual organization of the external environment, was a critical factor in maximizing performance. Hunt (1975) argued for future research directed at identifying the interactive nature of the personal and environmental characteristics of behavior.

Cronback and Snow (1977) advocated the consideration of the interaction of instructional methods with individual characteristics, as they maintained that the traditional method of classroom instruction was not optimal for all students. Steurfert, Suedefeld and Driver (1965) found that more complex subjects were less influenced by the environment than less complex subjects. In the same vein, Staszkiewicy (1977) indicated more cognitively complex students scored higher than less complex students in situations characterized by less teacher direction. Consequently, a closer examination of the interaction between person variables (cognitive style) with learning environment (EBCE vs. traditional classroom instruction) in the present investigation seeks to examine the contributions of each with respect to academic learning and retention.

More detailed and specific information is found in Appendix A.

Summary of Year-one Research

Past research on learning-in-work programs has generally relied on the pre-test/post-test control group design to detect differences in student performance. Usually, the results indicate few statistical differences in the acquisition of subject matter between students in the learning-in-work program and those in the control group. However, the authors believe that differences exist and that methodological and other problems may prevent the detection of subtle changes (Crowe, 1977, 1979). One reason for not detecting differences may be that the research design restricts the time required for differences to emerge. That is, demonstrable student performances or achievements may not occur until three to six months after program participation.

To test this assumption, the design of this study uses repeated measures at the beginning (pre-test) and end (post-test) of the learning experiences and after the summer recess (follow-up test). The time between the end of the program experiences and the end of the summer recess is considered as the retention phase of what students have learned. In other words, the patterns of student performances between post- and follow-up testing may reveal the extent to which mathematical and reading concepts are retained after participation in one of the two learning environments. Thus, the design and interpretation of results can be anchored to the broad concepts of memory and retention phenomena.

The basic theoretical position adopted by the investigators was that the learning environment to which students are exposed exerts a strong influence on subsequent levels of performance. To investigate some of the specifics of the interaction between students and their learning environments, two settings were selected which were seen to possess significantly different properties: (1) a "traditional" classroom environment, characterized by one teacher per class; subject matter organized by traditional discipline area (e.g., math, English); instruction confined to the classroom; and a schedule of five to six discrete instructional periods per day and (2) a "learning-in-work" environment, characterized by eighty percent of the student's time spent in community worksites with learning supervised by a "resource person" at each site; twenty percent of the student's time spent in a "learning center" where the student negotiated with a "learning coordinator" to plan his/her learning activities and evaluate his/her performance. A more thorough description of the Experience Based Career Education (EBCE) Program or what we have called a learning-in-work environment can be found in Appendix B.

The subjects for the first-year analyses were fifty-four students (twenty-seven for each environment) who were followed in their junior year (with tests at the start and end) and re-tested at the start of the following year. Accordingly, since the students in the learning-in-work program were roughly comparable to the students in the traditional environment, it was assumed that the design would afford a means to compare the performance of the two groups and infer the "effects" resulting from participation in different learning environments.

For the purposes of the preliminary investigation, the analyses used were primarily descriptive in nature. As a means to distinguish between environmental differences in learning and retention (as measured by performance on standardized academic tests of math and reading skills), repeated-measures analysis of variance analyses were conducted over the three observation periods (the start and end of junior year, and the start of senior year). A summary of these analyses is presented in figure 1, and a depiction of the performance means is given in figures 2 and 3. A more thorough description of the tests is found in chapter II.

The results for the math concepts showed that, contrary to expectations, performance of the students in the learning-in-work environment demonstrated decreasing slopes for the learning interval and increasing slopes for the retention interval. The retention of the reading concepts was essentially the same for both groups of students in that both groups showed increasing slopes for both the learning and retention intervals.

FIGURE 1

Year 1 Summary

		MAIN EFFECT & INTERACTION			SIMPLE EFFECTS			COMPARISONS OF MEANS (LSD, p = .05)		
		Program (T vs. C)	Tests (T_1, T_2, T_3)	Program X Tests	Program @ T1 Pre-test	Program @ T2 Post-test	Program @ T3 Follow-up	T1 vs. T2	T2 vs. T3	T1 vs. T3
Math Scales										
Concepts	1									
Application	2			X_2		X_1				
Recognition	3		X_1	X_2		X_2				
Translation	4									
Interpretation	5			X_2		X_2				
Analysis	6									
Reading Scales										
Comprehension	1		X_2							X_2
Recognition	2		X_1							
Translation	3									
Interpretation	4		X_2							X_2
Analysis	5			X_2						

$X_1 = p < .10$
$X_2 = p < .05$
n = 54
T = Learning-in-Work Environment
C = Traditional Environment

FIGURE 2

Student Performance on Reading Comprehension Scales for Three Testings

T = Learning-in-Work
C = Traditional Environment

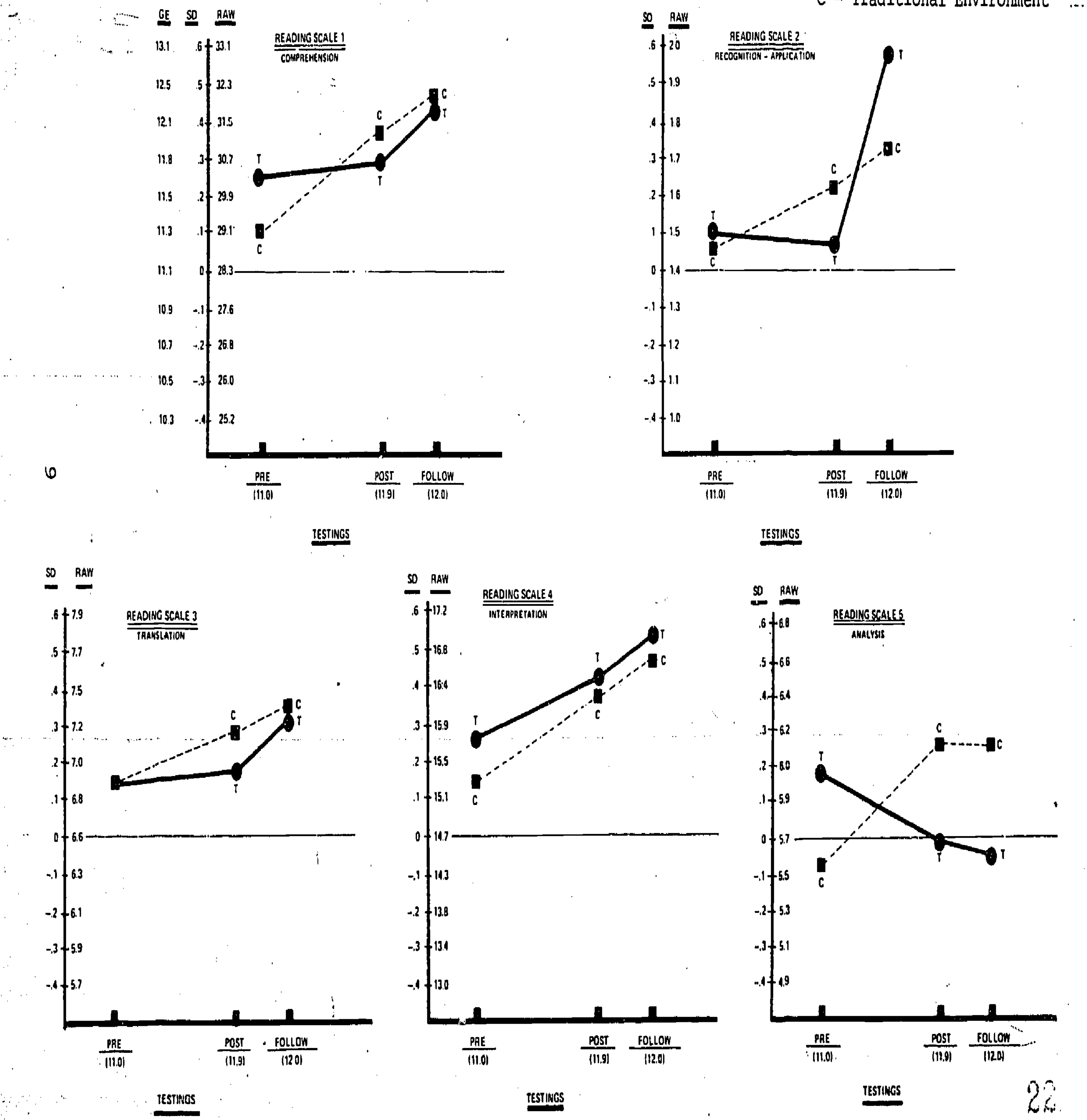
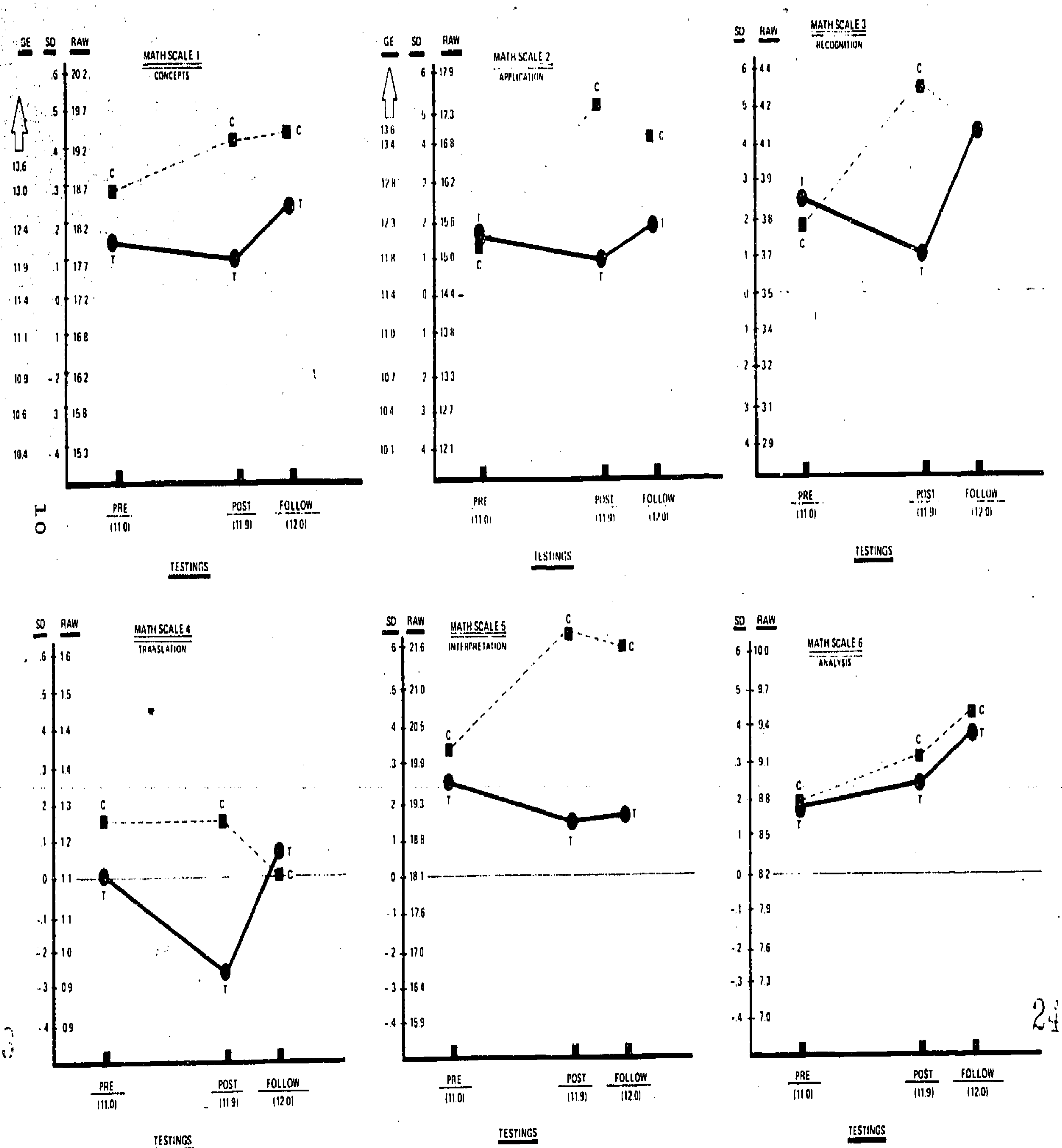


FIGURE 3

Student Performance on Math Scales for Three-Testings

T = Learning-in-Work
C = Traditional Environment



Patterns from student interviews and a prototype Learning Environment Questionnaire suggested that students in the learning-in-work environment perceived their learning environment as more complex, when compared to students in the traditional learning environment.

The results of the first year's analyses were interpreted in the context of a retroactive-interference design, which suggested that the rules for learning how to learn in the work environment interfered with those acquired for learning in the traditional school environment. Thus, the decreasing slopes of the learning-in-work students observed for the learning interval could indicate the extent to which the rules learned in the traditional school environment interfered. The observed increasing slopes for the retention interval could indicate an integration of the rules for learning to learn in the work environment with rules for learning in a school environment.

Problem Statement

The growth of learning-in-work programs such as Experience Based Career Education, Career Intern Program, and the Executive High School Internships Program expands student learning opportunities to include workplace environments and this expansion provides young people the option of choosing one learning environment over another. Inherent in this choice is the assumption that students choosing the learning-in-work environment learn concepts associated with traditional subject matter as well as or better than students choosing a traditional learning environment. This assumption is based, in part, on the fact that students in the learning-in-work environments are exploring real problems in the workplace that relate to subject matter disciplines, are learning under the guidance of a mentor who solves work-related problems, are having experiences that pair subject matter concepts and specific work tasks, are learning concepts in a concrete "hands-on" manner, and presumably are forming cognitive structures for storing and retrieving concepts similar to those of the mentor at the workplace.

Inspection of the results from the first wave of analyses led to two main conclusions. First, the performance patterns exhibited by the students on the reading scales of the CTBS were consistent with the expected results: the performance of both groups rose uniformly over time, with no significant differences between the group means at any of the testing occasions. It was assumed that these results illustrated a learning/retention function, demonstrating that students in both environments learned and retained skills in reading equally well. Math performance, however, did not conform to the pattern observed in the reading scales. Pronounced differences were seen between the two groups of students at the second testing (at the end of one academic year in their respective programs), which suggested that dissimilar processes were operating in the two environments with respect to learning/retaining/performing math skills.

The present report constitutes an extension of the first year's analyses based on the findings of differences in math performance between the two environments. The following general questions were raised. First, how did the environments differ, in terms of the students' perceptions of various characteristics which were common to both environments? Second, could support be obtained (through quasi-experimental analyses) for the hypothesis that different casual processes were operative as a function of differences in the learning environments? Third, were there student differences in the performance as a function of the types of worksite placements, and/or the types of summer activities? Finally, and of greater importance theoretically, could the predicted interaction of personal characteristics (cognitive complexity) by environmental characteristics (environmental complexity) be obtained using math performance as the dependent variable?

Thus, the general hypothesis to be examined is that there is relationship (interaction) between individual complexity and learning environment complexity (as a function of instruction received in traditional or learning-in-work environments) on the retention of cognitive skills.

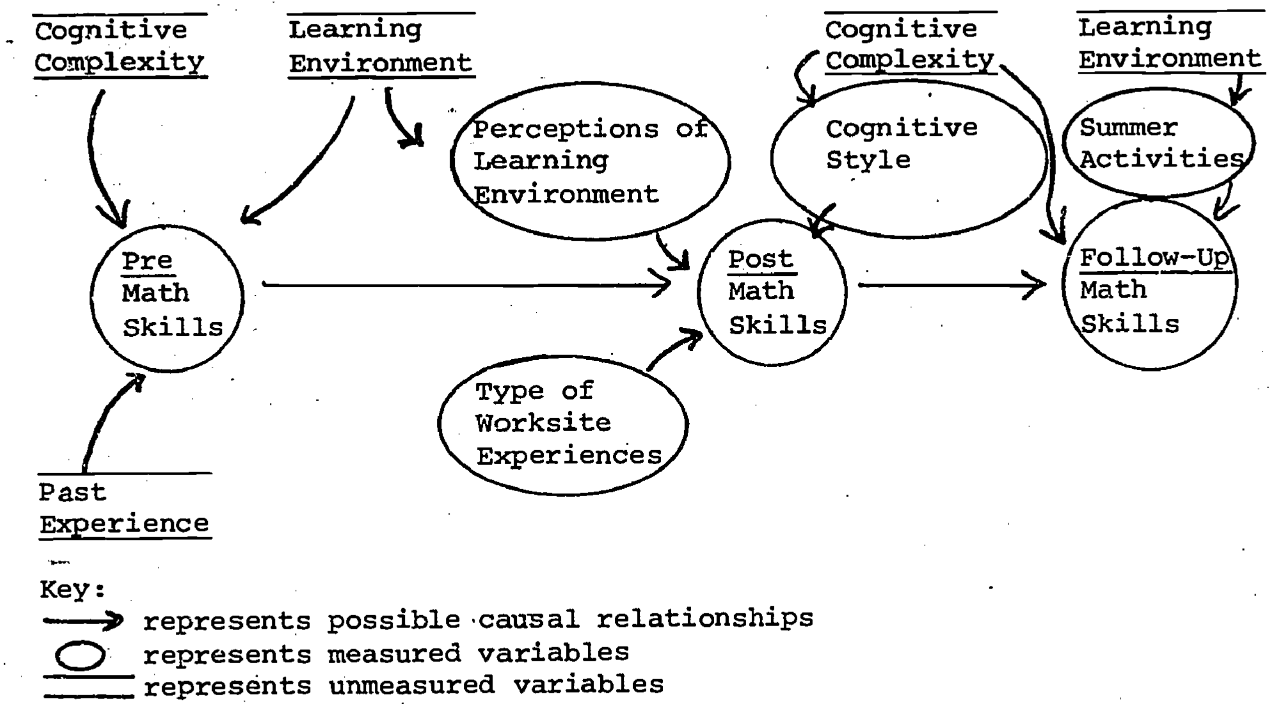
Research Framework

Heuristic Model and Causal Relationships

As a result of the preliminary examinations of the data and a desire to understand the cognitive processes and causal relationships underlying student learning in the learning-in-work environment, a heuristic model was used to guide the research questions for the present study. The model was used for two reasons: first, to permit questions to be asked in the context of causal relationships presumably operating for students in the learning-in-work environment; and secondly, to guide the analysis of the data. It should be noted that due to limitations of the data, the model is not being tested, but is rather being used as a road map to guide the current investigation. The heuristic model that represents the hypothesized causal relationships for students who are learning cognitive skills in a learning-in-work environment is as follows:

FIGURE 4

Heuristic Model for Investigating Student Cognitive Processes in Learning-in-Work Environments



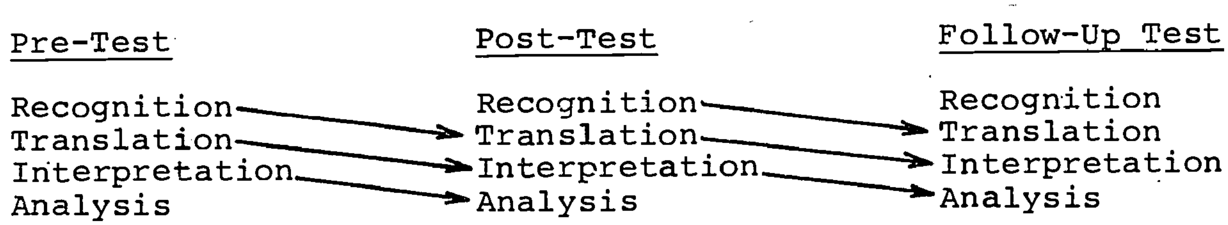
Two general relationships are inherent in this model: (1) that the pre-test scores and all other unmeasured experiences and personal characteristics in association with the learning environment cause post-test performance to occur in such a way as to be related to a hierarchical achievement of cognitive skills as defined by Bloom's taxonomy (and as measured by the CTBS); and (2) that the post-test scores and all unmeasured experiences and personal characteristics in association with the summer environment combine to cause follow-up performance.

Definition of Independent and Dependent Variables

Before the specific research questions are described, it may be useful to describe the measured independent and dependent variables. There are three classes of measures: environmental characteristics, personal characteristics, and performance effects. The environmental characteristics include (1) the worksite experiences both by number participating and as classified by the Worker Trait Group (WTG) from the *Dictionary of Occupational Titles* for the learning-in-work students; (2) the summer activities for both groups of students classified as full- or part-time work or summer school or a combination of work and school, and (3) the students' perceptions of the learning environment as measured by the Learning Environment Questionnaire (LEQ). The personal characteristic of cognitive complexity was determined by the Paragraph Completion Test (PCT), which resulted in a measure of cognitive style. The dependent variable was math performance as determined by the CTBS scores that are hierarchically developed along the lines of Bloom's taxonomy.

Research Questions

Based on the heuristic model for describing students' cognitive processes in learning environments and the measured variables obtained for students in this study, two research questions are investigated. First, student pre-test scores and exposure to either the learning-in-work environment or to the traditional learning environment caused math post-test performance (and follow-up performance) to occur in such a way as to be related to an hierarchical achievement of cognitive skills as defined by Bloom's taxonomy and as measured by the CTBS. That is, because the CTBS process scales of Recognition, Translation, Interpretation, and Analysis are hierarchically developed along the lines of Bloom's taxonomy, it is predicted that achievement of one process at time 1 will cause achievement of the next hierarchically-related process at time 2 as follows (⟶ represents causes):



Secondly, environmental characteristics will exhibit an interactive relationship with the student's personal characteristic of cognitive style in causing math performance.

In order to augment the investigation of these two causal relationships, the factor structure of the LEQ was determined for both groups of students, as well as the extent to which the number of and type of site experiences classified by WTG were associated with math performance for the learning-in-work students. Chapter II further delineates the research questions and their associated measured variables.

CHAPTER II

DESIGN AND METHODOLOGY OF THE STUDY

This chapter contains three sections that describe (1) the research background characteristics, (2) the description of the major measured variables (instruments), and (3) the analysis questions and strategies.

Background

Pre-Established Conditions

The exploratory nature of this investigation determined the eventual design and methodology employed. Through the assistance of the National Institute of Education Project Officer, Ron Bucknam, our staff located an AEL model of EBCE operating in Anoka, Minnesota. As part of the conditions of federal support for the initial operations of program, a third-party evaluation was being conducted. Given the opportunity for National Center research staff to work cooperatively with the EBCE staff at the Anoka site and to "piggy-back" an on-going evaluation supported by federal resources, we accepted the pre-established conditions of the third-party evaluation as part of the research design for this study. Additionally the staff of the Anoka-Hennepin School District No. 11 agreed to permit the testing of the evaluation students at the beginning of the following school year. Thus, we were able to establish a repeated-measures design to investigate the learning and retention of concepts.

The following pre-established conditions of the third-party evaluation were included:

- A pre- (September 1978) and post- (May 1979) testing of EBCE students and control students
- Control students chosen at random from master school rosters to match the volunteer EBCE students in respect to membership in home high school, grade point average, and sex
- Administration of the sub-tests of mathematical concepts, applications, and reading comprehension from the Comprehensive Tests of Basic Skills

Finally, in order to ensure that follow-up testing conditions remained similar to those of the pre- and post-testing sessions and to minimize interruptions to the EBCE program, the National Center contracted with the third-party evaluator to administer the follow-up tests (September, 1979) at the same time that new students were being tested for the third-year evaluation.

Research Design

Students could volunteer to participate in the EBCE program during their junior year at high school. We designated this group as the learning-in-work program. The control students were juniors enrolled in the traditional program at one of the three high schools and randomly selected from a master school roster to match the learning-in-work students as to the characteristics of membership in the home high schools, grade point average, and sex. This second group we designated as the traditional learning program.

The independent variables were the two learning environments (programs) and the learning and retention intervals (time). The dependent variables were student scores on the sub-tests of mathematical concepts, application, and reading comprehension of the Comprehensive Tests of Basic Skills. Both content scores and process dimension scores were yielded by these measures.

The design for this investigation is probably best described as quasi-experimental, since students were not randomly assigned to participate in the EBCE program. Pictorially, the design for this study is shown in Figure 5.

FIGURE 5

Design of the Investigation

Group	Events
Learning-in-Work	0_1 X_1 0_2 X_3 0_3
Traditional Learning	0_1 X_2 0_2 X_3 0_3

The treatment X_1 is the learning-in-work environment while X_2 is the traditional learning environment. The treatment X_3 is the summer recess, and it is assumed that the experiences of the students would be similar. The design is a repeated-measures one where the nature of the observations (0) is defined as follows (figure 6):

FIGURE 6

Descriptions of the Observations

Observation		
0_1	Pre-test administered September, 1978	Comparability of groups (To what extent were the groups similar on pre-test measures?)
0_2	Post-test administered May, 1979	Concepts achieved (What were the criterion performances? To what extent did students show growth for the concepts?)
0_3	Follow-up test administered September, 1979	Concepts retained (How much of the concepts were retained? Which concepts were retained?)
$0_2 - 0_1$	9 months	Learning Interval (Practice; acquisition of concepts)
$0_3 - 0_2$	3 months	Retention Interval (Integration of concepts in nonformal learning setting)

Generalizability

The lack of random selection of EBCE students affects the generalizability of the study's results. Because of the random selection of the control students and the extent to which the variables used for matching do not decrease representation, we would expect a reasonable ability to generalize to junior students from the same general background (e.g., region of country, socio-economic status). However, the fact that random assignment was not used to place students in the learning-in-work program places limitations on the extent to which generalization of the observed results of this EBCE program can be made to other samples/populations of students participating in an EBCE program. Because the students were "self-selected" for membership in the learning-in-work program, we do not know the extent to which they are atypical of the "average" high school student. Overall, it would not be prudent to state that our obtained observations can be expected for a group randomly assigned to the program. Essentially, for the learning-in-work group, we can only describe the way things are for our sample but cannot predict for a larger population with any substantial degree of confidence. To obtain that degree of generalizability, a "true experiment" would be necessary in which students are randomly assigned to both the traditional and EBCE programs.

Data-Collection Procedures

Data were collected in September, 1979; late May, 1979; and September, 1979. The pre- and post-testing was performed by Evaluation Consultants under a contract from the school district to conduct a third-party evaluation of EBCE. The follow-up testing was also conducted by Evaluation Consultants under a contract from the National Center.

Students from both programs were assembled at their home schools for testing, which proceeded according to CTBS guidelines. Therefore, testing conditions and times were identical for both the traditional and learning-in-work students (for each home high school). The LEQ was administered at the post-testing session. A make-up session following the above procedure was held for each observation to ensure the maximum number of responses. Testing time required about one hour.

Sample Size

Table 1 indicates the number of students available for testing at the time of the three testing observations, categorized according to their sex and home high school.

As can be seen, there was a 27.5 percent overall subject mortality, since only students who had complete instruments for all three testings were included in the analysis.

TABLE 1

Size of Sample

	Pre		Post		Follow-Up*	
	Learning-in-Work Environment	Traditional Learning Environment	Learning-in-Work Environment	Traditional Learning Environment	Learning-in-Work Environment	Traditional Learning Environment
Total Number of Students Tested	38	42	38	42	30	28
No. of Males	16	23	16	23	11	13
No. of Females	22	19	22	19	19	15
No. from High School #1	10	14	10	14	8	9
No. from High School #2	14	13	14	13	10	11
No. from High School #3	14	15	14	15	12	8

* Subjects for the analyses were drawn from these totals, but the usable sample size is smaller (T=27, C=27) than the total number surveyed, due to four subjects having incomplete data on pre-test and/or post-test.

Instrumentation

The instruments used for the investigation are described here. In addition to using the CTBS to measure student achievement of subject-matter content, the project staff, with the assistance of Dr. Harold Schroder, of the University of South Florida, developed an experimental instrument designed to describe student perceptions of the complexity of the learning environment (Learning Environment Questionnaire, LEQ). Finally, the staff used the Paragraph Completion Test (PCT) to obtain a measure of student cognitive complexity. The CTBS was administered at pre-, post-, and follow-up testings; the LEQ and PCT, at the post-test only.

Comprehensive Tests of Basic Skills

The test used to measure student retention of concepts was the Comprehensive Tests of Basic Skills (CTBS), Expanded Edition, level 4, form S, Test 2--Reading Comprehension; and Test 7--Mathematics Concepts and Application. According to the CTBS literature, the instrument measures skills and concepts. The Test Coordinator's Handbook (1967) describes the test as a measuring instrument thus:

> Measurement of the basic skills and abilities cannot be divorced entirely from the measurement of knowledge acquired through schooling, but it is not the intent of CTBS to measure this knowledge directly. The emphasis . . . is on measurement of the grasp of broad concepts and abstractions as developed by all curricula and on the facility in the skills that are required for effective use of language and number . . . .

To provide the readers with an overview of the instrument, the following excerpts from The Coordinator's Handbook are presented:

> Rationale. CTBS, Expanded Edition, was designed to measure the extent to which individual students have developed the capabilities and learned the skills that are prerequisite to studying and learning in subject-matter courses . . . .
>
> The basic skills are developed through exposure to a variety of curricula and instructional procedures . . . these tests of basic skills are not greatly affected by the particular content material used to teach students.

The emphasis . . . is a measurement of the grasp of broad concepts and abstractions as developed by all curricula . . . .

Test items. In the development of the tests, attention was given to long-term trends in curricula . . . items were excluded that could not be assumed to be based on common experience.

(through research), CTBS/McGraw Hill has attempted to identify and eliminate racial and ethnic bias . . . .

Classification scheme. The (classification) scheme is so arranged that there is an inherent hierarchy of skills, or levels of thinking, consistent with what is currently known about child development, cognitive structures, and learning processes.

The process classification of items for the CBTS follows essentially the approach presented in Taxonomy of Educational Objectives, edited by Bloom. This approach has been adapted to the CTBS design. Two major components provided the basis for devising the classification scheme for CTBS: the "process" dimension and the "content" dimension.

Process dimension. The emphasis in the process dimension is on the measurement of comprehension and application of concepts and principles rather than on the measurement of knowledge per se . . . . the tests measure knowledge of ways and means of dealing with these concepts and principles as reflected in applying rules . . . and processes.

The classification scheme is hierarchical in nature: as the level increases, more complex processes are used with greater frequency than simpler processes. There is also an increase in complexity and abstractness of the test items over the levels . . . .

Content dimension. The categories in the content dimensions differ . . . among the various levels of CTBS. The type of content was selected at each test level for its appropriateness to the students of the grades for which it was intended.

Content and process relationships. Figure 7 provides a description of the Content dimensions for the mathematics concepts and application tests. Figure 8 is the description of the Process dimensions that are applicable to the CTBS tests and that are related to Bloom's Taxonomy of Educational Objectives. Figure 9 describes the relationship of the mathematics concepts and application content categories to the process dimensions. The major purpose of these figures is to facilitate an understanding of the overall rationale, logic, and structure of the CTBS. Furthermore, they are intended to demonstrate that what is being measured, in addition to the mathematical content, is cognitive processes or operations underlying learning and memory.

Reliability and validity of CTBS. CTBS reliability and validity coefficients are obtained from the CTBS Technical Bulletin No. 1. Kuder-Richardson formula 20 (KR 20) equations were used to determine the reliability of the CTBS, and constitute an estimate of the tests' internal consistency. Reliability measures reported by CTBS are as follows: Reading Comprehension ($r = .91$); Math concepts ($r = .85$); and Math Applications ($r = .88$). These values are quite acceptable, and they presumably reflect the precision with which the CTBS scales were constructed. Content validity, or the extent to which the test samples a representative group of items from the total content domain, was assessed by a variety of procedures, including consistency of items with the total scores and the ability of the items to discriminate between achievement groups of students. Reading items were selected to measure critical skills of theme identification, character analysis, and inference. Math items were selected to measure concept recognition, selection of proper problem-solving strategies, and implementation of these strategies.

FIGURE 7

Description of the CTBS Content Dimensions for the Mathematics Concepts and Application Tests

Concept Dimension Categories	Description
Number/System/Properties	- Convert from one mathematical form to an equivalent form - Understand relationships of comparisons, number properties, and place value
Geometric Relationships	- Recognize curves, plane shapes - Understand formulas - Compute measurement of figures, given the formulas - Recognize, estimate, compare, compute measures of time, length, money, weight, area
Sets	- Understand set relationships - Determine sets described in problem
Graphs	- Interpret information from circle or line graphs - Interpret given point on graph
Mathematical Sentences	- Solve for unknown values in equations
Problem Solving	- Comprehend a problem - Select method to solve problem
Reasoning	- Determine information needed to solve problem - Determine logical conclusions

Note: Adapted from CTBS Test Coordinator's Handbook, p. 18.

FIGURE 8

Description of the CTBS Process Dimensions

Process Dimension Categories	Description
Recognition	- Recognize, or recall and apply facts, theories, concepts, structures previously learned
Translation	- Transform concepts and symbols into equivalent forms - Interpret graphically presented data
Interpretation	- Understand facts and concepts in, and make inferences from, written material - Associate data and ideas - Comprehend relationships - Summarize major themes or concepts
Application	- Apply prior knowledge of facts to solve problems - Use previously learning research skills to determine meaning of new material
Analysis	- Apply formal logic to synthesis of organizational patterns or components - Determine hierarchical arrangement of facts

Note: Adapted from CTBS <u>Test Coordinator's Handbook</u>, p. 7

FIGURE 9

Relationship of Mathematics Concepts
Content Categories to Process Dimensions

Process Dimensions

	Recognition	Translation	Interpretation	Analysis
Concepts Content Categories	Number Systems		- Number Systems - Sets - Measurement - Geometric Relationships - Problem Solving/ Reasoning	- Math Sentences - Geometric Relationships - Problem Solving/ Reasoning

Relationship of Mathematics Application
Content Categories to Process Dimensions

Process Dimensions

	Recognition	Translation	Interpretation	Analysis
Application Content Categories		-Measurement	-Measurement -Math Sentences -Geometric Relationships -Problem Solving/ Reasoning	-Problem Solving/ Reasoning

Note: Adapted from CTBS Test Coordinator's Handbook, p. 19.

Learning Environment Questionnaire (LEQ)

Because the investigation is concerned with learning and retention in two learning environments, a measure to assess student perceptions of the complexity of the environment was developed.

Two constructs were used to develop the LEQ: the student perception of environmental complexity and the degree of perceived internal or external control over learning tasks. Environmental complexity was considered in terms of different types of environments, one in which concepts are generated and another in which concepts are presented. Indicators of concept generators may include opportunities to observe, ask questions, experiment, develop ideas, and evolve alternative problem solutions. Indicators such as these can be characteristic of an open environment where individuals are supported and encouraged by the environment to achieve goals. On the other hand, indicators of environments which present concepts may include those in which learners are told what to do, are taught the correct or acceptable way to handle a situation, and are given a little encouragement to be creative in solving problems. Indicators such as these may be characteristic of a closed environment where individuals perceive the environment as nonsupportive of achievement of individual goals. A concept-generating environment may be considered more complex than a concept-giving environment, in part because decisions must be made without the benefit of readily available rules and predetermined consequences. Thus, individuals in these environments may have to consider more dimensions and make more judgements with finer discriminations to decide how to solve a problem.

Closely related to the concept of complexity is the degree to which individuals feel internally motivated for work. That is, if individuals believe that they are doing a good job in meaningful work and that they alone are responsible for completing the task, they may take their cues from an internal "sense of needs" for task performance (internal control). Conversely, individuals who perceive that they have limited opportunity to do meaningful work or solve problems and that they have limited control over decisions may take their cues from the environment for task performance (external control).

For purposes of this investigation, we would expect the learning-in-work environment to be more concept-generating than concept-giving and would expect the students to perceive more internal control than external control.

Figures 10 and 11 present the LEQ for the EBCE students and the students in the traditional learning environment respectively. The difference in the two LEQS accommodates the specific actors who guide the student learning (learning coordinator as compared with classroom teacher) in the two learning environments.

Learning Environment Questionnaire

This questionnaire asks about your learning situation in the Experience-Based Career Education program. The purpose is to find out your perceptions of situations where you learn and your reaction to them. There are no right or wrong answers. Place a check ☑ in the cell ☐ that best represents your opinion.

	Strongly Disagree	Moderately Disagree	Undecided	Moderately Agree	Strongly Agree
1. In the EBCE program I felt encouraged to find things out for myself	☐	☐	☐	☐	☐
2. I was able to tell by myself if I was doing a good job	☐	☐	☐	☐	☐
3. The learning coordinator taught me what I needed to know	☐	☐	☐	☐	☐
4. The resource person taught me what I needed to know	☐	☐	☐	☐	☐
5. In the EBCE program I was able to ask many questions about the work	☐	☐	☐	☐	☐
6. The results of what I did had meaning. I felt the results were important	☐	☐	☐	☐	☐
7. The learning coordinators described the way they wanted me to do my work	☐	☐	☐	☐	☐
8. The resource persons described the way they wanted me to do my work	☐	☐	☐	☐	☐
9. In the EBCE program I had opportunities to try things out for myself	☐	☐	☐	☐	☐
10. The work that I did offered me many different things to do	☐	☐	☐	☐	☐
11. The learning coordinator gave me the right way to do the work	☐	☐	☐	☐	☐
12. The resource person gave me the right way to do the work	☐	☐	☐	☐	☐
13. In the EBCE program I was encouraged to come up with my own ideas	☐	☐	☐	☐	☐
14. The resource person provided me opportunities to do meaningful work or solve problems	☐	☐	☐	☐	☐
15. The learning coordinator provided me opportunities to do meaningful work or solve problems	☐	☐	☐	☐	☐
16. The learning coordinators showed me what they required me to do	☐	☐	☐	☐	☐
17. The resource persons showed me what they required me to do	☐	☐	☐	☐	☐
18. The resource person encouraged me to decide for myself how I was going to do my work	☐	☐	☐	☐	☐
19. The learning coordinator encouraged me to decide for myself how I was going to do my work	☐	☐	☐	☐	☐

FIGURE 11

Learning Environment Questionnaire

This questionnaire asks about your learning situation in your school program. The purpose is to find out what you think of situations where you learn and your reaction to them. There are no right or wrong answers. Place a check ☑ in the cell ☐ that best represents your opinion.

	Strongly Disagree	Moderately Disagree	Undecided	Moderately Agree	Strongly Agree
1. In my school program I felt encouraged to find things out for myself	☐	☐	☐	☐	☐
2. I was able to tell by myself if I was doing a good job	☐	☐	☐	☐	☐
3. The teachers taught me what I needed to know	☐	☐	☐	☐	☐
4. In my school program I was able to ask many questions about the work	☐	☐	☐	☐	☐
5. The results of what I did had meaning. I felt the results were important	☐	☐	☐	☐	☐
6. The teachers described the way they wanted me to do my work	☐	☐	☐	☐	☐
7. In my school program I had opportunities to try things out for myself	☐	☐	☐	☐	☐
8. The work that I did offered me many different things to do	☐	☐	☐	☐	☐
9. The teachers gave me the right way to do the work	☐	☐	☐	☐	☐
10. In my school program I was encouraged to come up with my own ideas	☐	☐	☐	☐	☐
11. The teachers provided me opportunities to do meaningful work or solve problems	☐	☐	☐	☐	☐
12. The teachers showed me what they required me to do	☐	☐	☐	☐	☐
13. The teachers encouraged me to decide for myself how I was going to do my work	☐	☐	☐	☐	☐

Paragraph Completion Test (PCT)

The Paragraph Completion Test (PCT) derived from the work of Schroder, Diver, and Streufert (1967) represents an approach to the content-free measurement of cognitive style. This approach involves a projective technique of stem completion. The PCT presents the subject with five stems. Three sentences are to be written for each stem. The integrative or cognitive complexity score used for this study was the mean of the four most abstract responses after each stem had been scored on a seven-point scale. The stems used for this study were as follows:

1.	Your friend:	Rules! How do you feel about rules?
	Your answer:	Rules . . . . (complete the sentence and write 2 more.)
2.	Your friend:	Sometimes I feel doubt. When you are in doubt, how do you feel?
	Your answer:	When I am in doubt . . . .
3.	Your friend:	Sometimes my teacher disagrees with me, How do you feel about disagreement with your teacher?
	Your answer:	When someone disagrees with me . . . .
4.	Your friend:	Sometimes I feel confused. How do you feel when you are confused?
	Your answer:	Confusion . . . .
5.	Your friend:	Sometimes I am criticized. How do you feel when your teacher criticizes you?
	Your answer:	When others criticize me it usually means . . . .

The PCT was scored by Dr. Harold Schroder and associates.

An example of a concrete response to the stem "When I am criticized . . . ." is "I feel happy." "Anyway, I don't listen too carefully to criticism. I guess I'm occupied with my own little world, so outside criticism isn't very important to me" (Schroder and others, 1967, p. 192). An example of an abstract response to this stem is "I listen carefully. Criticism tells me much about the criticizer - how he thinks, what he believes in, what he expects of others. It also tells me how others see me. After that, I usually find myself changing my way of acting or thinking in order to take this into account" (Schroder and others, 1967, p. 193).

Analysis Considerations

Analytic Strategy

The present analyses were performed in order to address questions raised in the preliminary examination of the data. These questions can be profitably viewed in the context of an overall model of the causal processes presumed to be operative for this study. A graphic presentation and description of this model is depicted in chapter I, figure 4.

The model uses notation borrowed from the path-analytic literature (e.g., Kenny, 1979; Kerlinger and Pedhazur, 1973). While the use of this general model would seem to suggest an analytic strategy including estimation of path coefficients for such a model (i.e., a "path analysis"), this approach was rejected for the following reasons. First, and foremost, the present study did not allow the measurement of the number and kind of variables nor the measurement at specific observation periods desirable for a proper causal-modeling approach, due to constraints imposed by the particular characteristics of the sample selected for the study. For example, measures on a variety of background variables (e.g., I.Q., family structure, scholastic ability, student personality) would have been highly desirable <u>prior</u> to the initiation of the study and the formation of the groups. Additionally, both the small size of the sample, as well as the non-random assignment of subjects to the learning environments, would make the obtained parameter estimates both highly unstable and of questionable generality to the population of students eligible for participation in such programs.

Another common technique, the analysis of covariance, was also considered and rejected for these data. While the temptation was present to use "adjusted" means to assess the effect of the different educational environments (e.g., partialling such variables as sex, GPA, and pre-test score from the post-test and/or follow-up) on math and reading achievement, this strategy was deemed inappropriate. As is noted by Cohen and Cohen (1975, pp. 395-397), the potential for dual-direction causal relationships using existing, self-selected groups) and the concomitant problem of dividing the shared variance between these research factors would be expected to produce coefficients (and adjusted means) which would be at best mathematically unjustified, and at worst seriously misleading. The above-mentioned types of questions can only be addressed, in a valid fashion, through use of something approximating a "true" experimental design which includes experimenter control over assignment to treatment conditions, thereby guaranteeing no two-way causality between the research factors and the covariates.

TABLE 2

Existing-Group Differences on Background Variables on CTBS Scales

	Parameter	t	f
Pre-Test			
D.V.: CTBS - Applications			
Intercept	1.12	0.39	.70
Sex	-0.14	-0.14	.89
Number of Previous Math Classes	4.76	3.02	.004
GPA	3.43	4.84	.0001
			R^2 = .48
D.V.: CTBS - Concepts			
Intercept	-4.40	-1.24	.22
Sex	0.95	0.78	.44
Number of Previous Math Classes	7.06	3.52	.0009
GPA	2.44	2.70	.009
			R^2 = .37

Support for this position can be seen in Table 2. These differences would suggest that the two groups, as a function of the self-selection process, were not comparable and that there was good reason to suspect that whatever factor(s) caused the self selection could be related causally to the covariates (e.g., GPA, number of previous math classes). Thus, while the groups were not technically formed until the start of observation, the suspicion which precluded such techniques as analysis of covariance was that these groups "existed" prior to membership in the learning-in-work program; accordingly, it would be impossible to state that the covariates caused the observed differences in math performance as a function of the program.

Analysis Questions

Accepting the limitations imposed by the measured variables and the sampling strategy but desiring to ask provocative questions arising from the preliminary analysis of the data, we adopted the following analytic approach phrased in terms of five questions:

1. What is the factor structure of the learning environment questionnaire (LEQ)? Questions concern

the underlying dimensions measured by the LEQ including similarities and differences between student perceptions of the role of the learning coordinators, the on-site resource persons, and teachers.

II. How does Bloom's taxonomy as measured by the CTBS function for students in the two learning environments? Questions concern the applicability of the presumed Bloom predictions of a hierarchical structuring of scales (as defined and measured by the CTBS) in both learning environments, as well as the factoral structure of the CTBS with respect to measuring the Bloom "factors."

III. What is the effect of type-of-placement (as defined by the WTG of the DOT) on the learning-in-work student's performance? Questions in this section are concerned with the association between exposure to different worker trait group jobs at the students' placements (treatment students only) and subsequent performances on the CTBS.

IV. What is the effect of type of summer activity on follow-up performance? In this section, questions concerning the relationship between students' summer activities and follow-up performance are addressed. For example, was there a difference between students enrolled in formal coursework over the summer recess and those who were not, and was there a difference between students who worked over the summer break and those who didn't work.

V. Is there a moderating relationship involving the LEQ and the student's cognitive style? This question is concerned with the prediction of the authors that the relationship of the learning environment (perceptions) to performance will vary as a function of the student's cognitive style. More specifically, an interaction between cognitive style and the students' perceptions of the learning environment is predicted.

Chapter III describes the analysis of the findings for these five questions.

CHAPTER III

FINDINGS

Overview of Chapter

This chapter presents the findings for the research questions described in chapter I. Figure 12 is presented as an organizing aid to help structure the discussion in this chapter. The chart depicts the independent and dependent variables and the associated analysis/research question(s). Preceding the discussion of these questions, the LEQ is examined for its underlying structure. The chapter concludes with an overall summary and discussion of the research findings.

FIGURE 12

Relationship of Independent and Dependent Variables to the Analysis and Research Questions

Independent Variable	Dependent Variable	Analysis/Research Question
1. Learning-in-work and traditional learning students, and time intervals ($T_1 Vs T_2$, $T_1 Vs T_3$, $T_2 Vs T_3$)	CTBS math scores as defined by the process variables based on Bloom's taxonomy and measured at post- and follow-up testing. The hierarchical arrangement of the CTBS process (Blooms' taxonomy) scales are Recognition, Translation, Interpretation, and Analysis.	Did being in one of the two learning environments cause students to learn math skills as predicted by Bloom's taxonomy? According to CTBS, the math items were developed along the lines of Bloom's taxonomy, therefore, certain predictions can be evolved. (a) Mastery of Recognition items at time 1 causes an increase in Translation items at time 2. (b) Mastery of Translation items at time 1 causes an increase in Interpretation items at time 2. (c) Mastery of Interpretation items at time 1 causes an increase in Analysis items at time 2.

FIGURE 12 (cont.)

2. Number of site experiences, type of work experience by WTG for learning-in-work students	CTBS math scores of content and application at post- and follow-up testings.	Did the type of worksite exposure as defined by WTG cause math achievement for students in the learning-in-work environment?
3. Learning-in-work and traditional learning students, summer activities	CTBS math scores of content and application at the follow-up testing.	Did summer experiences contribute to math achievement and the end-of-summer (follow-up) testing for both learning groups?
4. LEQ and PCT	CTBS math scores of content and application at post- and follow-up testing.	Is there a main effect or interaction for perception of learning environment (LEQ) with cognitive style (PCT) for math achievement?

Factor Structure of LEQ

Results

In order to examine the underlying structure of the perceptions of the learning environment, as reflected in the items of the LEQ (figures 10 and 11), separate-factor analyses were performed for the set of LEQ items, including the item stems "learning coordinator" and "resource person" for the students in the learning-in-work environment. These stems were paired in each analysis with the corresponding "teacher" stems for the students in the "traditional" learning environment, whenever the stems were not judged identical in content (i.e., for LEQ items 3, 6, 9, 11, 12, 13).

Principal axis factor extraction, using the parallel analysis procedure, was performed on the correlation matrices generated from the data described above in order to generate eigenvalues for comparison, which indicated retaining three factors for each analysis. Squared multiple correlations (SMC) were used as community estimates for all analysis models. The common-factor model was chosen in view of the belief that a model which factors only common variance would provide the most reasonable and realistic view of our data. To obtain the final-factor solutions, iterated principal axis factor techniques were used with SMCs as initial estimates of the communalities, retaining three factors. Because orthogonal (uncorrelated) factors would seem to be an unrealistic constraint to impose on these solutions, Proxmax (K-3) oblique transformations of the factor-loading matrices were performed to produce a final solution for each set of item stems. The results of these analyses are presented in Table 3.

Comparison of the factor solutions was also accomplished by the calculation of coefficients of congruence, which provide a measure of the similarity of factors, as well as by calculation of root mean squares, which correspond to "distances" between corresponding elements of each vector. The results of these comparisons are presented in Table 4.

It is apparent from these results that the first factors in both solutions (i.e., based on "coordinator" and "resource person" items) are very similar, although the second and third factors exhibit some degree of difference. However, for interpretative purposes, both solutions would yield virtually identical classification of items.

Interpretation

It was originally predicted (Crowe and Harvey, 1979) that two factors were addressed by the LEQ: complexity of the environment (e.g., the degree to which the environment was perceived as generating

TABLE 3

LEQ Factor Solution

Promax (K=3) Primary-Factor Pattern Loadings

LEQ	Final h^2 (Resource Person)	I	II	III	h^2 (Learning Coordinator)	I	II	III
(4) Able to ask questions	.70	.67*	.00	.24	.71	.72*	-.07	.22
(5) Perceived importance/meaning in results	.55	.36*	.36*	.14	.50	.46*	.11	.25
(8) Many things to do	.74	.68*	-.12	.33*	.68	.60*	.16	.38*
(10) Encouraged to come up with ideas of own	.65	.67*	.00	.17	.73	.81*	-.02	.07
(11) Had opportunities to do meaningful work	.68	.72*	.25	-.12	.64	.78*	.18	-.14
(13) Able to decide how to do work	.45	.75*	.03	-.18	.42	.52*	.26	-.07
(3) Taught me what I needed to know	.63	.28	.48*	.14	.59	.35*	.46*	.11
(6) Way to do work described to me	.44	-.08	.60*	.17	.44	-.14	.71*	.04
(9) "Gave me right way to do the work"	.69	.21	.67*	.02	.64	.26	.66*	-.04
(12) "Showed me what was required to do"	.53	.00	.70*	.04	.47	.08	.54*	.19
(1) Encouraged to find things out for myself	.61	.07	.12	.75*	.60	.00	.05	.75*
(2) Able to tell if doing a good job	.54	.06	.15	.68*	.60	-.05	.16	.71*
(7) Able to try things out by myself	.64	.30*	.02	.56*	.64	.37*	-.04	.53*

Factor Correlations

Resource Person

	I	II	III
I	1.00	.62	.63
II	.62	1.00	.58
III	.63	.58	1.00

Learning Coordinator

	I	II	III
I	1.00	.49	.62
II	.49	1.00	.37
III	.62	.37	1.00

N = 93

* Denotes loadings judged to be "significant" and item membership factors.

TABLE 4

Factor Comparisons for LEQ

Coefficients of Congruence[1]

		Learning Coordinator I	Learning Coordinator II	Learning Coordinator III
Resource	I	.997	.051	-.022
Person	II	.047	-.458	.821
	III	.027	-8.160	-.496

Root Mean Squares[2]

		Learning Coordinator I	Learning Coordinator II	Learning Coordinator III
Resource	I	.063	.750	.748
Person	II	.711	.428	.132
	III	.709	.457	.361

[1]High values indicate greater similarity

[2]Small values indicate greater similarity

or giving (concepts and rules); and control (e.g., the degree to which the students perceived the environment as offering opportunities to initiate tasks, solve problems, and negotiate work with adults). It was hypothesized that the items comprising the complexity factor were 1, 4, 7, 10, 3, 6, 9, 12 while the remaining items comprised the control factor. As can be seen in Table 3, both similarities and discrepancies were observed with respect to the original predictions. Three factors appear to underlie the structures of the LEQ. Inspection of the items classified with "significant" loadings showed a general consistency with the predictions. Thus, while the original predictions were not totally supported, the factor solutions of LEQ items were both impressive in terms of magnitude of the loadings as well as the "cleanness" of the rotated solutions.

Summated scales based on these above classifications were formed to provide measures based on the factor analysis. Results of correlational comparisons of these scales between the two groups are reported in Table 5.

As can be seen in Table 5, the students in the learning-in-work environment (coded as "1") were significantly and consistently higher on these scales than the controls in the traditional environment (coded as "0"). In these analyses, the mean difference between the groups is given by the parameter for the "program" variable, expressed in raw LEQ scale units; the t value for this quantity is the test of the significance of this difference between means. These results are consistent with the item-by-item comparisons reported in the first year's report.

Given the factor solution of the LEQ, the following items were classified under factor I:

(4) . . . I was able to ask many questions about the work.
(8) The work that I did offered me many different things to do.
(10) . . . I was encouraged to come up with my own ideas.
(11) (the adult) provided me opportunities to do meaningful work or solve problems.
(13) (the adult) encouraged me to decide for myself how I was going to do my work.

and possibly:

(3) (the adult) taught me what I needed to know.
(5) The results of what I did had meaning. I felt the results were important.
(7) . . . . I had opportunities to try things out for myself.

TABLE 5

Prediction of LEQ Scores from Program Membership

		mean[1]	std	range[2]
Treatment				
LEQ I		4.30	.58	3-5
LEQ II		4.02	.72	1.75-5
LEQ III		4.42	.73	1-5
Controls				
LEQ I		3.66	.73	1.8-5
LEQ II		3.68	.55	2-5
LEQ III		3.76	.58	2.3-5
		Parameter	t[3]	p
LEQ I	Intercept	3.66		
	Program[4]	0.64	4.38	.0001
	$R^2 = .194$			
LEQ II	Intercept	3.68		
	Program	0.34	2.40	.02
	$R^2 = .067$			
LEQ III	Intercept	3.76		
	Program	0.66	4.53	.0001
	$R^2 = .204$			

---

[1] All scores were summed, then divided by the number of items to give mean values for the scale scores.

[2] Possible range was from lowest = 1 to highest = 5.

[3] N = 82

[4] Treatment students coded as 1; control students coded as 0.

The following items were classified under factor II:

(3) (the adult) taught me what I needed to know.
(6) (the adult) described how I was to do my work.
(9) (the adult) gave me the right way to do the work.
(12) (the adult) showed me what was required of me.

and possibly:

(5) The results of what I did had meaning. I felt the results were important.

The following items were classified under factor III:

(1) . . . I felt encouraged to find things out for myself.
(2) I was able to tell by myself whether I was doing a good job.
(7) . . . I had opportunities to try things out for myself.

and possibly:

(8) The work that I did offered me many different things to do.

Although the LEQ requires additional research for validation, the analysis suggests that it does discriminate between student perceptions of learning-in-work and traditional learning environments. With the additional information from the factor analysis of student responses, the three factors may be interpreted as students' perceiving (1) the environment as providing an <u>opportunity</u> for generating concepts or engaging in a variety of experiences, (2) the environment as providing a <u>structure</u> that permits learning and negotiating with adults who are responsible for guiding the learning, and (3) the environment as providing <u>gratification</u> (feeling of self-confidence) for initiating and carrying out work. Environmental complexity is suggested when higher levels of the factors are perceived as being present in the environment. That is, an environment that is perceived as having more opportunities for generating concepts is more complex than one that is perceived as having fewer opportunities. When we apply this interpretation of the LEQ to the two groups of students in this study, the learning-in-work students when compared to the traditional learning students perceived their environment as providing (1) greater opportunity to generate concepts, (2) more structure for negotiating work, and (3) more gratification for initiating and completing work. Thus, according to this measure (LEQ) and the current sample of students, the learning-in-work students appeared to perceive a more complex environment for learning than did the traditional learning students.

Cross-Lagged Analysis of Math Scores Based on Predictions from Bloom's Taxonomy

Introduction

The intent of the second area of inquiry was to explore further the unusual patterns of performance exhibited on the mathematics scales of the CTBS. As illustrated in the preliminary report, the patterns of learning/retention, when broken down by program, suggested that different processes were involved for the two different learning environments.

One technique for assessing the validity of the above hypothesis of different causal processes in the group is cross-lagged panel correlation (CLPC). For the purposes of our analyses of the CTBS math performance, CLPC techniques were used according to the procedures outlined by Kenny (1975, 1979). Briefly, CLPC is a quasi-experimental design that attempts to rule out alternative hypotheses to a causal effect between two variables. The primary alternative hypothesis in these cases is that of spuriousness: i.e., one variable does not cause the other; instead, they are related by virtue of a common relationships to a third (unmeasured) variable. For example, the correlation between height and math achievement may not be due to a causal relationship between the two; instead, they could be related because increases in both are caused by maturation. The usefulness of CLPC lies in its ability to provide support for the existence (and form) of a causal relationship between variables by ruling out the alternative hypothesis of spuriousness.

CLPC assesses the presence/absence of a true causal effect through an examination of the correlations among variables measured at two points in time. Since CLPC has a somewhat non-standard terminology associated with it, the following section will define a few key terms. Basically there are three types of correlations in CLPC: autocorrelations, synchronous, and cross-lags.

Given two variables, A and B, each measured at two time periods, 1 and 2, autocorrelation is defined as the correlation of a given variable with itself, measured at two different time periods. Accordingly, there are two autocorrelations in our example: correlation of A at time 1 with A at time 2, and B at time 1 with B at time 2. Synchronous correlations are defined as correlations among different variables measured at the same time. Therefore, there are two synchronous correlations in our example: A at time 1, with B at time 1, and A with time 2 with B at time 2. Finally, crosslag correlations are defined as correlations of a given variable, at one time period, with a second variable measured at another time period. So, there are two crosslags in this sample: A at time 1 with B at time 2, and B at time 1 with A at time 2. Given the correctness of the assumptions of synchronicity (the variables are measured at the same times at each wave) and stationarity (that the causal processes, or structural equations of each variable, remain constant or proportional over the observation time), the null hypothesis of CLPC is that the cross-lagged correlations (of the variable A at time 1 with variable B at time 2, and vice versa) are equal. Equality of the two crosslags is seen to indicate a spurious relationship between the two variables.

Significantly different crosslags, given the validity of the synchronicity and stationarity assumptions, are seen to indicate the presence and form of a causal effect between the variables. With respect to the satisfaction of the assumptions, synchronicity can be assured if the measures were gathered at the same time for each wave, not aggregated over time. Stationarity, on the other hand, can be evaluated by examination of corrected synchronous correlations, corrected by the process outlined in Kenny (1975). For these analyses, the model of stationarity assumed was quasi-stationarity, which implies that the synchronous correlations will be equal when corrected for shifts in reliability (or, more correctly, communality) over the observation periods.

For the purposes of these analyses, the CLPC techniques will be used as suggested by Kenny (1979), in that significant crosslag differences will be seen only as indicators of a potential causal relationship between the variables, and not as "proof" of causation. The basic strategy in this section is to compare CLPC results between the two groups for corresponding time lags, using variable time lags on all subjects with complete data at these points. This use of subjects is different from that used in the preliminary report, which used only students with complete data at all administrations; however, the current approach was taken in order to use the strategy of Kenny (1979) in replicating the analyses on as many as possible combinations of subjects and time lags in order to increase confidence in the findings. While the experimenters are well aware of the limitations and potential instability of the parameters of the CLPC models obtained from small samples (like those used here), these replications of significant results, when viewed in combination with other analyses on these data, may then suggest profitable future areas for more thorough research.

Results

The CLPC analyses were conducted separately for the treatment (learning-in-work environment) and control (traditional learning environment) students. First, correlation matrices were completed for both groups on all subjects present at the following time periods: pre-test and post-test; pre-test and follow-up; and post-test and follow-up. Since several students had at least one set of missing data, this procedure resulted in the maximum sample size for each period, which in turn contributed to an increase in power for the $\underline{Z}$ test of the crosslag difference.

The correlations were computed on four variables constructed from the two CTBS math scales according to instructions in the CTBS test manual. These scales were designed to measure cognitive properties/processes, derived from Bloom's Taxonomy of Educational Objectives, in the following areas: Recognition, Translation, Interpretation, and Analysis. More information on the items used in these scales was presented in chapter II.

Results of the individual CLPC analyses are presented in Appendix C and are summarized in figure 13.

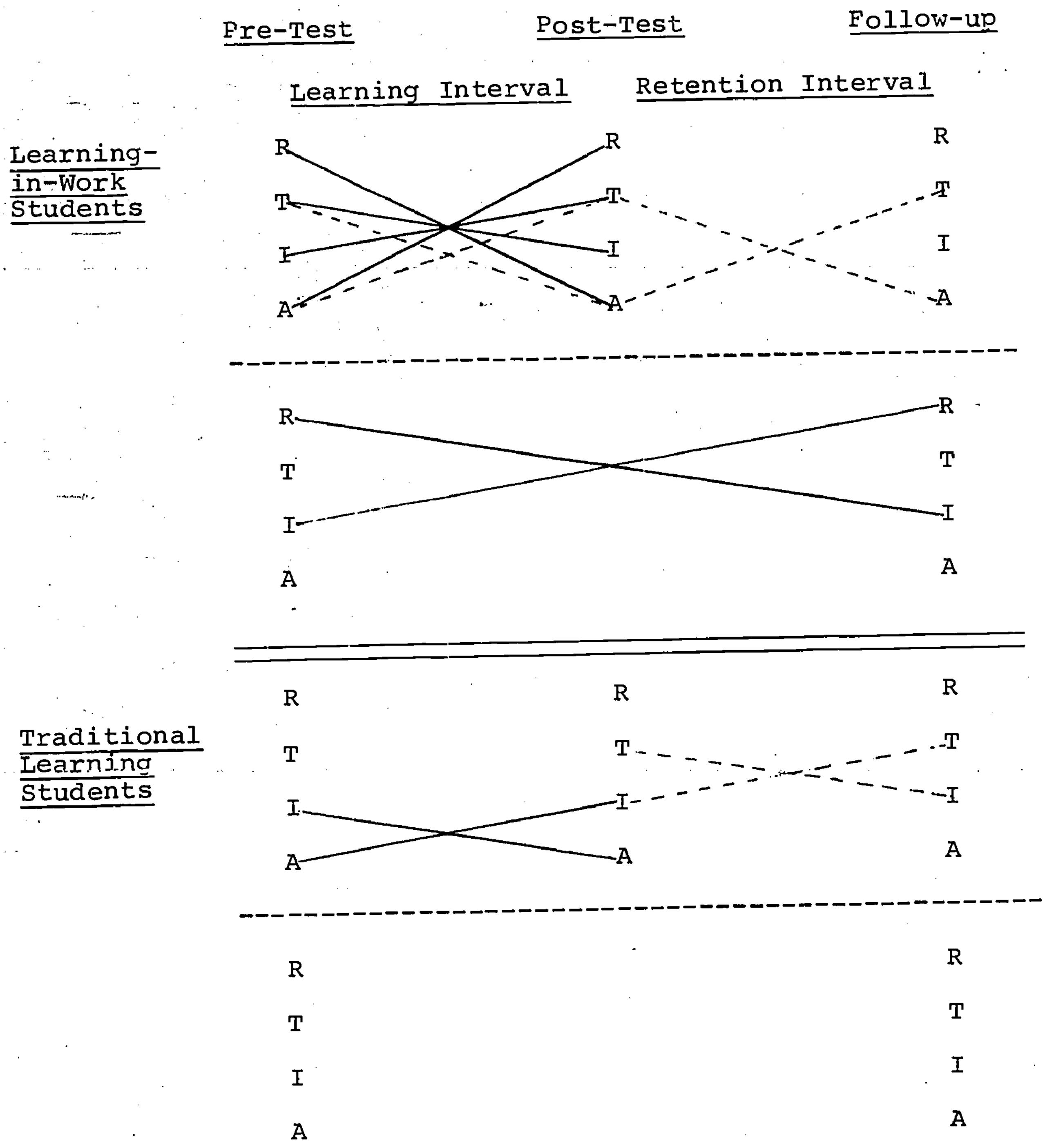
As a means to validate the CTBS grouping of items to form the scales to measure concepts derived from Bloom's taxonomy, a factor analysis was performed on CTBS items 1-50 at pre-test on all subjects. The analysis employed the same procedures used in the factor analysis of the LEQ described earlier. Results of the Promax transformation of the three factor solution are presented in Table 6. Criteria for retention of factors were (1) parallel analysis results, which indicated three factors with eigenvalues greater than those expected from random data and (2) examination of discontinuity in the eigenvalues, which showed a sharp break after the third factor. Other decision rules (e.g., retaining eigenvalues greater than one) were rejected as both arbitrary and inappropriate for these data.

The results of the factor analysis, while clearly not consistent with the grouping of items as performed by CTBS, were deemed useful in allowing another, more empirically-based, summation strategy to form research variables for use in CLPC. Starred item loadings in Table 6 indicate the items used to form each of the three CTBS factor-based scales. These scales, like the scales formed from the LEQ items earlier, are not based on factor scores; instead, the present strategy was to use the sum of unit-weighted (1 or -1, depending on the sign of the loading) CTBS items corresponding to non-trivial (over .30) loadings on the oblique factor solution. Means and other summary statistics are reported for these variables in Table 7.

The results of the individual CLPC analyses on the factor-based CTBS scales are presented in Appendix D and a summary of the findings is depicted in figure 14.

FIGURE 13

Summary CLPC Results for CTBS-Bloom Scales[1]



[1] Solid line indicates significant differences, at $p < .10$. Dotted lines indicate differences at $p < .20$.

TABLE 6

Promax-Rotated CTBS Math Factor Solution

PRIMARY FACTOR PATTERN

ITEM	RESULTS OF PRESENT ANALYSIS I	II	III	CTBS/BLOOM'S SCALES R	T	I	A
1	.50*	.23	.00			*	
2	.25	.31*	.23	*			
3	-.04	.15	.38*	*			
4	.06	.51*	-.20			*	
5	-.04	.60*	.20	*			
6	-.01	.51*	.33*	*			
7	-.03	.14	.56*	*			
8	-.06	.23	.11			*	
9	-.15	.13	.34*			*	
10	.32*	.06	.15				*
11	.15	.08	.15				*
12	.44*	.07	-.14			*	
13	.51*	.15	-.05				*
14	.02	.06	.60*				*
15	.23	.23	-.15				*
16	-.18	.44*	.14			*	
17	.04	.04	.57*				*
18	.10	-.10	.42*			*	
19	-.19	.38*	.59*			*	
20	.20	.33*	.11			*	
21	.42*	.33*	-.10				*
22	.40*	.02	.24			*	
23	.10	.01	.30*			*	
24	.21	.36*	-.14			*	
25	.28	.59*	-.11				*
26	.18	.60*	.14			*	
27	.35*	.45*	.08			*	
28	.09	.28	.26			*	
29	.29	.05	.24			*	
30	.00	.07	.00			*	
31	.09	.09	.28			*	
32	-.10	.43*	.29			*	
33	-.09	.11	.50*		*		
34	.48*	.24	.13			*	
35	.65*	.09	.06		*		
36	.39*	.14	-.14			*	
37	.49*	.20	-.08			*	
38	.42*	.06	.02			*	
39	.23	.00	.40*			*	
40	.29	-.06	.29			*	
41	.66*	.07	.10				*
42	.42*	.12	.12				*
43	.06	-.22	.54*			*	
44	.46*	-.12	.32			*	
45	.48*	-.12	-.06				*
46	.72*	-.19	.06				*
47	.36*	.01	.10			*	
48	.42*	-.12	.14				*
49	.33*	-.29	.13			*	
50	.37*	-.32*	.45*			*	

*Indicates items associated with the factor or scale

N = 80

Factor Correlations

	I	II	III
I	1.00	.35	.44
II	.35	1.00	.33
III	.44	.33	1.00

TABLE 7

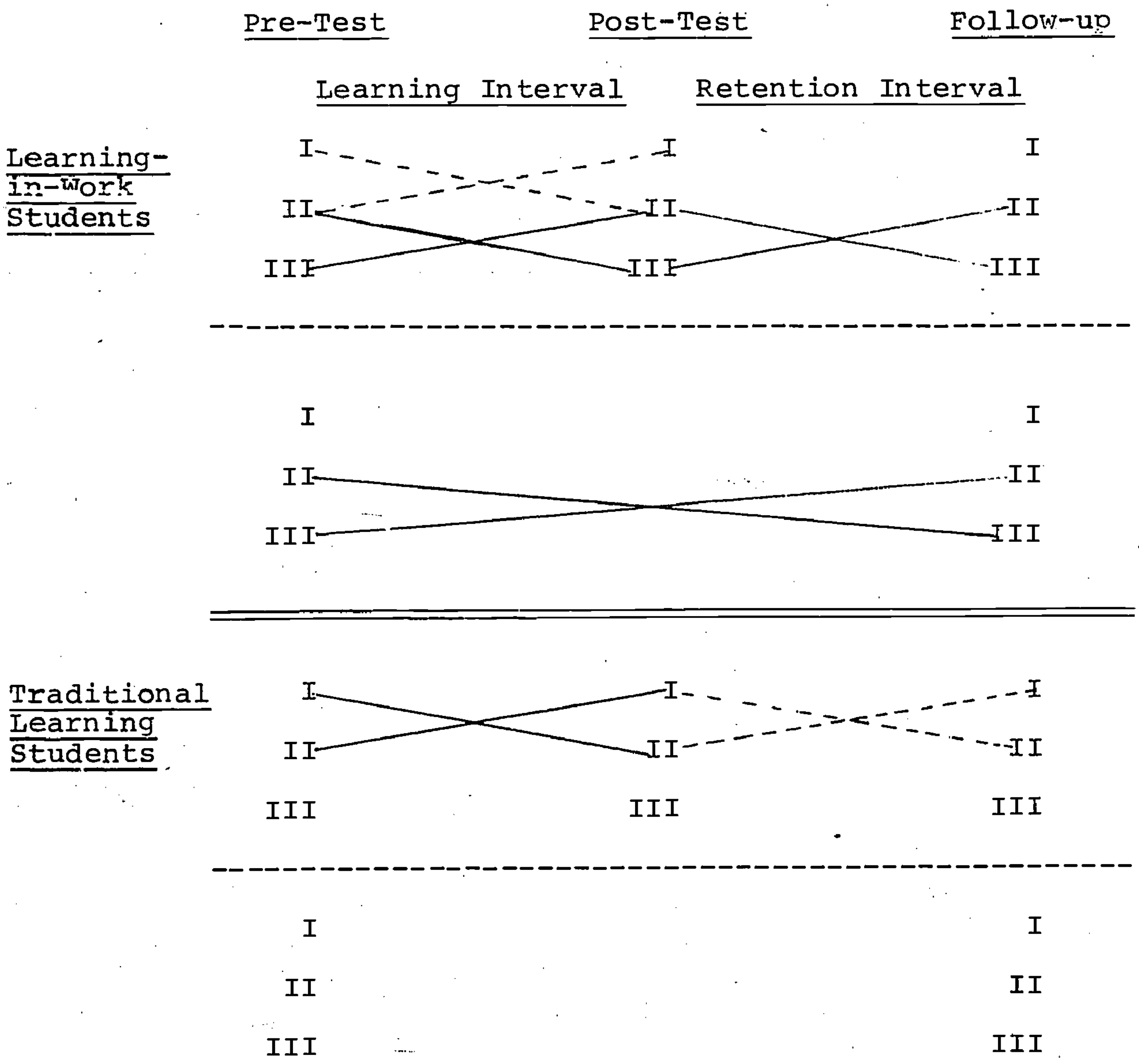
Summary Statistics for CTBS-Factor Scales[1]

Pre-Test (N = 80)	Mean	Standard Deviation
CTBS I	0.621	0.254
CTBS II	0.769	0.227
CTBS III	0.571	0.265
Post-Test (N = 94)		
CTBS I	0.629	0.253
CTBS II	0.759	0.244
CTBS III	0.574	0.264
Follow-up (N = 66)		
CTBS I	0.633	0.275
CTBS II	0.791	0.217
CTBS III	0.622	0.250

[1] Range is from 0 to 1, where 1 = correct, 0 = incorrect

FIGURE 14

Summary CLPC Results for
CTBS Factor-based Scales[1]



[1] Solid lines indicate $p < .10$ crosslag differences; dotted lines indicate $p < .20$ differences.

Interpretation

The present interpretations and uses of CLPC are somewhat atypical, in that CLPC was employed to estimate the parameters of the CLPC model for separate groups of subjects. These models were then examined subjectively to detect patterns in the significant crosslags for each group that would assist us in evaluating the presumed dissimilar causal processes in the two groups. However, the purpose of these analyses is not to "prove" the existence of specific causal relationship in the CTBS scales/concepts; rather it is to discover significant and also marginally significant differences (given the low power of the Pearson-Filon Z test) in the crosslags or nonsymmetric patterns (i.e., for treatment vs. control). These differences or patterns would be seen as offering support (1) to the hypothesis that different causal processes were operative in these two learning environments, insofar as the variables represented by our observed variables are concerned and (2) to the initiation of controlled, systematic investigations into the effects of different environmental conditions on the acquisition of knowledge and academic performance, where stronger inferences of causality seem possible.

As a consequence of this "exploratory" use of CLPC, interpretations of the results summarized in figures 25 and 32 will be restricted to specific differences in sign of the significant crossLag differentials. It is asserted here that these sign differences reflect, at the least, differences in the relationships among the variables measured in our sample (i.e., solely descriptive of different structure). At best, these differences may suggest true differences which may be a function of the different structuring of the two learning environments.

Inspection of the CLPC results revealed no consistent patterns of suspected causal relationships between the two groups. With regard to the predictions generated from Bloom's taxonomy, the signs of the crosslag differentials (on significant pairs) were not consistent with the notion that lower-order concepts should cause higher-level concepts. That is, if R was seen as causing an increase in T, then the correlation of R at time 1 with T at time 2 minus the correlations of R at time 2 with T at time 1 should be a positive value.

To illustrate, Figure 14 shows the crosslag differential between the R and A variables to be significant ($p = .06$). This differential is composed of the difference: $R_1A_2 - R_2A_1$, or .45 - .68, or -.23. This would be consistent with increases in R (recognition) causing a decrease in levels of A (analysis, a higher-level concept) at time 2.

Overall, the results of the CLPC analyses indicated (1) the presence of several cases (pairs of variables) for which the null hypotheses of no causal relationship (i.e., spuriousness) was deemed unacceptable and (2) an asymmetric structure of those cases, such that both their locations and effect-signs (crosslag differentials) were different for treatment versus control student samples. Little support was seen for the predictions of hierarchical relationships for the CTBS/Bloom's taxonomy scales or for the same processes operating in both environments.

Effects of Placement Experiences on Performance

Results

In the course of their program activities, the students in the learning-in-work group chose placements at various sites in the community, where their "hands on" experiences took place. It was of interest in the present analyses to determine whether differences occurred in math performance of students as a function of differences in site placements. Specifically, were there differences between students who had at least one exposure to one of the twelve worker-trait-group-classified job clusters, and those who did not have exposure to that cluster? If these clusters were valid for the purpose of classifying the characteristics of a given site and if some of these characteristics also had an impact on the acquisition of math skills, then it would be expected that there would be differences (on post-test and/or follow-up CTBS scores) between participants and non-participants in those worker trait groups (WTG) which had an impact on math-skill acquisition. While this type of analysis could certainly not address the issue of which caused the other (i.e., did the WTG classification experience cause later math achievement), the discovery of differences as a function of placement would tend to contribute support to the EBCE hypothesis that the type of site characteristics has an impact on what is learned at the site. In addition to the fact that the students self-selected themselves into the sites, the presence of differences could also be due to an interactive effect of the self-selection and the characteristics of the site. This alternative explanation, however, could not be addressed in this analysis.

It was also of interest to examine the importance of the number of discrete site experiences in explaining the math performance variance. That is, does knowledge of the number of different sites a student was exposed to during the academic year help to account for the differences in CTBS performance?

The breakdowns of participation in each of the WTG classified sites is presented in Table 8. Examination of Table 8 shows that several of the WTG classifications had very few students participants (e.g., WTG 2, 4, 6, 9, and 12 had fewer than 25 percent of students taking even one experience in the group). Because of the small sample size (since only learning-in-work students participated) and the large number of predictor variables, only WTG groups 1, 3, 5, 7, 8, 10, and 11 were used in the analysis in the interest of maximizing the power of the statistical tests. Results of simultaneous regression analyses using the two overall CTBS math scales as dependent variables are reported in Table 9.

Results of the correlations of the number of sites with the same CTBS scales used above are reported in Table 10.

Interpretation

While differences between the participants and non-participants are apparent at post-test for WTG classifications 1 and 11 in concepts, and WTG 11 and application (all p's $<$ .10), which would tend to suggest an effect for these classifications, inspection of the results for these same students at pre-test (before exposure to the sites) reveals that these same variables showed tendencies toward the same differences seen at post-test. For example, although students with exposure to sites classified under WTG 11 showed a 5.06 point post-test (in CTBS units) superiority (on the average) to students without such experience (holding the other variables constant), these same students were 3.64 units higher on the average at pre-test also. No comparisons approached significance at the following period.

The presence of these initial differences before on-site experience casts strong doubt on the efficacy of the worker trait classifications as causal agents in this sample. As a result of the type of analysis used here (simultaneous analysis, using dummy coded variables), these findings represent mean differences while holding the effects of the other WTG variables constant; this strategy was deemed appropriate for this analysis, since the significance of the overall multiple correlation was not a prerequisite for the interpretation of the regression coefficients. While separate F-tests of each of the WTG groupings would have been expected to show more "significant" differences between students on the basis of participation in each WTG, this strategy was rejected since it did not control for the effects of the other WTG groupings.

TABLE 8

Participation in WTG Sites

	Frequency	Percent
WTG 1 - Artistic		
No	22	58
Yes	16	42
WTG 2- Scientific		
No	31	82
Yes	7	18
WTG 3 - Nature		
No	24	63
Yes	14	37
WTG 4 - Authority		
No	30	79
Yes	8	21
WTG 5 - Mechanical		
No	15	40
Yes	23	60
WTG 6 - Industrial		
No	36	95
Yes	2	5
WTG 7 - Business		
No	26	68
Yes	12	32
WTG 8 - Sales		
No	14	37
Yes	24	63
WTG 9 - Accommodating		
No	31	82
Yes	7	18
WTG 10 - Humanitarian		
No	17	45
Yes	21	55
WTG 11 - Social		
No	14	37
Yes	24	63
WTG 12 - Physical Performing		
No	36	95
Yes	2	5

n = 38

TABLE 9

Results of Regression Analysis of WTG Placements

Pre-Test

D.V. = CTBS - Concepts

	Parameter	t	p	
WTG 1	2.22	1.16	.26	
WTG 3	1.45	0.76	.45	
WTG 5	-1.42	-0.53	.60	
WTG 7	1.06	0.49	.63	
WTG 8	1.24	0.61	.54	
WTG 10	-0.54	-0.21	.83	
WTG 11	3.64	1.68	.10	$R^2 = .18$

D.V. = CTBS - Applications

	Parameter	t	p	
WTG 1	-0.38	-0.16	.87	
WTG 3	-0.61	-0.26	.80	
WTG 5	-0.87	-0.27	.80	
WTG 7	-0.09	-0.03	.97	
WTG 8	1.06	0.43	.67	
WTG 10	0.57	0.19	.85	
WTG 11	3.76	1.43	.16	$R^2 = .11$

Post-Test

D.V. = CTBS - Concepts

	Parameter	t	p	
WTG 1	3.57	1.88	.07	
WTG 3	1.96	1.04	.31	
WTG 5	-0.85	-0.32	.75	
WTG 7	1.83	0.85	.40	
WTG 8	0.68	0.34	.74	
WTG 10	-1.00	-0.40	.69	
WTG 11	5.06	2.36	.02	$R^2 = .28$

D.V.= CTBS - Application

	Parameter	t	p	
WTG 1	0.45	0.21	.83	
WTG 3	1.76	0.83	.41	
WTG 5	3.81	1.37	.18	
WTG 7	0.24	0.10	.92	
WTG 8	-1.22	-0.53	.59	
WTG 10	0.42	0.16	.87	
WTG 11	4.77	2.09	.05	$R^2 = .20$

N = 38

TABLE 9 (continued)

Results of Regression Analysis of WTG Placements

Follow-up

	Parameter	t	p	
D.V. = CTBS - Concepts				
WTG 1	1.75	0.72	.48	
WTG 3	1.60	0.65	.52	
WTG 5	-2.22	-0.69	.49	
WTG 7	0.52	0.20	.84	
WTG 8	3.19	1.24	.22	
WTG 10	-2.09	-0.64	.52	
WTG 11	2.31	0.74	.47	R^2 = .13
D.V. = CTBS - Application				
WTG 1	0.72	0.25	.80	
WTG 3	1.80	0.60	.55	
WTG 5	-4.66	-1.20	.24	
WTG 7	-3.02	-0.99	.33	
WTG 8	3.67	1.18	.25	
WTG 10	-3.17	-0.80	.43	
WTG 11	1.67	0.44	.66	R^2 = .13

n = 30

TABLE 10

Squared Correlations of Number of Site Experiences with Math Scores

	CTBS - Concepts	CTBS - Application
Pre-Test (N = 38)	.021	.011
Post-Test (N = 38)	.068[1]	.055[2]
Follow-Up (N = 30)	.069[1]	.009

---

1 $p < .10$
2 $p < .15$

Effects of Summer Activities on Performance

Results

The research question addressed by this section concerned student activities during the summer break (i.e., between post- and follow-up test) and their association with math achievement. Specifically, these analyses addressed the issue of whether distinctions (1) between summer school or no summer school, (2) between work or no work, and (3) between treatment or control would account for significant amounts of CTBS score variance.

An alternative explanation of the increase in scores observed following the summer recess could be that this increase was an artifact, resulting from greater exposure to learning situations (i.e., summer school). If the students had worked during the summer, a similar increase in performance might have been expected due to the opportunity to practice skills learned during the school year (provided that such an opportunity existed). Another alternative explanation to significant differences between students on the summer-work and summer-school variables could be that these differences represented pre-existing differences; thus, a hypothetical finding that students in summer school scored higher at the follow-up test could be due to their superiority at pre- and post-test, rather than to the extra classwork. To address these issues, simultaneous regression analyses were conducted at all testing periods. The effect of summer school attendance and a summer job was examined on CTBS math performance, while the effect of the program variable was held constant (i.e., partialled from each). The result of these analyses are presented in Table 11.

Table 12 presents means for the four groups formed by the combinations of summer school (yes or no) and summer job (yes or no) for the total sample of learning-in-work group only-by-the control students only.

Interpretation

As is evident in Table 11, summer activities did not make much of a contribution to explaining CTBS score variance, independent of program effects: none of the multiple correlations were significant at $p = .05$, and only summer school participation showed strong effects (on math content, at post-test and follow-up). The general pattern was that students who went to summer school during the break showed lower mean math scores at all testings, while students who worked showed generally higher mean scores. These results suggest non-comparability of students in that there are relatively consistent trends for differences in students when classified by summer activity.

TABLE 11

Results of Analysis of Summer Activities

CTBS - Math Content

Pre-Test	Parameter	t	
Intercept	17.27		
Summer School[1]	-2.74	-1.28	
Work[2]	1.53	0.88	
Program[3]	-0.78	-0.61	R^2 = .04
Post-Test			
Intercept	18.28		
Summer School	-4.19	-2.05**	
Work	1.32	0.75	
Program	-1.97	-1.51	R^2 = .11*
Follow-up			
Intercept	18.19		
Summer School	-4.26	-2.00**	
Work	1.68	0.92	
Program	-1.32	-0.97	R^2 = .09

CTBS - Math Application

Pre-Test	Parameter	t	
Intercept	15.91		
Summer School	-1.05	-0.41	
Work	-0.86	-0.42	
Program	-0.69	-0.45	R^2 = .01
Post-Test			
Intercept	16.68		
Summer School	-3.17	-1.34	
Work	1.17	0.58	
Program	-2.69	-1.82*	R^2 = .10
Follow-up			
Intercept	16.28		
Summer School	-2.12	-0.80	
Work	0.39	0.17	
Program	-1.97	-1.16	R^2 = .04

n = 54
* $p < .10$
**$p < .05$

1. Summer school participation coded 1; otherwise, 0
2. Work participation coded 1; otherwise, 0
3. Program coded 1 if learning-in-work students; otherwise, 0

TABLE 12

CTBS Mean Scores by Summer Jobs and Summer School

	Total	Treatment	Controls
CTBS - Content			
Pre-Test			
SS* and Work	15.7	15.2	16.0
SS only	14.1	13.7	14.5
Work only	18.4	18.0	18.8
None	16.8	16.4	17.2
Post-Test			
SS and Work	14.3	13.4	15.4
SS only	12.8	12.1	14.0
Work only	18.6	17.6	19.6
None	17.1	16.3	18.2
Follow-up			
SS and Work	14.9	14.2	15.6
SS only	13.0	12.6	13.9
Work only	19.2	18.5	19.8
None	17.4	16.8	18.1
CTBS-Application			
Pre-Test			
SS and Work	13.7	13.3	14.0
SS only	14.4	14.1	14.8
Work only	14.7	14.3	15.0
None	15.5	15.2	15.9
Post-Test			
SS and Work	13.4	11.9	14.6
SS only	11.7	10.8	13.5
Work only	16.6	15.1	17.8
None	14.9	13.9	16.6
Follow-up			
SS and Work	13.4	12.8	14.5
SS only	12.8	12.1	14.1
Work only	15.7	14.7	16.6
None	15.1	14.3	16.2
*SS = Summer School	n = 54	n = 27	n = 27

Relationships between Student's Perceptions of the Learning Environment and Cognitive Style on Performance

Results

This section of the analysis is concerned with the form of the person-environment relationship. For this study, the personal characteristic of cognitive style was measured by the paragraph completion test (PCT), and the student's perception of the complexity of the environment was measured by the LEQ. The PCT is a content-free measure of cognitive style or integrative complexity. It measures an individual's ability to generate ideas or to differentiate among alternative solutions. It also is a measure of the person's ability to organize ideas or concepts in a hierarchical system. Table 13 displays the means and standard deviations for the students' cognitive style scores.

TABLE 13

PCT Means and Standard Deviations

EBCE (n = 52)	
Mean	2.33
Standard Deviation	0.82
Control (n = 41)	
Mean	2.15
Standard Deviation	0.75
Total (n = 93)	
Mean	2.25
Standard Deviation	0.79

The position of the authors is that the relationship of person, environment, and performance (as measured by the CTBS) is interactive, because the relationship of the structure of the learning environment to performance in that environment will vary as a function of the characteristics of the person (the cognitive style). In this sample, optimum performance is predicted for students who perceive a more complex environment, as indicated by higher LEQ scores, and who exhibit greater integrative complexity as measured by the PCT. Thus, when the level of environmental complexity is controlled for, the performance of students is predicted to be uniformly higher as a function of increased integrative complexity or cognitive style. Accordingly, a significant "main effect" for the cognitive style variable is predicted, together with a significant interaction effect when performance is predicted from perceived environmental complexity and cognitive style. Overall, the hypothesis is that performance is maximized when the students' level of cognitive style is matched with similar levels of perceived environmental complexity and that performance is minimized when there is a "mismatch" between the two variables (e.g., when students with less integrative complexity are placed in an environment perceived as complex).

To assess the predictions regarding the environmental and cognitive complexity interaction, hierarchical regression analyses were used as follows. First, the variables representing the PCT and LEQ were used as predictors of CTBS math performance (scales for Application and Content). Then, the set of product terms representing the interactions (i.e., PCT x LEQI, PCT x LEQII, and PCT x LEQIII) was entered, and the squared multiple semipartial correlation for the interaction used as a measure of the contribution of these terms. While the membership in either of the two environments could conceivably have been used as an "objective" measure of environmental complexity, this approach was rejected at this stage, since it was felt that individual differences in perceptions would constitute more meaningful information than the "program" variable. The results of the hierarchical regressions are reported in Table 14.

These results indicated that no interactive relationship was present for the cognitive style and environmental complexity variables, as seen by the non-significant $\underline{F}$ values for the increment in R^2 with the addition of the interaction terms. However, the prediction of a "main effect" for the cognitive style variable was supported (using the model without the interaction terms) as seen in Table 15. Specifically, higher scores on the PCT were associated with higher achievement (as measured by the CTBS) across all of the levels of perceived environmental complexity (as seen in the significant $\underline{t}$ values for PCT at both post-test and follow-up. A smaller main effect was seen for the LEQ/ environmental characteristics set, which was strongest at post-test. Although weak relationships were observed, generally an increase in the LEQ factors I and III produced a small decrease in math scores at both post- and follow-up testings. Increases in LEQ factor II showed a decrease in math content scores at post- and follow-up testings and an increase in math applications scores at both testings.

In an attempt to discover the person-by-environment interaction through a different conceptualization of the "environment" construct, variables representing other aspects of the environment were added to the model: (1) summer activities, consisting of whether the student attended summer school during the junior-senior break and whether the student was employed in paid employment during that period; and (2) academic program, whether the student was enrolled in learning-in-work or "traditional" curriculum structure. It was reasoned that the inclusion of the above variables would perhaps provide a more complete representation of salient environmental characteristics, and therefore a more accurate test of the person x environment hypothesis.

The analyses reported in Table 14 were replicated with the addition of summer activity variables to the set of variables representing the environmental characteristics factor. These results are summarized in Table 16.

The results of using summer activities and the program classification were the same as found for using the LEQ scales alone in that the non-interactive variance and the interaction of PCT by environment produced no significant increase in explained variance beyond the non-interactive model.

Interpretation

When we noted the parallel nature of the above findings with respect to an interactive relationship between personal characteristics and environmental characteristics, it was concluded that no support for this interactive hypothesis was provided. However, as seen in Table 15, the prediction of a "main effect" for PCT was supported, since higher scores on this measure of cognitive complexity were associated with higher scores on the CTBS scales (controlling for the effects of different perceptions of the complexity of the environment). Additionally, some indication was given to a "main effect" for the LEQ scales, though this was not of such magnitude as the PCT effect.

TABLE 14

Tests of Interactions

Post-Test

CTBS - Math Content (n = 82)

Variables added to equation	Cumulative R^2	ΔR^2	Incremental F
PCT, LEQI-LEQIII	.205		4.97***
PCT x LEQI, PCT x LEQII PCT x LEQIII	.215	.010	0.32

CTBS - Math Application

Variables added to equation	Cumulative R^2	ΔR^2	Incremental F
PCT, LEQI-LEQIII	.127		2.62**
PCT x LEQI, PCT x LEQII, PCT x LEQIII	.131	.004	0.11

Follow-up

CTBS - Math Content (n = 59)

Variables added to equation	Cumulative R^2	ΔR^2	Incremental F
PCT, LEQI-LEQIII	.260		4.75***
PCT x LEQI, PCT x LEQII, PCT x LEQIII	.265	.005	0.12

CTBS - Math Application

Variables added to equation	Cumulative R^2	ΔR^2	Incremental F
PCT, LEQI-LEQIII	.143		2.24*
PCT x LEQI, PCT x LEQII, PCT x LEQIII	.149	.006	0.12

* $p < .10$
** $p < .05$
*** $p < .01$

TABLE 15

Partial Coefficients of Noninteractive Model

Post-Test (n = 82)				
CTBS - Math Content	Raw Score Regression Coefficient	Squared Semipartial Correlation	t	F
Intercept	16.73			
PCT	3.02	.194	4.34***	
LEQI	-0.82		-0.89	
LEQII	-0.46	.030	-0.47	2.91**
LEQIII	-0.26		-0.28	
CTBS - Math Application				
Intercept	13.77			
PCT	2.38	.107	2.97***	
LEQI	-1.48		-1.38	
LEQII	1.26	.036	1.02	3.18**
LEQIII	-0.53		-0.46	
Follow-up (n = 59)				
CTBS - Math Content				
Intercept	17.03			
PCT	3.19	.239	4.18***	
LEQI	-1.53		-1.34	
LEQII	-0.09	.036	-0.08	2.63*
LEQIII	-0.10		0.11	
CTBS - Math Application				
Intercept	12.99			
PCT	2.92	.137	2.93***	
LEQI	-1.29		-0.87	
LEQII	0.61	.017	0.42	1.07
LEQIII	-0.39		0.30	

* $p < .10$
** $p < .05$
*** $p < .01$

TABLE 16

Tests of Interactions[1]

	Cumulative R^2	ΔR^2	F for Increment
Pre-Test			
Content			
PCT, LEQ, SS, Work, Program	.209	----	1.93
+ Interaction	.320	.111	1.22
Application			
PCT, LEQ, SS, Work, Program	.223	----	2.09
+ Interaction	.276	.053	0.55
Post-Test			
Content			
PCT, LEQ, SS, Work, Program	.357	----	4.04**
+ Interaction	.490	.133	1.96
Application			
PCT, LEQ, SS, Work, Program	.289	----	2.96**
+ Interaction	.351	.062	0.72
Follow-up			
Content			
PCT, LEQ, SS, Work, Program	.347	----	3.87**
+ Interaction	.482	.135	1.96
Application			
PCT+LEQ, SS, Work, Program	.195	----	1.76
+ Interaction	.288	.093	0.98

*** $p < .01$
** $p < .05$ n = 59

[1] Interaction refers to the interactions of the personal characteristic of cognitive style with the set of environmental characteristics of Work, SS, LEQ and Program.

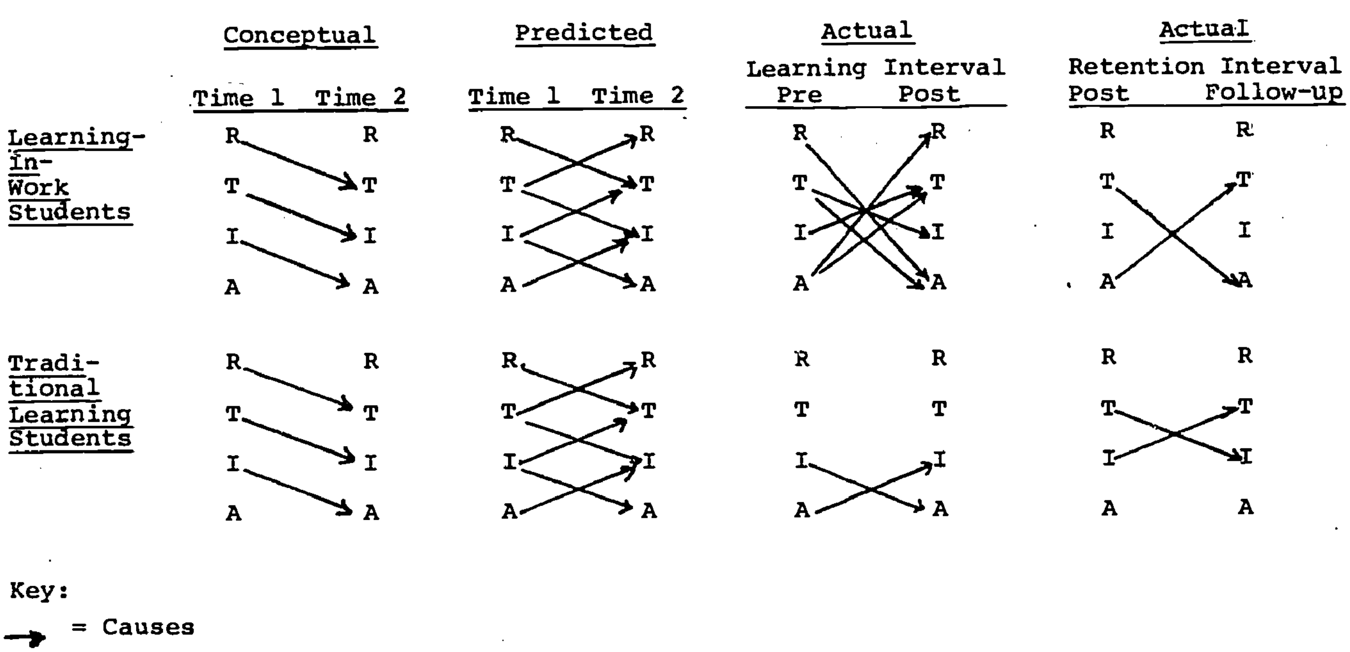
Discussion of Results

In chapter I, (figure 4) the authors postulated an heuristic model for investigating student cognitive processes in learning-in-work environments. The discussion of the results of the hypothesized causal relationships reflects the structure of that model.

First, did being in one of the two learning environments cause students during the learning or retention intervals to learn math skills as predicted by Bloom's taxonomy and as measured by the CTBS? The CTBS process scales of Recognition (R), Translation (T), Interpretation (I), and Analysis (A) were hierarchically developed along the lines of Bloom's Taxonomy; therefore, it was hypothesized that students would learn the concepts in such a way that, for example, a mastery of the cognitive skill of Recognition at pre-test would increase the students' performance in the skill of Translation at the post-test. The predicted and actual results of learning the cognitive skills is depicted in Figure 33.

FIGURE 15

Predicted and Actual Causal Relationships between Cognitive Concepts for Students in the Two Learning Environments



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The results suggested that the cognitive concepts were causally related but not in the hierarchical order predicted by Bloom's taxonomy as interpreted and measured by CTBS. Furthermore, the results would indicate that different causal processes were operating in the two environments as manifested by the number and type of relationships. The learning interval for the learning-in-work students showed the greatest number of potential causal relationships. During the retention interval both groups showed relationships between two variables, but for different cognitive concepts. Overall, these results are consistent with the hypothesis that there are different causal processes operating for learning math concepts as a function of being in one of the two learning environments.

Secondly, for the learning-in-work students, did exposure to worksites, either by the number engaged in or by the WTG classification, affect math performance during the learning or retention interval? While differences between participants and non-participants are apparent at post-test for WTG classifications 1 (Artistic) and 11 (Social) on the math scale of concepts and WTG 11 on the math scale of applications, inspection of the results for the same students as at pre-test reveals that their same variables showed patterns toward the same differences observed at post-test. Thus, the presence of these initial differences before the experience casts strong doubt on the efficacy of the WTG classification as causal agents in this sample. That is, exposure to sites as classified by WTG was not related to math achievement.

Thirdly, did the students' summer activities affect math performance during the retention interval? Generally, summer activities did not contribute much to explain math performance at the follow-up testing. However, the general pattern was that students who attended summer school showed lower mean math scores at all testings and had the greatest gains over the summer, while students who worked during the retention interval tended to perform higher on the math scales.

Finally, is there a person-by-environment interaction for math performance for either the learning or retention interval? Using the LEQ as a measure of perceived environmental complexity and the PCT as a measure of cognitive style, we observed a main effect for both variables. That is, higher cognitive style scores were associated with higher achievement for both the learning and retention intervals across all levels of perceived environmental complexity. Although weak, a reverse relationship was generally observed for the perceived environmental complexity in that an increase in LEQ scores was associated with small decreases in math performance. The addition of other measures of environmental characteristics (i.e., learning-in-work vs. traditional classroom, type of summer activity chosen) did not change these findings of no interaction. Overall, the cognitive style variable exhibited uniform effects on math performance, the environmental perceptions (LEQ) showed a smaller, less consistent effect, and the predicted person-by-environment interaction failed to materialize.

CHAPTER IV

IMPLICATIONS AND RECOMMENDATIONS FOR RESEARCH, PRACTICE, AND POLICY

Introduction

Although the findings from the second-year study resulted in an interesting set of conclusions regarding the process and content of learning-in-work environments, the question still remains, "In the light of what is known, how can the findings contribute to policy decision making and future research?"

Even though this study is a preliminary investigation, several provocative findings were revealed; nevertheless, prudent researchers are correct when they caution that the findings were derived from an imperfect data set. This situation evolved from the fact that students that were not randomly assigned to the two learning environments and the dependent measures were standardized achievement test scores, which may not have been the most appropriate outcome measure either in terms of the content to be learned by the student or its psychometric properties. For example, selected test items maximize the discrimination among student populations at one given time, rather than measuring change in performance over a period of time; the small sample size reduced the power for detecting student learning patterns in the two environments; and the treatments were units of instruction occurring naturally in a large school district, thereby precluding a priori specification of cognitive variables that could have been used as covariates or independent variables for a better understanding of learning and retention of basic skills in alternative learning environments.

To address the question of implications and recommendations for research, practice, and policy, comments are incorporated from papers that were commissioned (Appendix B) to review the results of the first-year study. The commissioned researchers were David P. Ausubel, Distinguished Professor Emeritus, Ph.D. Program in Educational Psychology, Graduate School, City University of New York; Henry C. Ellis, Chairman, Department of Psychology, University of New Mexico; and Benton J. Underwood, Stanley G. Harris Professor of Social Science, Northwestern University. These men were commissioned to review the results of the first-year study and, through extensions of their research and learning theories, to provide a perspective for investigating the psychological and pedagogical implications of learning and forgetting patterns in learning-in-work and traditional environments.

The investigators acknowledge that the interpretations of the papers are theirs and accept responsibility for any misinterpretations that may be perceived by the commissioned authors.

Implications for Research, Practice and Policy

No longer is formal schooling limited to learning in a classroom environment. Not only do youth have the opportunity to choose their learni.g environments, but educators concentrate on designing and implementing alternative environments that seem likely to maximize student learning. Thus, a key question emerges: "For whom, when, and under what conditions are alternative learning environments effective in promoting the learning and retention of basic skills?" As a function of this research effort with its focus on an investigation of the learning and retention of basic skills in a learning-in-work environment, four issues seem to be related to this question: the relationships between learning in a classroom environment and in a work environment, the relationships between environmental complexity and the learning environment, the interaction of student characteristics and environmental complexity, and the relationship between learning outcomes and their measurement.

Issue: The Relationships between Environments and Learning

For this investigation, the environments studied have two factors: the learning process itself and the physical environment where learning occurs. Based on the terminology of David Ausubel, the program structures for these two factors would appear as follows:

FIGURE 16

The Relationship between Environment and the Process of Learning for Two Types of Programs

Learning Environments	Process of Learning: Experiential	Process of Learning: Didactic
Worksite	EBCE (Learning-in-Work) (80% time)	
Learning Center	EBCE (20% time)	
Classroom		Traditional (100% time)

Thus, in this study we have equated the learning-in-work environment with experiential learning and worksite exposure; and, the traditional learning environment with both didactic learning and classroom exposure. In reality, neither program is absolutely one or the other, and this fact highlights one difficulty in measuring the acquisition of basic skills in naturalistic settings. Extrapolating further from Ausubel's paper and including the dimensions of reception and discovery learning with meaningful and rote learning, we depict the relationship among the variables as follows:

FIGURE 17

Reception-Discovery and Rote-Meaningful Dimensions of Learning

	Process of Learning			
Environments	Experiential		Didactic	
	Reception	Discovery	Reception	Discovery
Worksite	Rote or Meaningful Learning		Rote or Meaningful Learning	
Learning Center	Rote or Meaningful Learning		Rote or Meaningful Learning	
Classroom	Rote or Meaningful Learning		Rote or Meaningful Learning	

Definitions (Ausubel, 1980, p. 9):

Reception Learning - the principal content of the material to be learned is presented to the learner in a more or less final form and he/she need only integrate it into his/her cognitive structure for the purposes of retention and transfer to new learning experiences.

Discovery Learning - the principal content of what is to be learned (i.e., new successful problem-solving proposition) must first be discovered by transforming relevant background knowledge (previously acquired concepts, facts) in such a way as to constitute a means to the end specified in a problem-setting proposition. Once an acceptable problem-solving proposition is discovered, it is then internalized in precisely the same way as in reception learning.

Meaningful Learning - (1) if the student employs a meaningful learning set to his/her existing structure of knowledge and (2) if the learning task itself is potentially meaningful.

Although the addition of these variables to the environment in which learning occurs adds precision to the types of questions that can be asked and researched, it increases the complexity of attributing changes in performance to single environments alone. However, in reference to our central question and this particular issue, the following types of questions can be raised:

- Which students (e.g., cognitive style, age) learn through reception learning and which learn through discovery learning?
- Do experiential-type programs increase student exposure to discovery learning?
- Do worksite environments stress discovery learning more than reception learning?
- What is the proportion of experiential to didactic learning in worksite environments?
- Is there an interaction between basic-skill acquisition and retention through experiential/didactic, reception/discovery learning and environment?
- Meaningful learning is acquired by which students in which environments and under what conditions (experiential/didactic, reception/discovery)?

While our study only scratched the surface with regard to questions of this type, we do have evidence, even with methodological reservations, that math skills learned in a learning-in-work environment may be learned and retained in ways that are different from those learned in a traditional environment (figure 3). Furthermore, evidence from the CLPC of the math process variables (figure 15) suggests that the decrement observed at post-test for the learning-in-work students may be due to different causal cognitive processes that operate in the two environments. With regard to reading comprehension, our evidence suggests that student performance in either environment is almost equivalent.

Because students in the learning-in-work environment are bringing ten years of past school knowledge and learning processes to the workplace, the concept of transfer is an important issue. While we cannot be certain, one possible explanation for the decrement in the math scores of these students at post-test may be attributable to interference from past school learning. Thus, for students who are making the transition to the workplace as well as for those who are experiencing other alternative environments, transfer variables not present in the classroom environment may be operating in such a way as to interfere with math performance at post-testing. Two such variables suggested by Henry Ellis 1980, p. 9) are depth of processing and cognitive effort. For example, due to the nature of learning activities, students in the learning-in-work environment may not process the information they have learned at the same depth or at the same intensity as students in the classroom. Thus, while increased performance (higher math achievement) is important for classroom learning, learning at a workplace may require less depth of processing or cognitive effort for student success, thereby resulting in lower math achievement at post-testing. If such mediating cognitive variables are operating in worksite environments but not in other learning environments, then they should be included in future research for studying basic-skill acquisition and retention.

Issue: The Relationships between Environmental Complexity and Learning

The second issue of environmental complexity and its relationship to learning environments refers to those characteristics inherent (or perceived) in an environment that affect student performance. These characteristics are further delineations for classifying and studying learning environments. This issue was addressed because our prior knowledge of learning-in-work programs suggested that two characteristics, participation and negotiation, distinguished this environment from traditional learning environments. For example, learning tasks were negotiated by the student with the worksite mentor or program coordinator, affording students the opportunity to decide and help structure what they wanted to do. In the EBCE program this process was formalized through the completion of the activity sheets. Since activities at the worksite were completed with other workers, students participated with adults in successfully completing tasks.

Much of the discussion in this section results from conversations and correspondence between Harold Schroder and the project staff. Initial thinking regarding environmental characteristics that can affect performance centered on the contrast between environments that "generate concepts" and those that "give concepts." In "concept generating" environments, according to the theory, students learn to search for information, generate ideas, try them out, and receive feedback. The hypothesis was that "concept generating" environments develop skills that later may also help students acquire knowledge. In Henry Ellis's commissioned paper he called attention to the generation effect in recall (Slamecka and Graf, 1978). The basic finding was that if subjects have to generate an answer rather than simply to remember a solution, recall is enhanced. As Ellis suggests, (1980, p. 7), these findings support the concept of learning-by-discovery and would appear to be operative in a learning-in-work environment. To some extent the generation effect appears to be similar to our notion of "concept generating" environments.

The concept of environmental complexity may also be related to the means (process) and ends (goals) of the learning task as defined by the parameters of the learning environments. The traditional learning environment is designed to maximize the acquisition of knowledge. In this environment the knowledge (content) goals are specified and taught explicity (means). In the learning-in-work environment the ends (goals of learning task) are negotiated between student and coordinator, thereby providing a structure for the task but learning some of the means (how activities are completed) unstructured and the student at the worksite rather than waiting for instructions, must initiate action to complete the tasks. The point is motivation of students should be preserved so that they may develop a capacity to make judgments and decisions necessary to act with personal independence.

To furnish a measure of environmental complexity for the two environments in this study, the Learning Environment Questionnaire (LEQ) was developed. Analysis of this instrument suggests three factors related to student perception of the learning environment: (1) an opportunity for generating concepts or engaging in a variety of experiences, (2) a structure that permits learning and negotiating with adults, and (3) gratification (feeling of self-confidence) for initiating and carrying out work. Environmental complexity is suggested when higher levels of the factors are present (or perceived) in the environment.

Data from this study suggest that the learning-in-work students perceived more environmental complexity (as determined by higher test scores) than students in the traditional environment perceived. It also suggested that student perceptions of environmental complexity affect math performance at post- and follow-up testings. Overall, since higher levels of perceived environmental complexity resulted in slightly lower math performance, then if these environmental characteristics are considered important for learning, math achievement (as currently structured and measured) may be better in those environments not emphasizing factors measured by the LEQ.

Another environmental characteristic studied for this study was the exposure of learning-in-work students to worksites by the WTG classification. Although math differences were observed at post-test for the WTG's of Artistic and Social, these variables showed similar patterns of differences at pre-test. Thus, for this sample, there is doubt as to the efficacy of WTG classification as a causal environmental variable.

The implications of this issue may best be stated by the question "In accordance with individual characteristics, to what extent can alternative learning environments enhance performance over what can be attributed to personal characteristics alone?" Although basic skills (especially math) were the dependent variable for this study, outcomes or performances other than math should be investigated. Thus, environmental factors such as participation, variety, autonomy, and feedback may be differentially related to the acquisition and retention of subject-matter content.

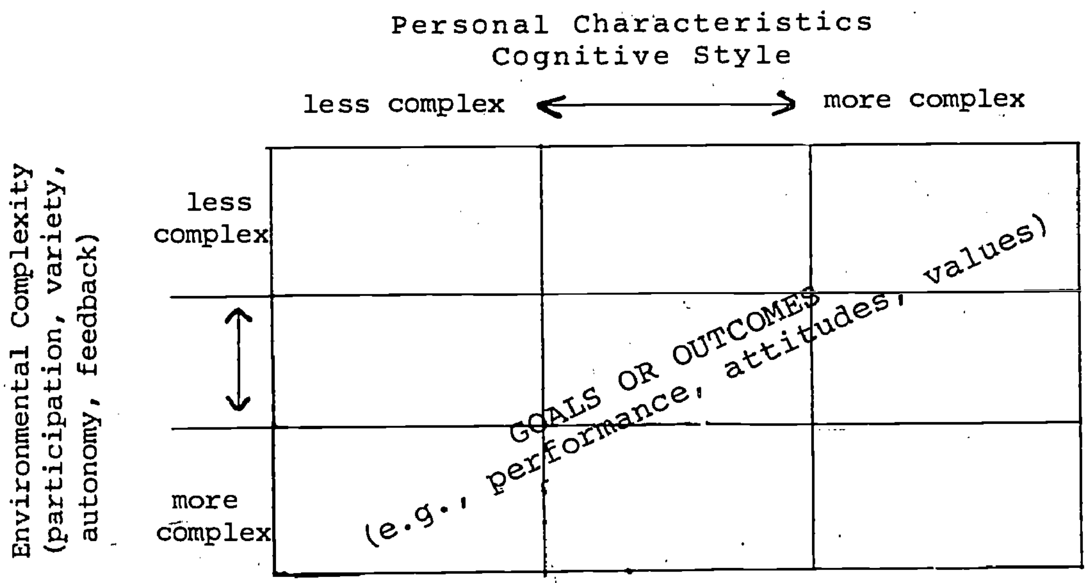
Issue: Interactions between Personal Characteristics and Environmental Complexity

The issue of interactions between personal characteristics and environmental complexity is related to a growing body of literature directed at identifying the interactive nature of the personal and environmental determinants of behavior. Thus, is the interaction of personal characteristics with environmental complexity a more powerful predictor of performance than is either variable alone?

For this study, the personal characteristic of cognitive style was measured by the Paragraph Completion Test (PCT). The PCT yields an integrative complexity score for the individual's ability to generate ideas and to organize ideas or concepts in a hierarchical system. Results showed that higher integrative complexity scores were associated with higher math achievement at post- and follow-up testings for students in both learning environments. However, the predicted interaction between cognitive style and perceived environmental complexity (LEQ) on math performance was not observed for this sample. Even without the predicted interaction for this study, there is sufficient evidence to support research into the interactive nature of personal and environmental characteristics. Such a framework for studying the interactions effect is depicted in figure 18.

FIGURE 18

Framework for Studying the Interaction between Personal Characteristics and Environmental Complexity



Implications are for research questions of the following types:

- Is performance maximized when the personal characteristics of cognitive complexity is matched to the same level of environmental complexity?
- What dependent variables (performance) are best predicted by the interaction?
- Do specific groups of students prefer one environmental complexity over another?
- Are specific groups of students exposed to only one type of environmental complexity to the exclusion of others?
- How does performance vary as a function of the individual's cognitive style?
- Are experiential-type programs more environmentally complex than didactic-type programs?

Issue: The Relationships of Learning Outcomes and Their Measurement

The major issue is the appropriateness of the criteria for successful learning. For this study, increased achievement of math and reading comprehension skills was the learning criterion. As discussed earlier, this criterion is appropriate for the traditional classroom learning environment. However, the mere lack of increased scores for the learning-in-work students may not imply that learning did not occur, but rather that the work environment, because of its complexity, caused decreased scores and produced increases in other outcomes not measured in this study. Thus, the criterion of increased cognitive knowledge may not be the appropriate learning criterion for a work environment.

Another factor to be considered is the interpretation of the findings within a classical framework of learning and retention. In this study, nine months served as the learning interval and three months as the retention interval. Most classical studies use shorter time frames for the learning and retention intervals with precise control over the learning task and random assignment of subjects. In effect, we are overlaying group data and macro time intervals on the micro cognitive process studies in the classical learning and retention paradigms. Thus, not only must we overcome the problem of separating the non-school effects from school in the presence of the two types of effects (especially in non-experimental designs), but we must find ways to apply learning theories (classical or contemporary) to alternative learning environments to understand the tradeoffs of learning and retention of basic skills.

Recommendations

The preliminary research from this two-year effort has resulted in findings that support different patterns of learning and retention of basic skills as a result of experience in one of two learning environments: traditional classroom or learning-in-work. At this stage of the research effort, we prefer to consider our research as a line of inquiry. With this view, we will offer recommendations for research, practice, and policy. Our findings to date, while interesting, do not justify a specific "do" or "don't" for researchers or practitioners. Rather, they suggest alternative ways to think about the learning and retention of basic skills. The recommendations assume that alternative learning environments are under investigation.

Research Recommendations

- Expand evaluation studies to include a retention interval or design the studies for longitudinal data collection, thus increasing the power of the research design to explain environmental effects on skills being learning.
- Include other measures of outcomes in addition to basic skills to determine the effectiveness of alternative learning environments.
- Use controlled experiments to test the hypothesis that there is an interference of past learning with learning occurring in the workplace.
- Use environmental complexity characteristics not only as independent variables to describe the results of new curricula, but also as independent variables to predict which environmental factors are related to the learning of basic skills.
- Test the viability of the transfer concepts of processing and cognitive effort for students in learning-in-work environments as possible explanations for decreased learning curves and increased retention curves.
- Design studies to test for the interaction between the personal characteristic of an individual's ability to search for information and use it effectively to solve problems and the perceived complexity of the environment. The hypothesis to be tested is that productivity (amount learned and retained) can be increased when there is a match between an individual's cognitive style and the level of environmental complexity.
- Design methods to assess learning environments according to three or four independent dimensions.
- Design criteria measures that are sensitive to the assessment of cognitive skills as well as to content acquisition.

Educational Practice Recommendations

- Curriculum developers should not only design the curriculum but also design the environment (e.g., variety, autonomy, feedback) for learning basic skills.

- Alternative learning environments should be classified in such a way as to provide students with real choices in the selection of learning programs.
- Students should be encouraged to sample or test alternative learning environments to determine under which conditions they function best.

Policy Recommendations

- Include in the regulations for federally-sponsored evaluations the use of environmental complexity and cognitive style measures so as to better understand the effects of environments on learning.
- Fund research to develop/validate dependent measures appropriate for alternative learning environments.

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APPENDIX A

REVIEW OF LITERATURE

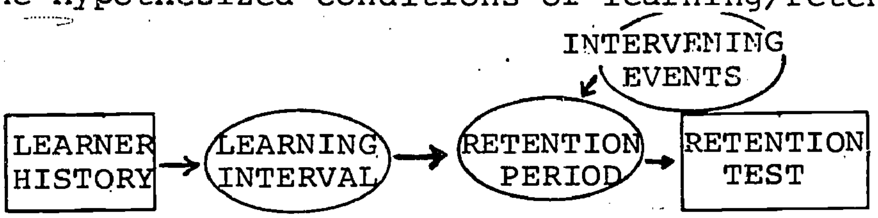
LITERATURE REVIEW

The literature reviewed for the present investigation centered on two categories that represent the different conceptual aspects of the phenomena under investigation. Reviewed first is a collection of laboratory-oriented research on basic learning and retention processes. This is followed by a review of studies on the relationship of personal and environmental characteristics to achievement, with emphasis on approaches that utilize the person-environment interaction model.

Learning/Retention Research

A wide variety of studies examining human learning and retention in an education context would seem to have relevance to the present investigation. Although there is an apparent lack of research dealing specifically with the retention of reading and mathematical competencies as a function of the particular characteristics of the learning environment under study, the principles derived from related research may be applicable to the present investigation of the learning-in-work and traditional environments. Ausubel (1968, p. 83-115) asserted that learning and retention of material is superior among those who have been given meaningful, as opposed to rote-memorized material. The basis for this finding centers on the following promises: (1) meaningful material is more easily related to information previously learned; (2) meaningful material can be incorporated with the learner's store of information more easily than material simply memorized by rote and unrelated to other stored material; (3) retention of meaningful material is facilitated by the fact that there is more information available to retrieve, since meaningful material is learned better originally. The overall effect of meaningful information stored, is a more gradual retention decrement. Material which is "rote-learned" was observed to be subject to a much steeper forgetting gradient as a consequence of poorer original learning.

Gagne'(1978) offered further insights on the nature of learning/retention for these two environments: EBCE or learning-in-work vs. traditional. The following model illustrates the hypothesized conditions of learning/retention:



Under this conceptualization of the learning/retention process, pre-learning history refers to the events preceding the learning interval under study. The learning interval is the time given to transmitting the material to be learned. The retention period consists of the time between the learning interval and a follow-up retention test. Events which occur during this period are seen as able to control (through interference) the exact level of retention possible or the level appearing on the retention test.

Research on the components of this model is seen to have implications for the present study. Improved retention was seen as a result of greater prior experience (learning history) in studies by Johnson (1973). Scores on recognition of items were seen to suffer from interference created by previously learned, similar items (Sulin and Dooling, 1974). However, in a laboratory study, Shuell and Keppel (1970) found no difference in later retention of learning from unequal prior learning. Overall, it appears that prior experience with the learning tasks should facilitate subsequent retention, although this relationship can depend on the particular recall task at hand (i.e., recognition vs. application).

Research on practice or usage of learning, which occurs during the retention interval, has revealed some clear trends. Boker (1974) and later Anderson and Biddle (1975) demonstrated a strong relationship between the number of chances to apply the learned material and subsequent retention. The relationship indicated that increased practice leads to superior retention. The beneficial effect of using the acquired material in other non-school situations is borne out by later performance on a retention test. La Porte and Voss (1975) reinforced this finding, demonstrating that the best results on retention tests are achieved when learners can use the information learned and can receive feedback on their performance. This fact was interpreted by La Porte and Voss as suggesting that the effect resulted from strengthened retrieval paths and to a learning facilitated by feedback. Further support for the beneficial effects of practice was offered by Rickards and Friedman (1978), who found that forcing students to use previously learning material leads to better retention performance. This effect was explained as a strengthening of the original memory, which results from the usage of the material. The effect of practice was further generalized by Kulhary and Anderson (1972), who found that even delayed practice facilitates subsequent retention. In the context of the present study, these findings may be interpreted as predicting superior retention performance both at the end of the school year and at the end of summer for those students who have the greatest opportunity to use previously learned material (e.g., the EBCE students, who apply concepts previously learned to the on-site experiences).

In a study of the most effective learning environment dimensions, Weber (1976) concluded that learning is maximized under specific conditions: (1) if the learning materials allow considerable feedback; (2) if teachers are highly directive and have the ability to provide feedback on specific learning tasks; and (3) if situations in teacher-student interactions are structured to provide immediate feedback. As applied to the present study, these results would suggest that learning will be facilitated for the group having the greatest access to teachers giving task-references and to specific feedback as soon as possible.

Of the two learning environments surveyed here, the EBCE condition would seem more effective because of (1) access it provides to learning materials in a concrete form, thereby facilitating observation of performance; (2) access it provides for resource persons available for giving specific directive feedback on job performance; and (3) a one-to-one ratio of supervisor (resource person) to student for each site, thereby allowing the closest possible monitoring of and feedback on performance.

Kerrigan (1976) compared the effectiveness of traditional and "individualized" learning systems in producing achievement in mathematics instruction. The individualized approach was characterized as structuring the progress and content of the learning material to fit the learning rate and style of each student. Results of this study revealed that the individualized approach produces the highest level of overall math achievement at the end of the course and also achieves the greatest improvement in scores for low-ability students in the program. To the extent that the EBCE environment offers individual programs for learning material, it may be expected that students (especially lower-ability students) enrolled in these programs should exhibit the greatest gains in learning mathematics competencies.

Person/Environment Research

A wide variety of studies have examined the joint contributions of personal characteristics and environmental structure as they affect performance. These studies may be further grouped as follows: studies dealing with the relationship of "person" variables (i.e., cognitive style) to task performance and studies dealing with the interaction of the environment and the person characteristics. It is hoped that such classifications of persons and environments will facilitate understanding of the processes operating in the present study.

Cognitive-Style Studies

Gray and Knief (1975) investigated the relationship of cognitive style, defined as stable preferences of individuals with respect to conceptual categorization and perceptual organization of the external environment, to academic achievement. Results indicated that the strongest effects were observed when the correlations of cognitive style to achievement were computed on an individual classroom basis. However, when overall results were completed, averaging across the classes, these effects were trivial. No clear pattern was evident for the classroom-level analyses. It was concluded that an interactive effect (changing relations as a function of classroom environment) was present, which would account for the lack of clear "main effects" of cognitive style on performance.

Davey (1976) investigated the relationship of cognitive style to academic achievement, concluding that the match of the students' cognitive styles to the instructional method was a critical factor in maximizing performance. Learning by discovery and other "individualized" instructional programs were seen to be better suited for more complex, field-independent students. More structured programs were seen to be better for less complex, field-dependent students.

Russell and Sandilands (1973) investigated the relationship of conceptual complexity (Harvey, Hunt and Schroder, 1961) or cognitive style to a variety of biographic and demographic variables. Results indicated that both the paragraph completion test (Schroder, Driver, and Streufert, 1967) and the Interpersonal Topical Inventory (Tuckman, 1966), which were used as measures of cognitive style, were unrelated to age, sex, birth order, and grade-point average.

Interaction Studies

A growing body of research has emphasized the applicability of a paradigm which includes both individual differences and environmental effects in a joint capacity as determinants of behavior (e.g., Cronbach, 1967). Hunt (1975) provided a strong statement of the necessity of including both types of variables, particularly when the effects of different learning environments are being investigated. Conceding that research would not be likely to produce findings that are applicable to "persons in general" and that many personal characteristics would be expected to have differential effectiveness in different environments, Hunt argued for future research directed at identifying the interactive nature of the personal and environmental characteristics of behavior.

With respect to the variables of interest in the present study (i.e., environmental and conceptual complexity), several studies have suggested that an interactive effect may be present. For example, Streufert, Suedfeld, and Driver (1965) using a simulation task, found that an interactive effect was present: the relationship of environmental complexity to performance on the task was different as a function of the conceptual complexity of the subject, since more complex subjects were less influenced by the environment than less complex subjects. Staszkiewicz (1977) examined the relationship of cognitive complexity and "classroom climate" (a measure of the degree of direction given by the instructors) to mathematics achievements in a sample of high school students. Results indicated that an interactive effect existed between these variables, since more cognitively complex students scored higher than less complex students in situations characterized by less teacher direction.

A review of the literature relevant to environmental and individual complexity (Goldstein and Blackman, 1977) indicated that an interactive relationship may be expected between these variables. The predictions of superior performance by more complex individuals at all levels of environmental complexity, combined with optimal performance for complex subjects occurring in more complex environments than for less complex subjects, have been supported in a variety of simulation studies (e.g., Karlins, Coffman, Lamm, and Schroder, 1967; Streufert and Schroder, 1965).

Summary

While no research on learning and retention was discovered that directly examined the conditions under study in the present investigation, the references above do appear to provide a framework on which predictions of learning and of retention performance of EBCE as compared with traditional students may be based.

In terms of the Gagne' . . . model, generalization to the present investigation would identify (1) learning history as all prior school performance, to be examined for inequality at pre-test (on CTBS scales); (2) learning interval as the period from grade 11.0 to 11.9, during which students will be exposed to the two learning environments with a "learning test" administered at grade 11.9 to determine the degree of equal or unequal learning; (3) retention test as the test given at grade 12.0 to determine the degree to which students have retained the information learned in the junior year and the degree to which they have assimilated this information with previous learning; and (4) intervening events as those facilitating factors leading to assimilation of material and the interfering factors leading to poor transfer or assimilation of material.

Relevant research would suggest that improved performance on the learning and retention tests results from the frequency, concreteness, and meaningfulness of feedback, the chances for practice (use) of learned material; and the contingent feedback during both the learning interval and the retention interval.

Research has emphasized the need to investigate the interactions of personal characteristics (i.e., individual differences) with characteristics of environments. An application of this methodology relevant to the present investigation has been the research investigating the interaction of environmental complexity and individual complexity. Considerable support is present, at least on controlled settings, for the notion that the relationship of personal complexity to performance will vary as a function of the complexity of environment in which the behavior occurs.

APPENDIX B

DESCRIPTION OF LEARNING-IN-WORK PROGRAM

Description of the Learning-in-Work Program

In order to provide the reader a better understanding of the learning-in-work program under investigation, a description of its major structural features is provided. The program is the Appalachia Education Laboratory (AEL) model of Experience-Based Career Education (EBCE) located in the Anoka-Hennepin District II, Anoka, Minnesota. The Anoka-Hennepin District II public schools were selected as the Minnesota (EBCE) demonstration site. The program was implemented during the 1977-78 school year, and students from the three high schools in the district began participation during the second semester. An anthropological description of the program can be found in Learning and Work Programs: Transitional Educative Cultures (Crowe and Twarog, 1979).

Background Information

The EBCE program is designed as an academically oriented community-based career exploration program bridging the gaps between school and the community and between study and experience by emphasis on basic skills and varied career explorations.

The program at Anoka consists of three learning coordinators (LC), a site analyst, and a program director. The learning coordinators are primarily concerned with supervising the individual learning activities of students. The major vehicle for designing student experiences is the activity sheet negotiated jointly by the student and LC; and during the course of a year, a student completes approximately one hundred of these sheets. The site analyst is primarily responsible for maintaining and upgrading the work placements and for assisting students in choosing a site for career exploration. During a school year, students may have from three to twelve site experiences depending on their preferences and purposes for selecting the sites. Each site (workplace) provides a resource person (RP) responsible for supervising and guiding the learning of the student at the placement.

Students spend the first week becoming oriented to the program and assessing their career interests and academic needs. After orientation, their week is divided with four days spent at the site and one at the learning center. Time at the site parallels normal school hours, from 8:30 to 2:30. Learners do not receive pay for the worksite experiences but do earn academic credit toward high school graduation.

Description of the Instructional Process

What is the instructional sequence of students? Figure 1, illustrating the macro-flow of student instructional activities, was developed from an analysis of the Student Program Guide (1976) and our observations of the program. Our view is that major steps are six-fold: (1) assessing career interests and aptitudes; (2) assessing academic interests and needs; (3) integrating career interests and academic needs; (4) designing learning experiences; (5) implementing the plan; and (6) evaluating the experiences.

Before each step is described, it is important to document one of the assumptions about what students are learning in the program. The assumption was that students were learning traditional subject-matter content through experiences at the worksite. In this EBCE model, traditional school subject matter is demonstrably related to both the Worker Trait Groups of the Dictionary of Occupational Titles (DOT) and the twenty-eight EBCE courses. An example of the chart that students use to relate school subject matter to occupations through worker trait groups is as follows:

Mathematics (Student Program Guide, 1976, p. 10)

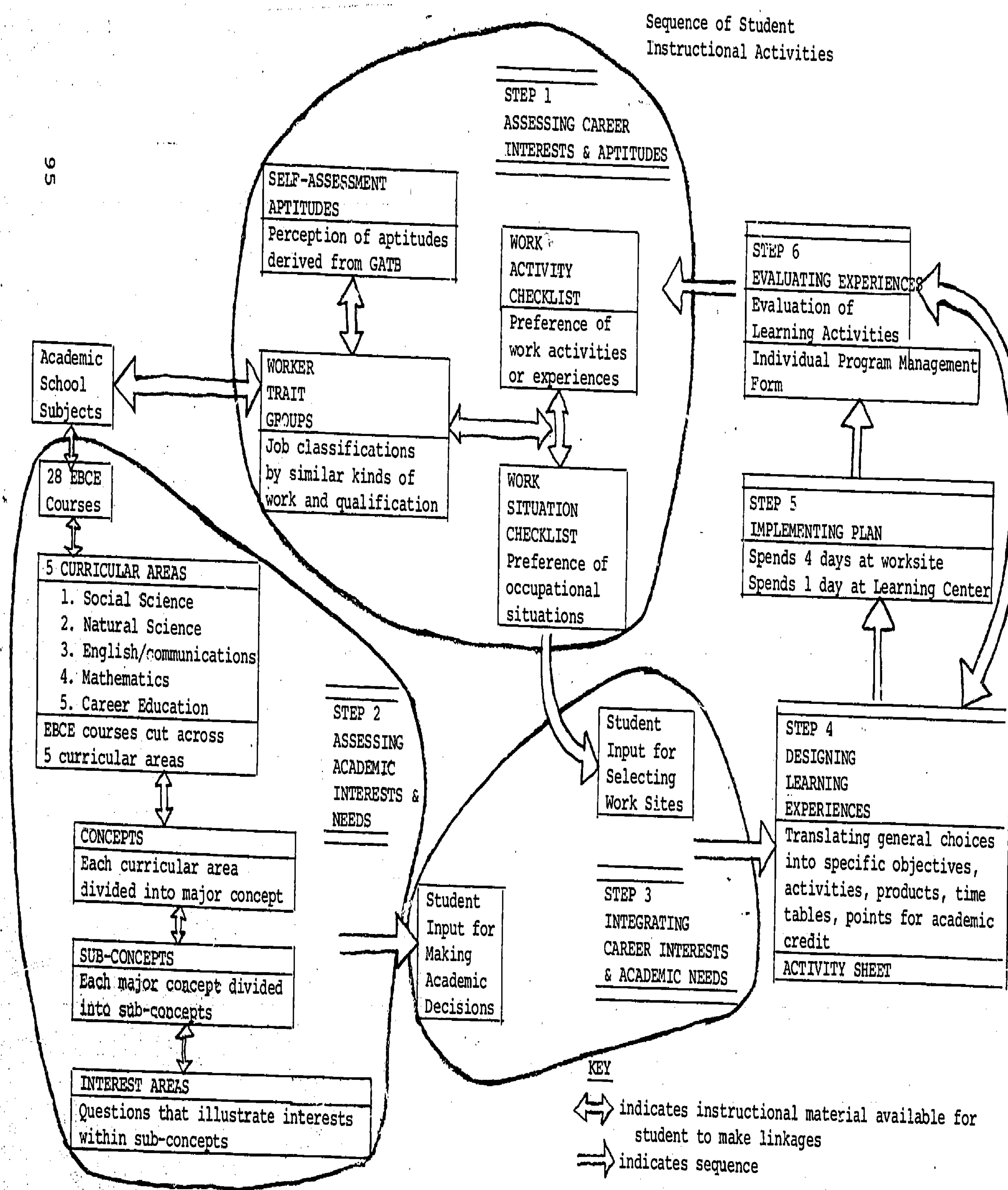
School Subjects	Selected Worker Trait Groups
General Mathematics	9, 13, 16, 24, 44
Algebra, Geometry	13, 44, 55, 59, 60
Trigonometry	13, 44, 58, 60, 88

Student course selections in EBCE are also related to school subject matter as reflected in the following three selected EBCE descriptions of courses appearing in the Student Program Guide (1976, p. 83-89):

Student Program Guide, Charleston, W.Va.: Applachia Educational Laboratory, 1976.

FIGURE 1

Sequence of Student Instructional Activities



ALGEBRA is a standard mathematics course with which you are probably familiar. It is strongly related to some 14 Math Sub-concepts (Logarithms & Exponents, Functions, Equalities & Inequalities, etc.) in the EBCE system. It also relates to some 6 Natural Science Sub-concepts (Atomic Structure, Electricity, etc.), and to 8 English/Communications Sub-concepts (mostly dealing with Research, Reading Comprehension and Reporting Skills). Some application to community sites is possible (e.g., a chemical research laboratory), but you should expect much skills-practice and problem-solving through extensive use of in-house materials. Many of the relationships in EBCE of Algebra to other course structures involve skill-building for more sophisticated mathematical and scientific applications.

FUNDAMENTAL MATHEMATICS focuses on "brushing up" on such basic math skills as computation (adding, subtracting, multiplying, dividing), percentages, conversions, measurements, and ratio and proportion; these are skills that you will need no matter what career you choose. This course relates strongly to all five curricular areas: 11 Math Sub-concepts (Whole Numbers, Ratio, Tables & Graphs, Consumer Math); 8 Natural Science Sub-concepts (matter & Energy, Electricity, Complex Machines); 12 English Communications Sub-concepts (Reading, Writing, Research, Reporting); 3 Social Science Sub-concepts (Price, Physical & Human Geography); and 2 Career Education Sub-concepts (Personal Aspects of Work and The Work Place. You can pick up and practice these fundamental math skills at virtually every experience site, ranging from stores to newspapers to governmental agencies.

MODERN TECHNOLOGY is perhaps EBCE's broadest course area, for it is concerned with the impact of technology on all aspects of our society. It can involve the influence of new or better ways of performing technical tasks (e.g., machinery, equipment, science, computers); our political, economic, and social institutions (e.g., elections, business cycles, labor unions, ecology); our communications processes (TV, radio, magazines); our career patterns and trends (obsolescence, new careers); or our individual and interpersonal relations (mental health, leisure time, travel). This course area relates heavily to all five curricula: to 17 Social Science Sub-concepts (Distribution, Decision-Making, Geography, Philosophy; to 12 Natural Science Sub-concepts (Atomic Structure, Light, Biochemistry, Engineering Systems); to 12 Math Sub-concepts (Logarithms, Whole Numbers, Probability/ Statistics); to 12 English/Communications Sub-concepts (Research, Writing, Reading, Speaking, Reporting); and to 2 Career Education Sub-concepts (The Work Place, Job Mobility/ Security). You can study some aspect of Modern Technology on virtually any experience site after careful selection of the aspects most appropriate for you.

The purpose of including this specific information is to show that the program explicitly relates traditional subject-matter disciplines to occupations and worker traits required for a job, to experiences at the worksite, and to the courses that students choose. Thus, we have some assurance that students have an available opportunity to learn and retain traditional mathematical and reading concepts (skills).

Step 1: Assessing career interests and aptitudes. During this phase students may choose to complete several diagnostic instruments designed to assess their career interests and aptitudes. Upon completing these assessments, students then review "Experience Site Learning Guides" for the purpose of determining a match between their career interests and the learning activities at a worksite. The Guide details specific information about the worksite career opportunities and job duties (keyed to the D.O.L. worker trait group).

Step 2: Assessing academic interests and needs. During this phase, students decide which EBCE courses they will select. After choosing a course, they refer to the EBCE course and interest area matrix for the purpose of choosing the academic sub-concepts and interest areas that will define the parameters for developing short-term learning activities.

Step 3: Integrating career interests and academic needs. Although this is not a formal step in the instructional process, to the researchers it represents a time when students can reflect on their decisions and thinking about the kinds of activities they would like to have at the worksite.

Step 4: Designing learning experiences. The major tool for this stage is the activity sheet, that students and learning coordinators use to translate the student choices made in Steps 1 and 2 to specific learning activities. The activity sheets spell out student tasks, estimate the time frame the activity will require, and furnish the basis for measuring progress. They also relate subject-matter concepts to learning objectives and site experiences. Students may be completing up to five or six activity sheets at any given time. Activity sheet assignments are expected to be completed at the worksite. That is, there are no homework expectations for students.

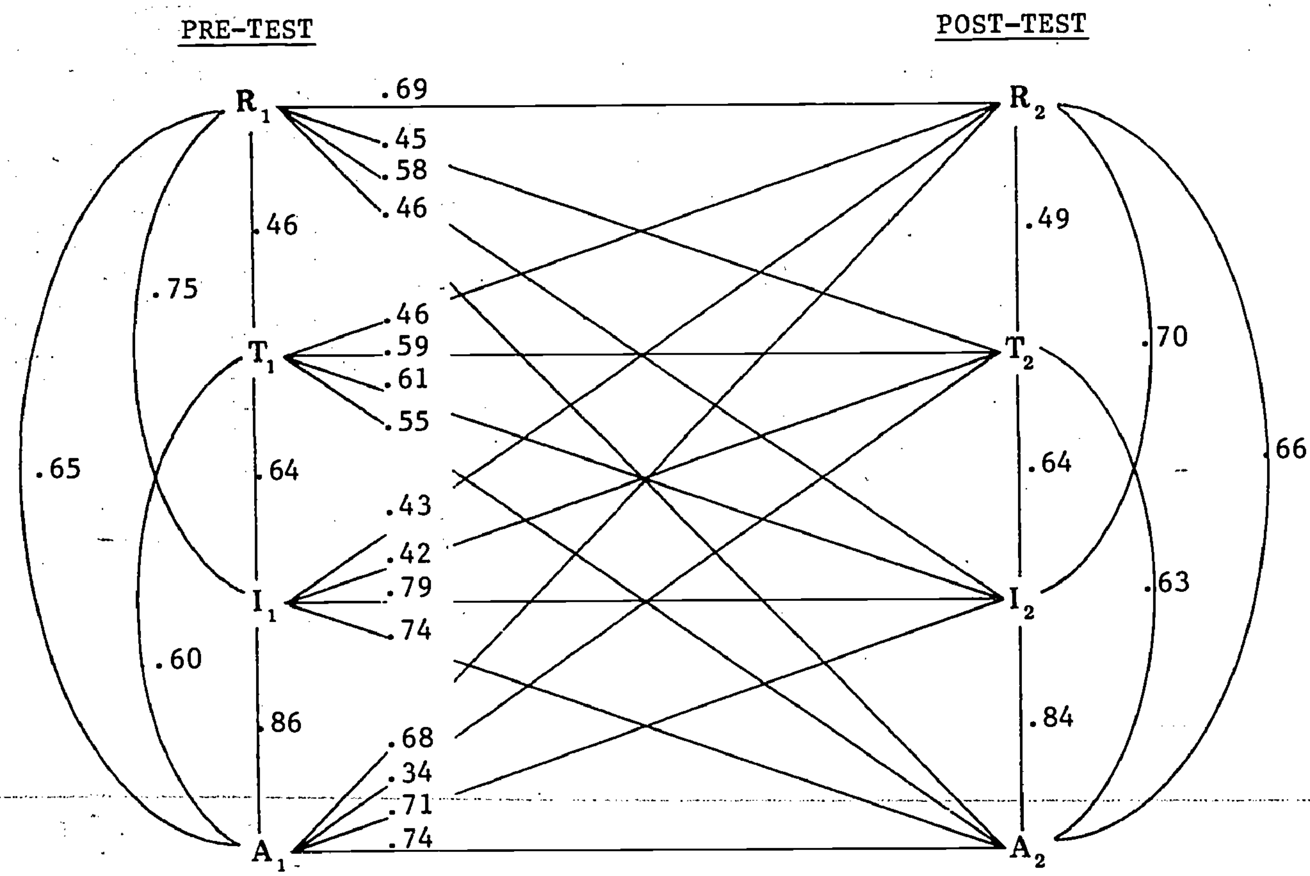
Step 5: Implementing plan. After the activity sheet has been completed and accepted by the student and learning coordinator, it becomes a guide for student learning both at the worksite and the learning center.

Step 6: Evaluating. The final step in the instructional process is the evaluation of the learning activities. That is conducted jointly by the learning coordinator and the student. Students are given the opportunity to do additional work if they desire a better evaluation. Upon satisfactory completion of the activity sheet, students record their progress on an Individual Program Management Form and begin a re-assessment of their career interests and academic needs.

APPENDIX C

CROSS-LAGGED PANEL CORRELATIONS OF
MATH CTBS-BLOOM SCALES FOR
TREATMENT (LEARNING-IN-WORK) AND
CONTROL (TRADITIONAL LEARNING) STUDENTS

Uncorrected CLPC Results of Math CTBS-Bloom Scales for Treatment Students' Pre- and Post-Test Scores



KEY: Process Variables

R = Recognition
T = Translation
I = Interpretation
A = Analysis

$K_R^2 = 0.99$

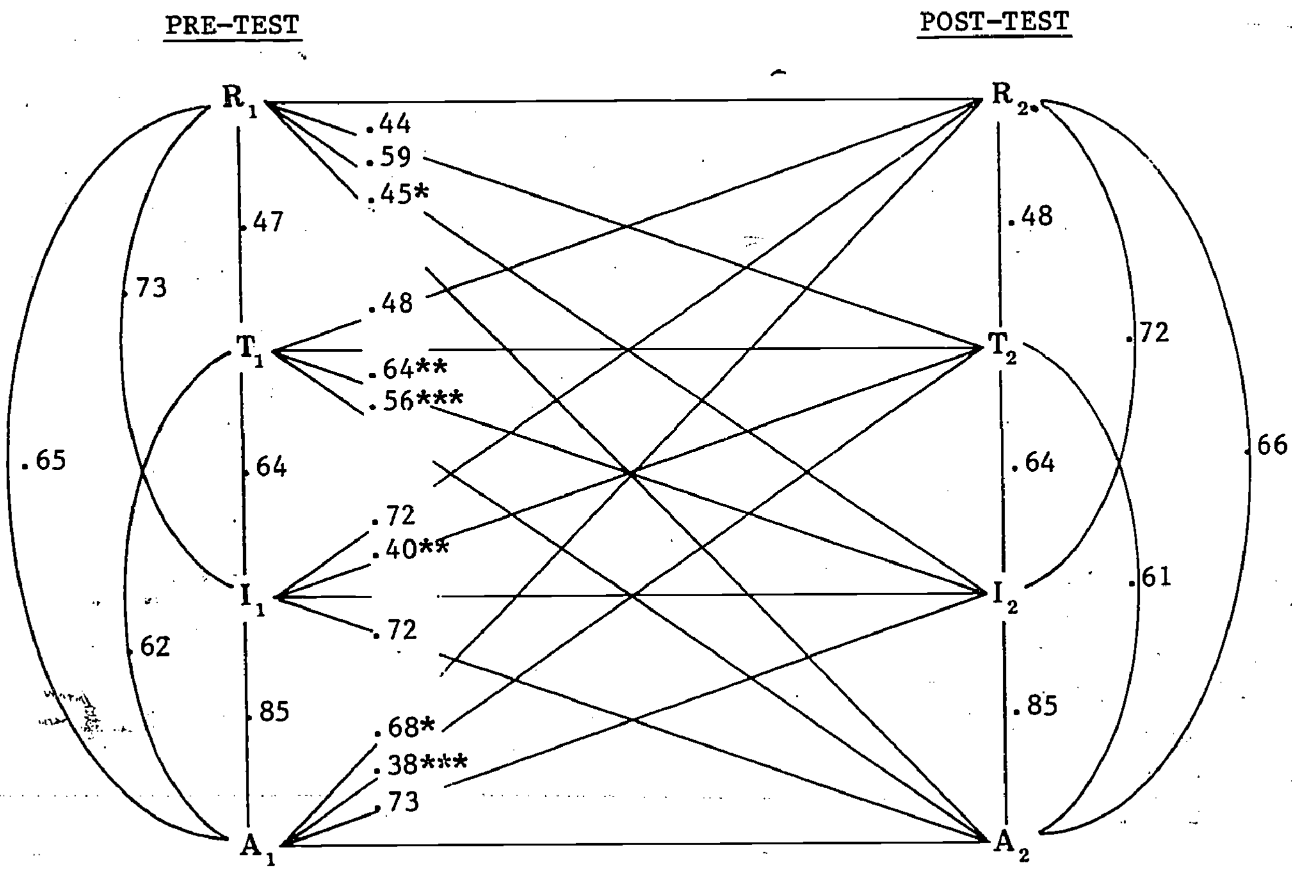
$K_T^2 = 1.12$

$K_I^2 = 0.91$

$K_A^2 = 1.02$

n = 38

Corrected CLPC Results of Math CTBS-Bloom Scales
for Treatment Students' Pre- and Post-Test Scores



KEY: Process Variables

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$K_R^2 = 0.99$

$K_T^2 = 1.12$

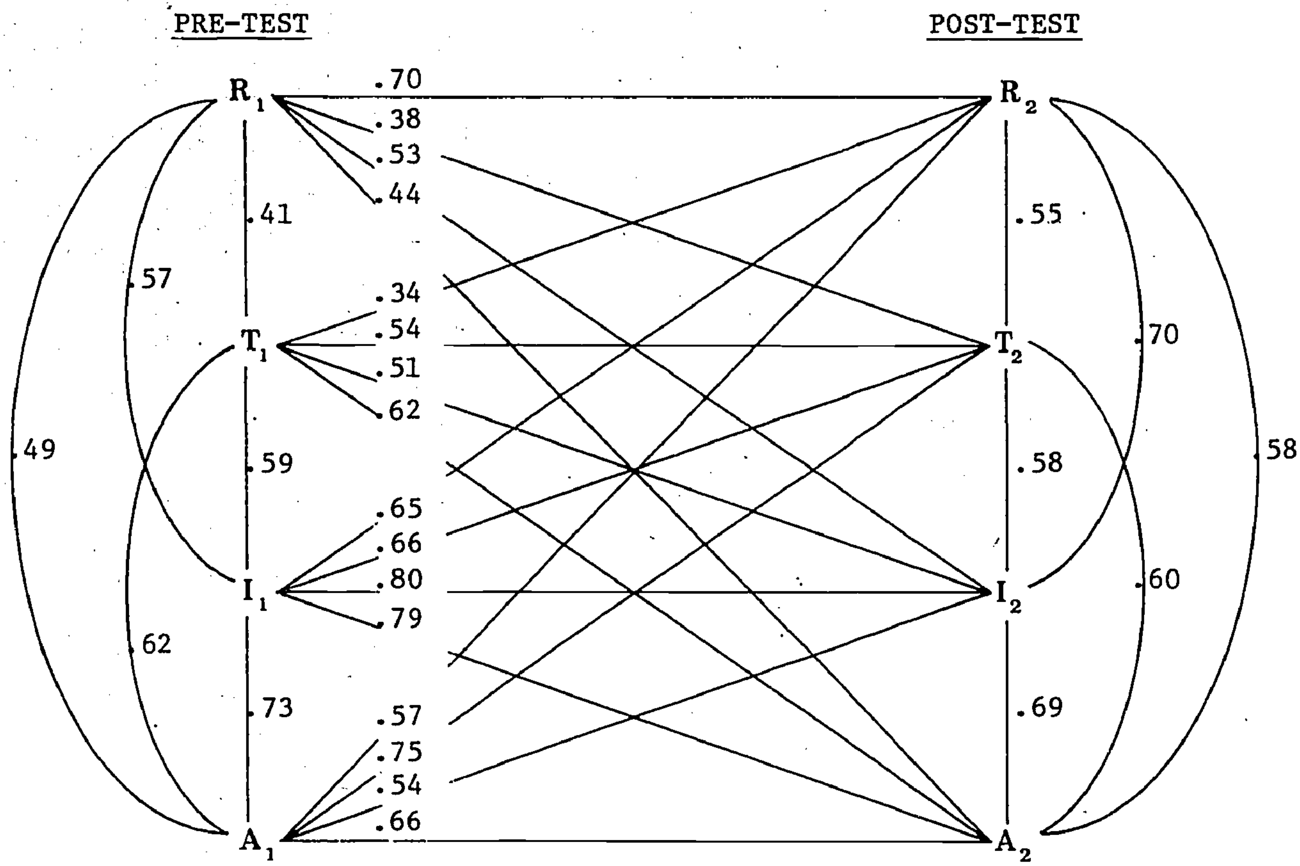
$K_I^2 = 0.91$

$K_A^2 = 1.02$

* Z = -1.85, p = .06
** Z = 1.80, p = .07
*** Z = 1.31, p = .19

n = 38

Uncorrected CLPC Results of Math CTBS-Bloom Scales for Control Students' Pre- and Post-Test Scores



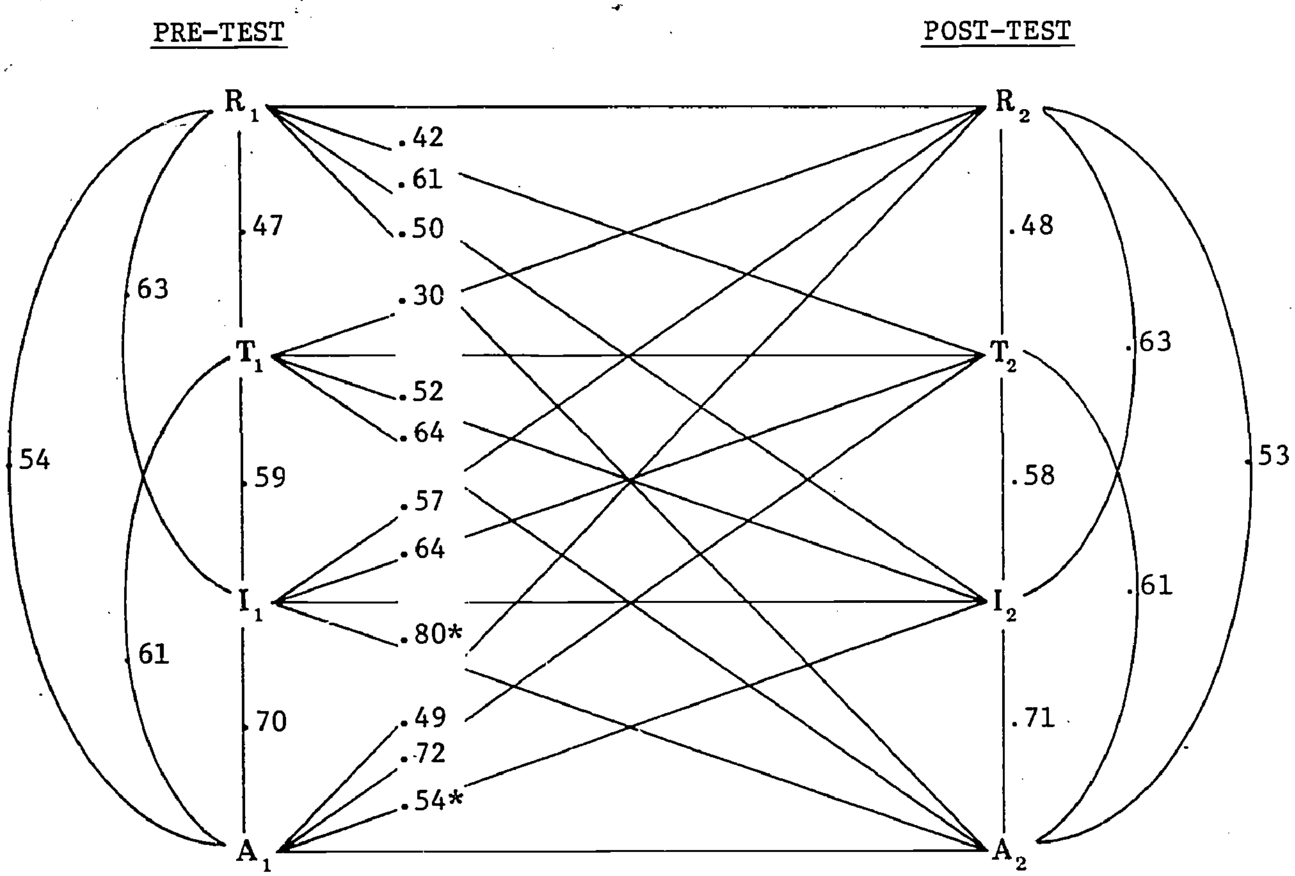
KEY: Process Variables

R = Recognition
T = Translation
I = Interpretation
A = Analysis

n = 42

$K_R^2 = 1.60$
$K_T^2 = 1.04$
$K_I^2 = 0.95$
$K_A^2 = 0.90$

Corrected CLPC Results of Math CTBS-Bloom Scales for Control Students' Pre- and Post-Test Scores



KEY: Process Variables

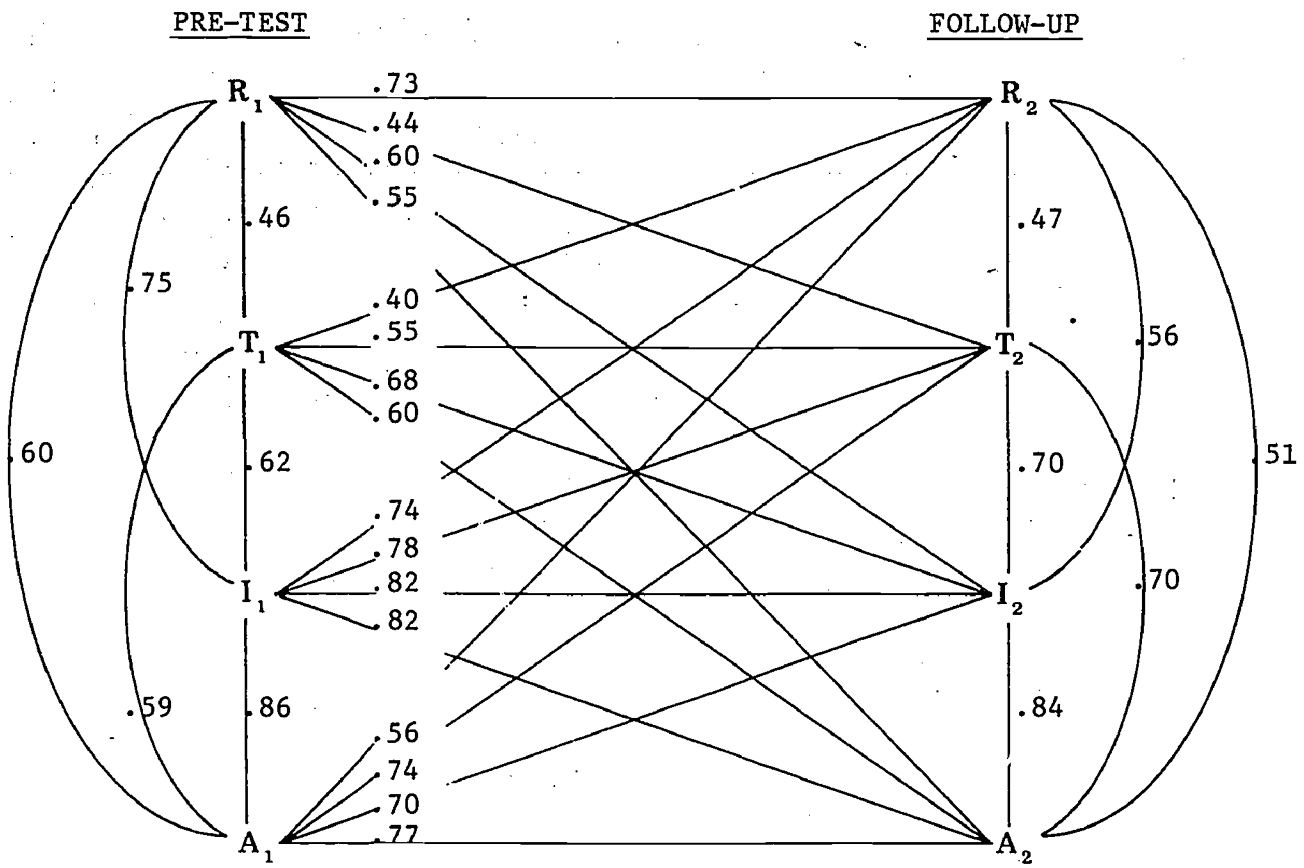
R = Recognition
T = Translation
I = Interpretation
A = Analysis

$K_R^2 = 1.60$
$K_T^2 = 1.04$
$K_I^2 = 0.95$
$K_A^2 = 0.90$

* Z = 2.52, p .02

n = 42

Uncorrected CLPC Results of Math CTBS-Bloom Scales
for Treatment Students' Pre- and Follow-up Scores



KEY: Process Variables

R = Recognition
T = Translation
I = Interpretation
A = Analysis

n = 30

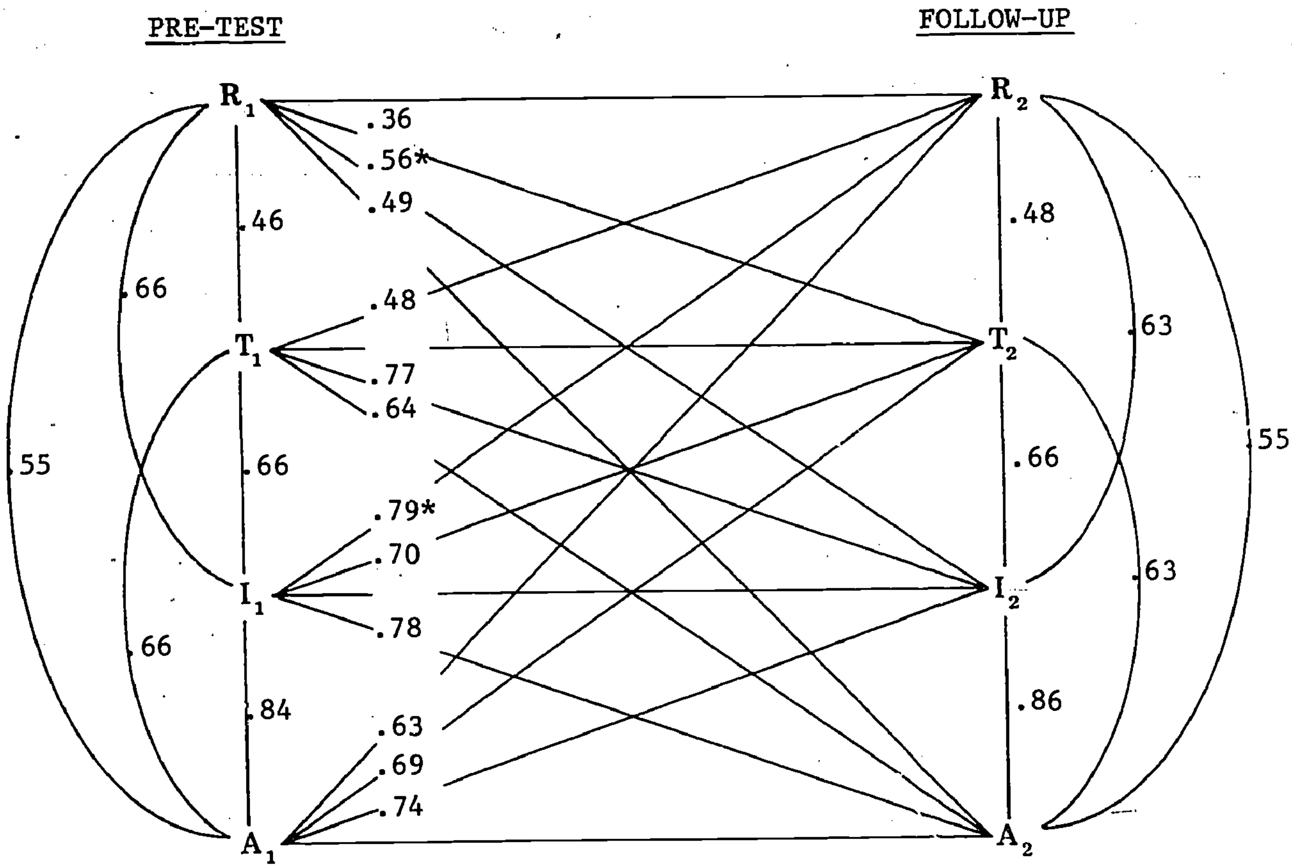
$K_R^2 = 0.70$

$K_T^2 = 1.44$

$K_I^2 = 0.88$

$K_A^2 = 1.06$

Corrected CLPC Results of Math CTBS-Bloom Scales
for Treatment Students' Pre- and Follow-up Scores



KEY: Process Variables

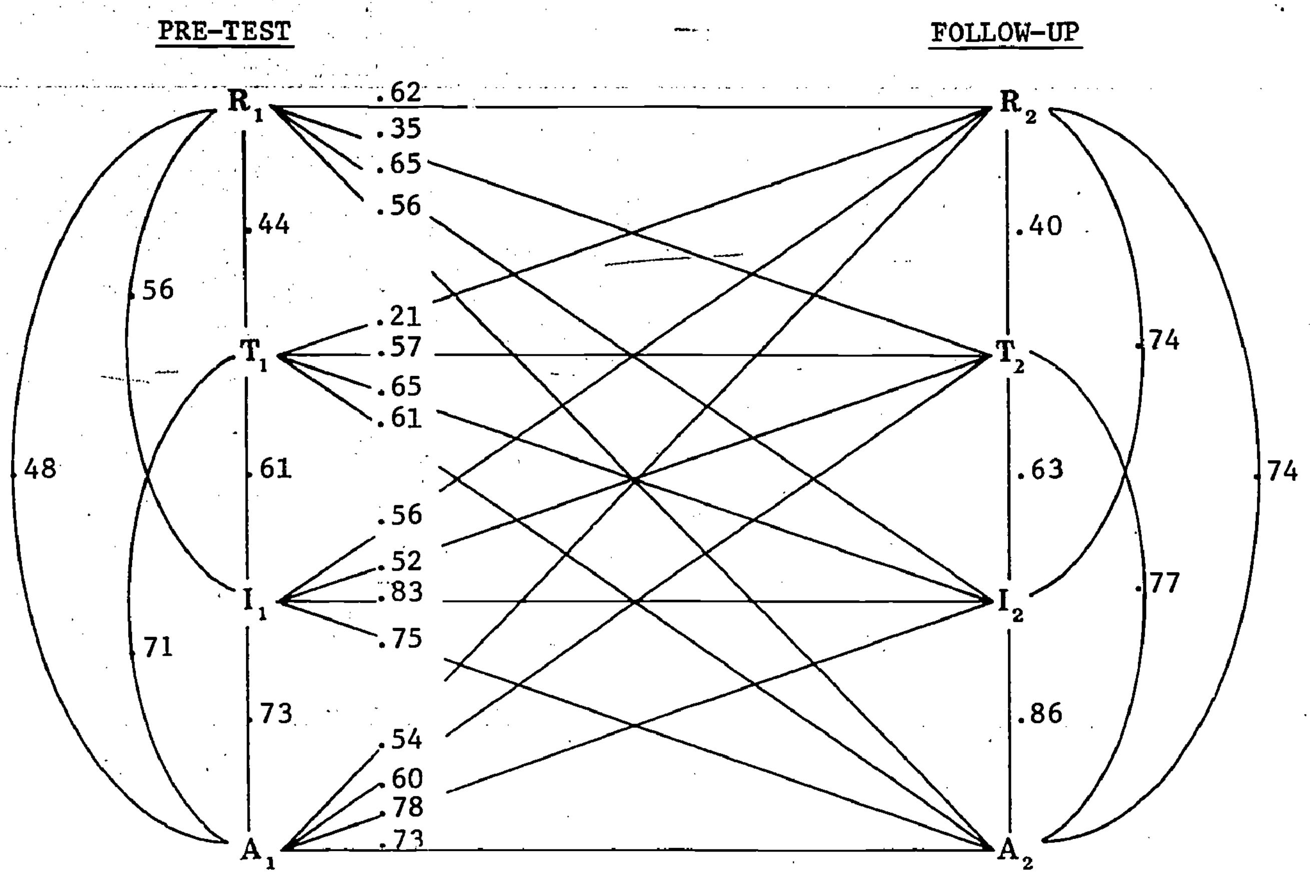
R = Recognition
T = Translation
I = Interpretation
A = Analysis

$K_R^2 = 0.70$
$K_T^2 = 1.44$
$K_I^2 = 0.88$
$K_A^2 = 1.06$

* Z = -1.96, p .05

n = 30

Uncorrected CLPC Results of Math CTBS-Bloom Scales for Control Students' Pre- and Follow-up Scores



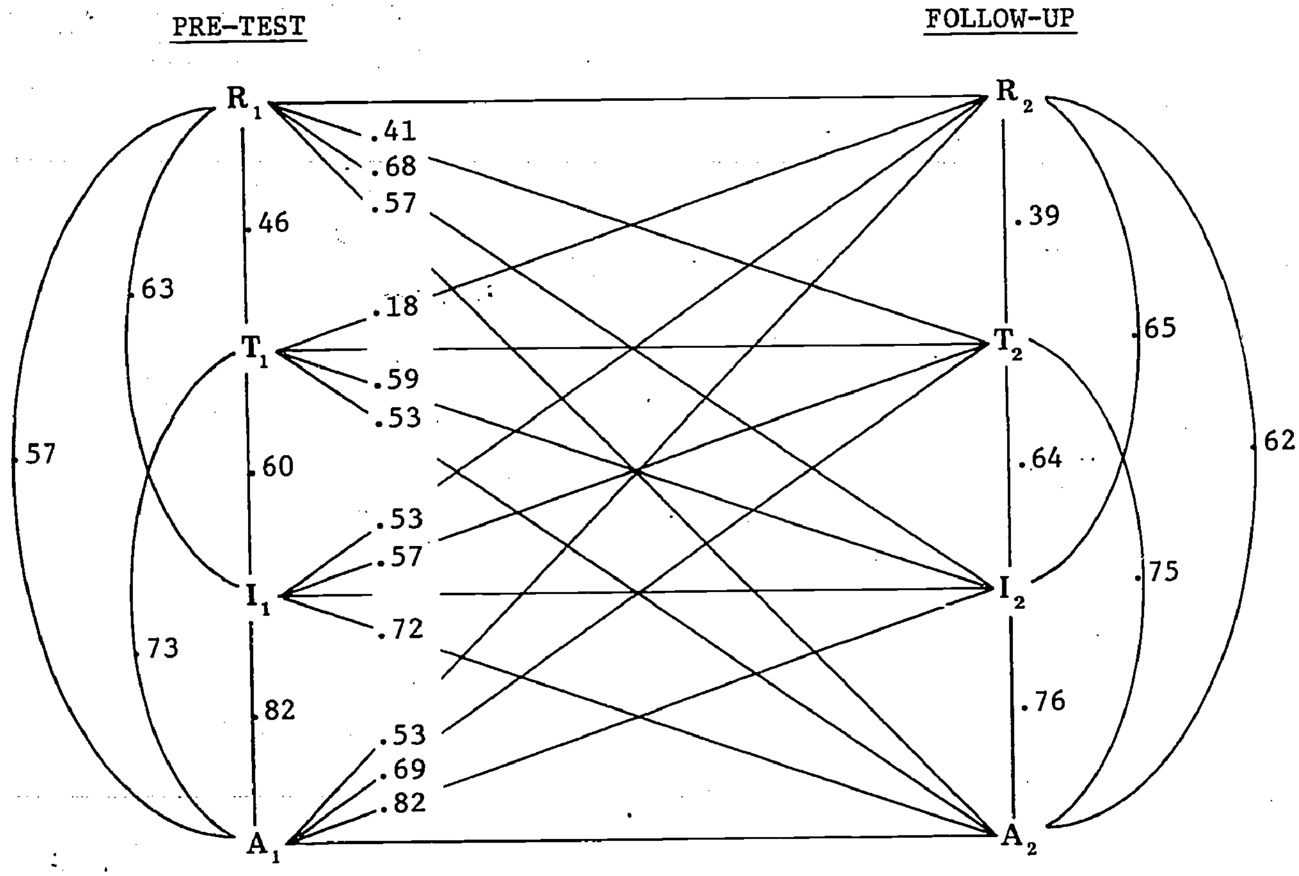
KEY: Process Variables

R = Recognition
T = Translation
I = Interpretation
A = Analysis

$K_R^2 = 1.44$
$K_T^2 = 0.80$
$K_I^2 = 1.15$
$K_A^2 = 1.40$

n = 28

Corrected CLPC Results of Math CTBS-Bloom Scales
for Control Students' Pre- and Follow-up Scores



KEY: Process Variables

R = Recognition
T = Translation
I = Interpretation
A = Analysis

$K^2_R = 1.44$

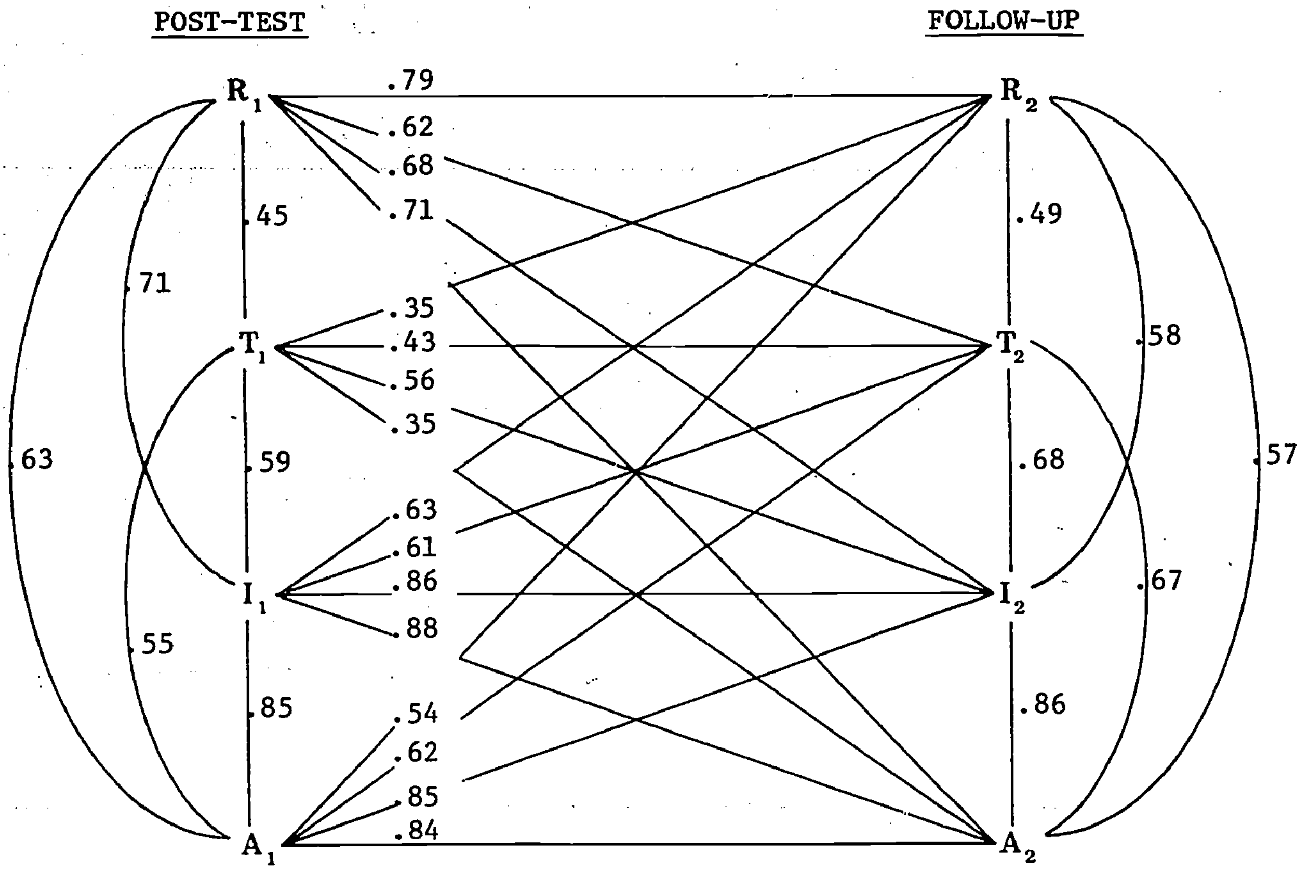
$K^2_T = 0.80$

$K^2_I = 1.15$

$K^2_A = 1.40$

n = 28

Uncorrected CLPC Results of Math CTBS-Bloom Scales for Treatment Students' Post- and Follow-up Scores



KEY: Process Variables

R = Recognition
T = Translation
I = Interpretation
A = Analysis

n = 38

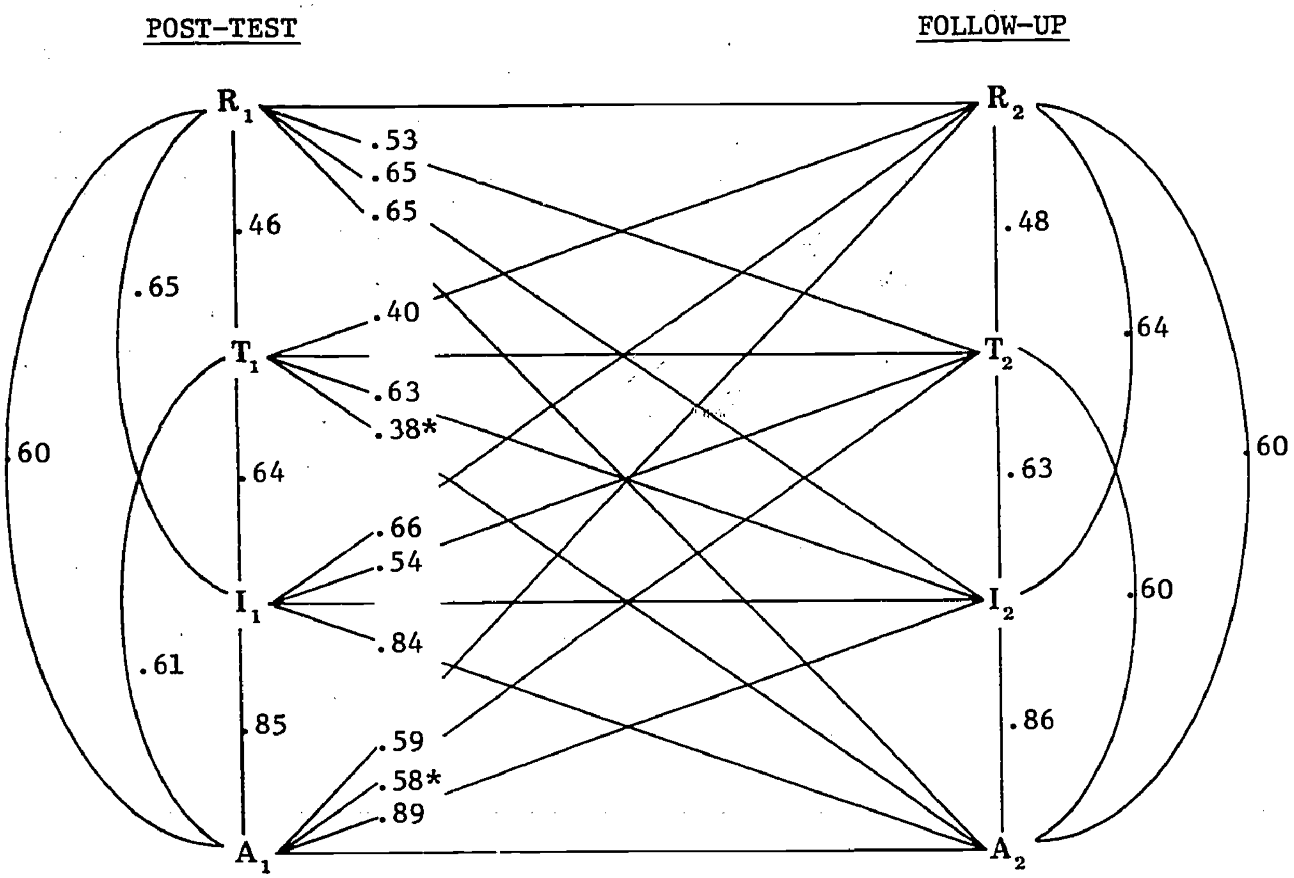
$K_R^2 = 0.77$

$K_T^2 = 1.44$

$K_I^2 = 0.91$

$K_A^2 = 1.09$

Corrected CLPC Results of Math CTBS-Bloom Scales
for Treatment Students' Post- and Follow-up Scores



KEY: Process Variables

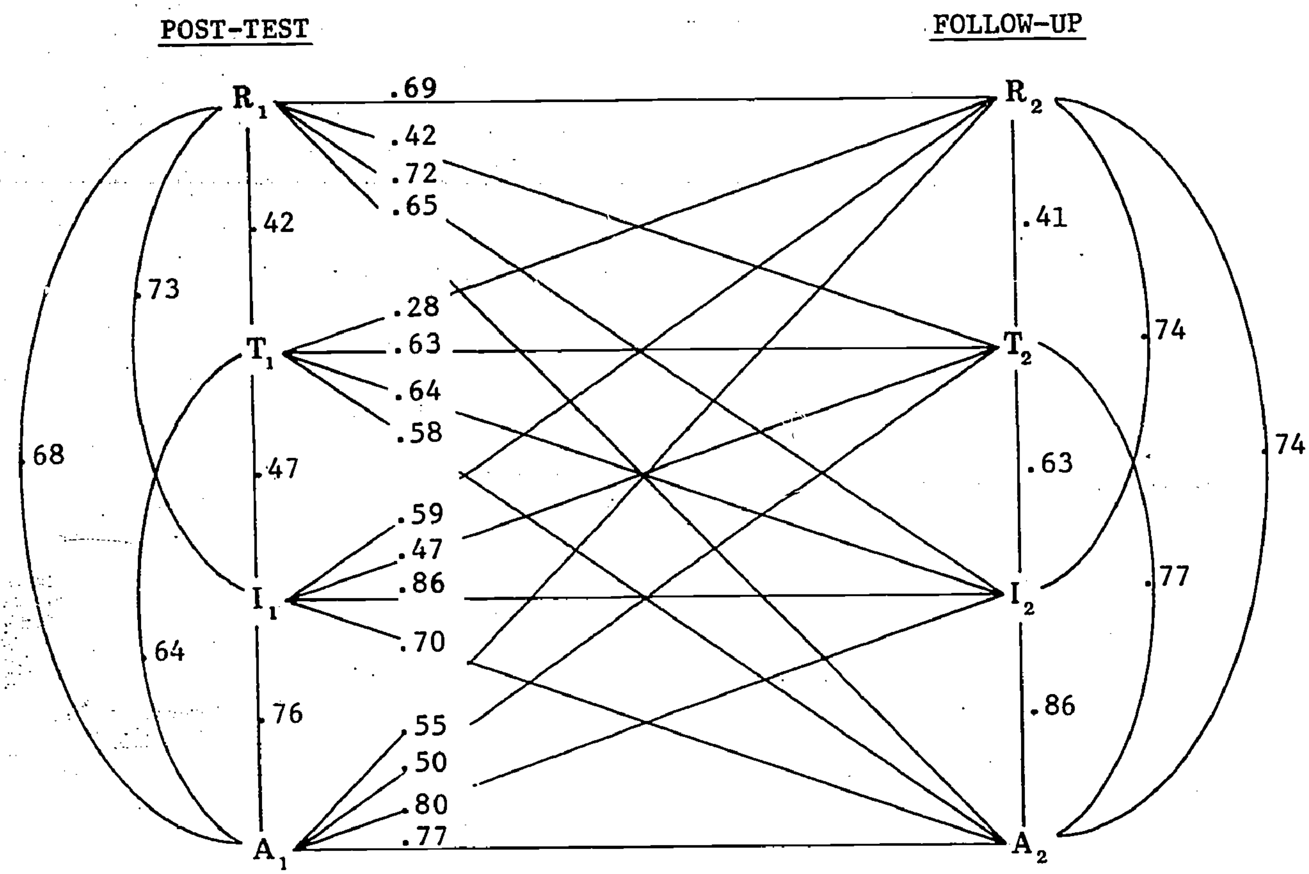
R = Recognition
T = Translation
I = Interpretation
A = Analysis

$K^2_R = 0.77$
$K^2_T = 1.44$
$K^2_I = 0.91$
$K^2_A = 1.09$

* Z = -1.35, p = .18

n = 38

Uncorrected CLPC Results of Math CTBS-Bloom Scales for Control Students' Post- and Follow-up Scores



KEY: Process Variables

R = Recognition
T = Translation
I = Interpretation
A = Analysis

$K_R^2 = 0.87$

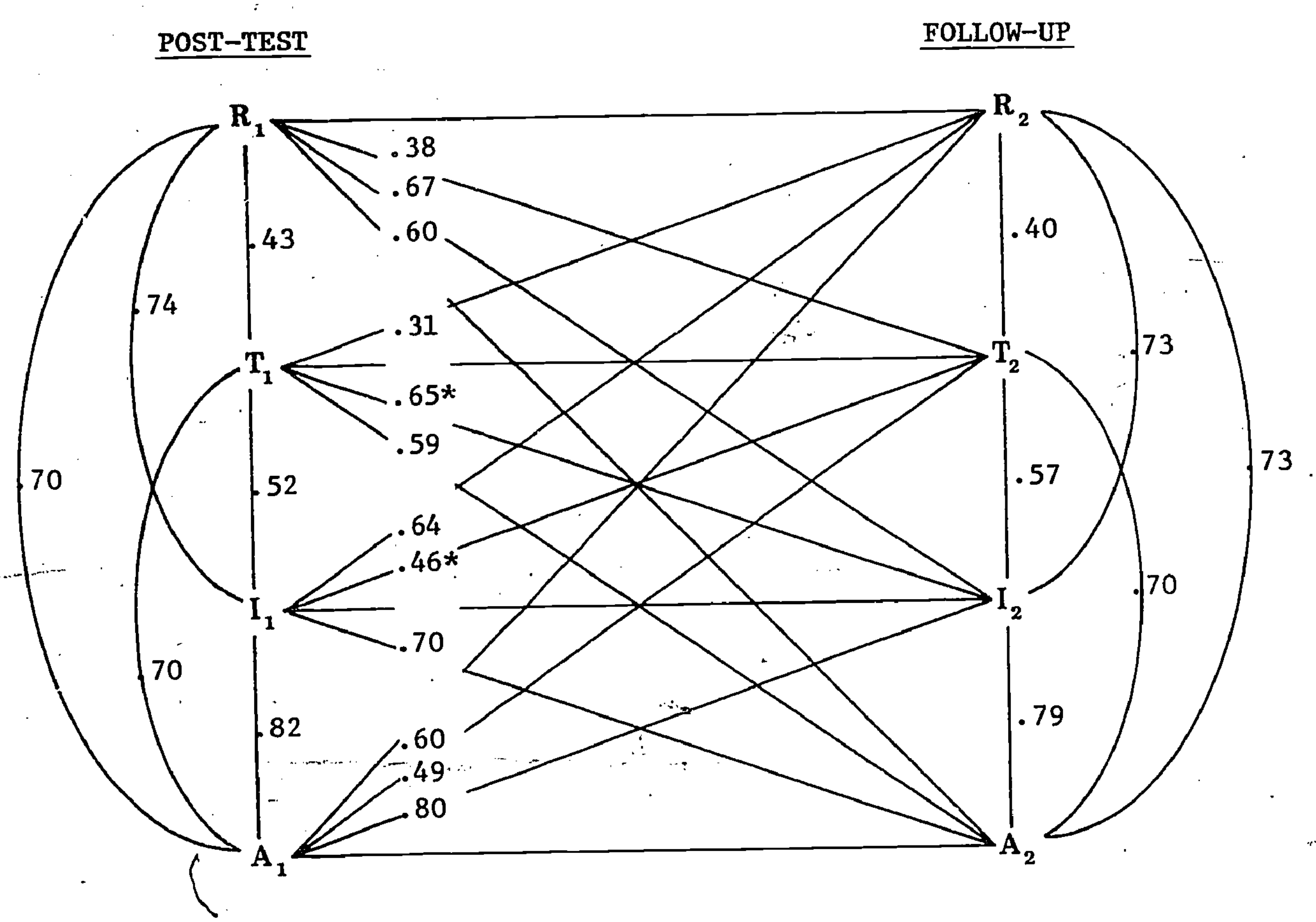
$K_T^2 = 1.26$

$K_I^2 = 1.19$

$K_A^2 = 1.18$

n = 28

Corrected CLPC Results of Math CTBS-Bloom Scales for Control Students' Post- and Follow-up Scores



KEY: Process Variables

R = Recognition
T = Translation
I = Interpretation
A = Analysis

$K_R^2 = 0.87$

$K_T^2 = 1.26$

$K_I^2 = 1.19$

$K_A^2 = 1.18$

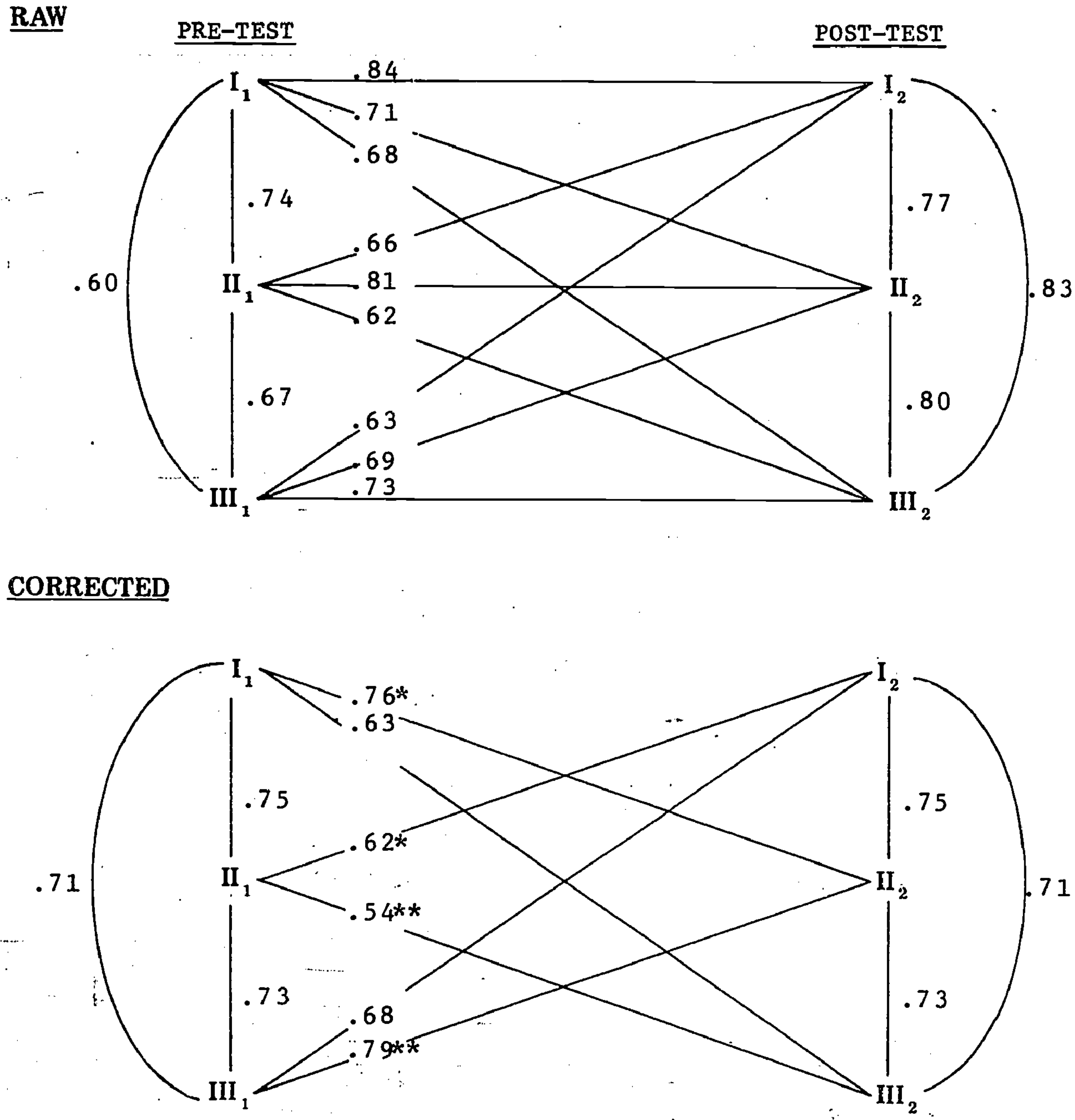
* $Z = 1.34$, $p = .18$

$n = 28$

APPENDIX D

CROSS-LAGGED PANEL CORRELATIONS OF MATH CTBS FACTOR-BASED SCALES FOR TREATMENT (LEARNING-IN-WORK) AND CONTROL (TRADITIONAL LEARNING) STUDENTS

CLPC Results of Math CTBS Factor-based Scales for Treatment Students' Pre- and Post-Test Scores



* $Z = 1.47$, $p = .14$

** $Z = -2.40$, $p = .02$

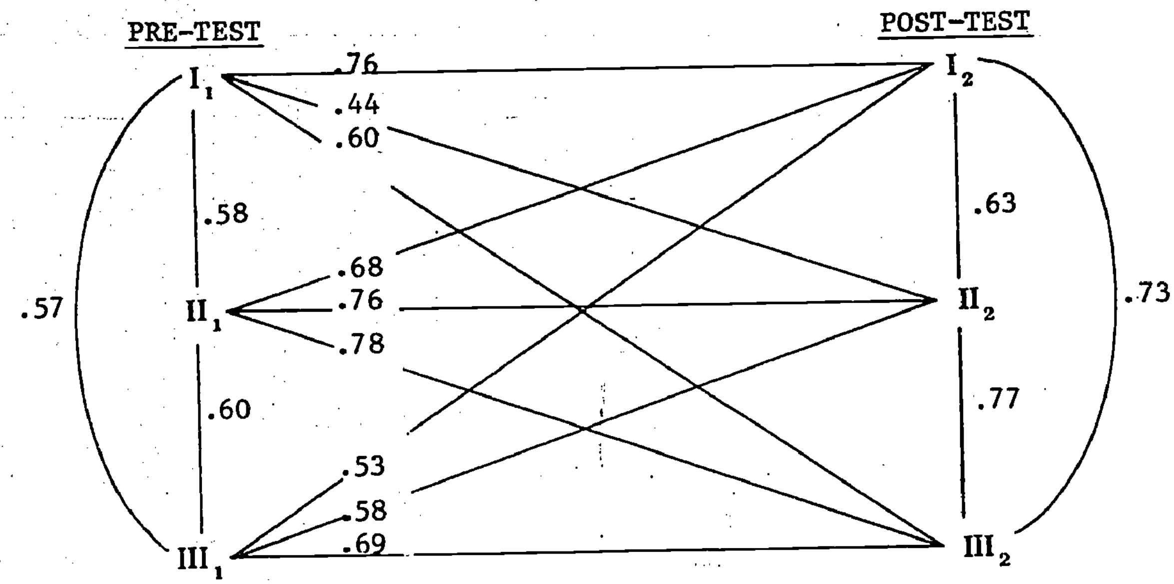
$K_{I}^{2} = 1.18$

$K_{II}^{2} = 0.91$

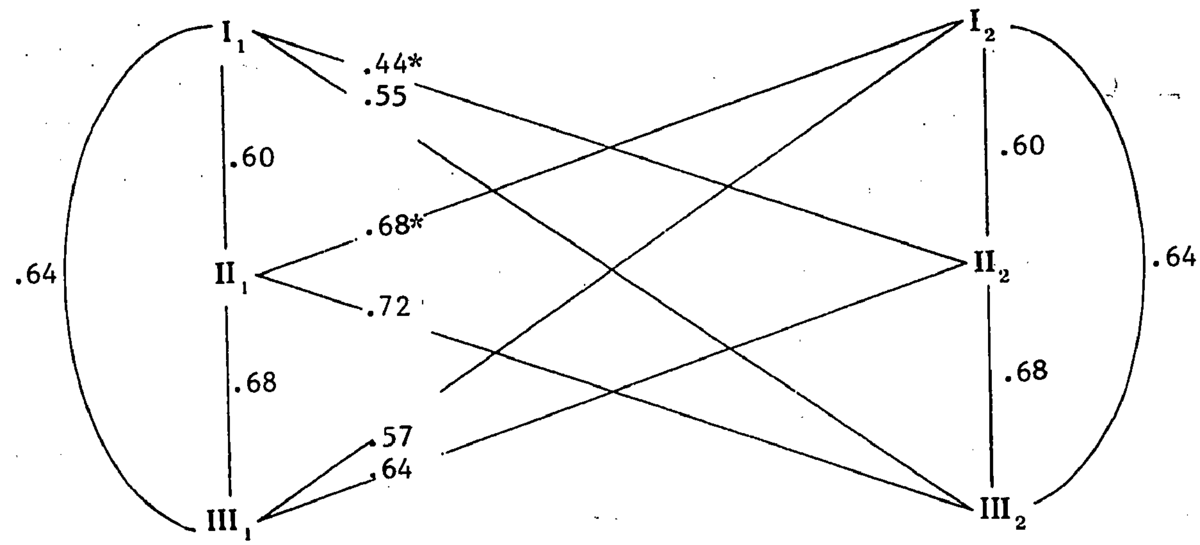
$K_{III}^{2} = 1.60$

CLPC Results of Math CTBS Factor-based Scales
for Control Students' Pre- and Post-Test Scores

RAW



CORRECTED



* Z = -2.12, p = .03

n = 42

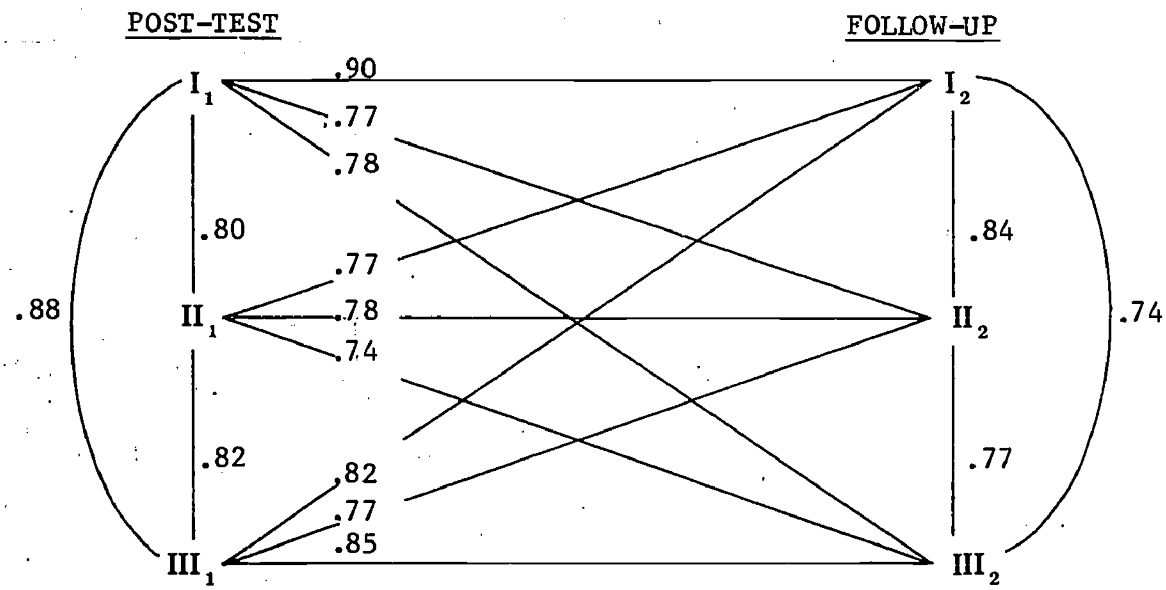
K^2_I = 1.09

K^2_{II} = 1.09

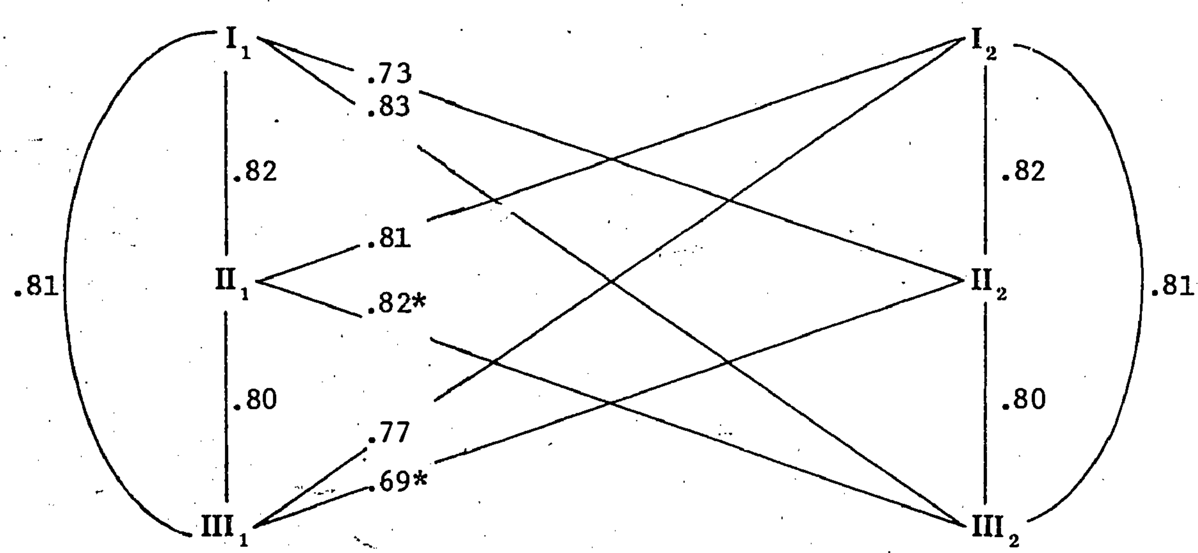
K^2_{III} = 1.53

CLPC Results of Math CTBS Factor-based Scales
for Treatment Students' Post- and Follow-up Scores

RAW



CORRECTED



* $Z = 1.67$, $p = .09$

$n = 38$

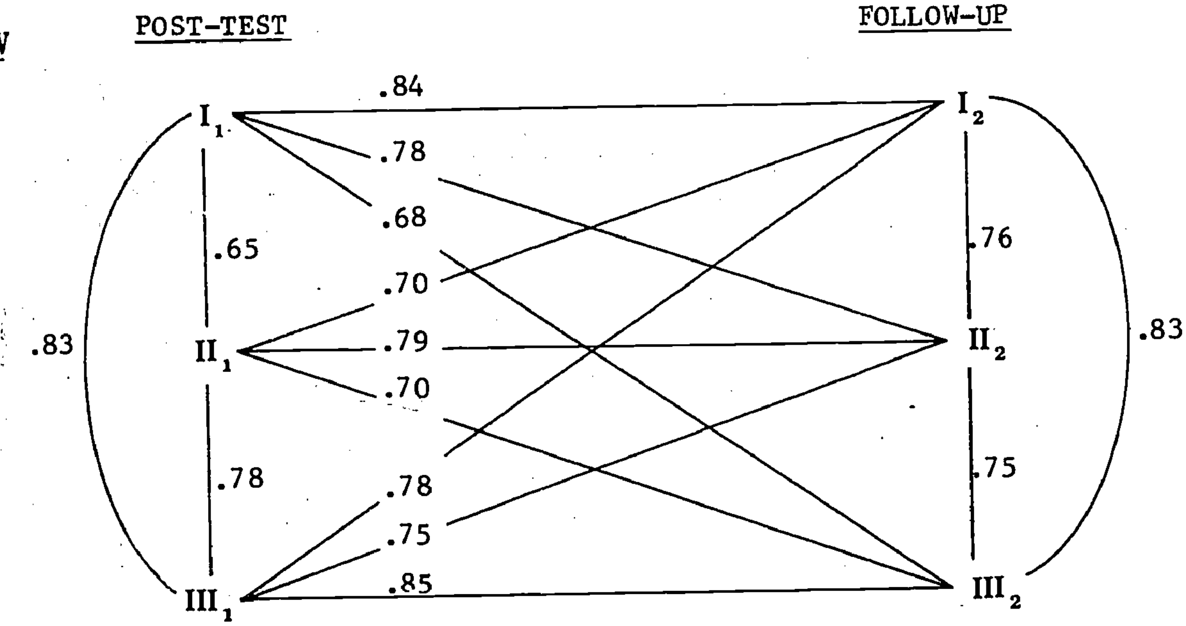
$K_I^2 = 0.96$

$K_{II}^2 = 1.15$

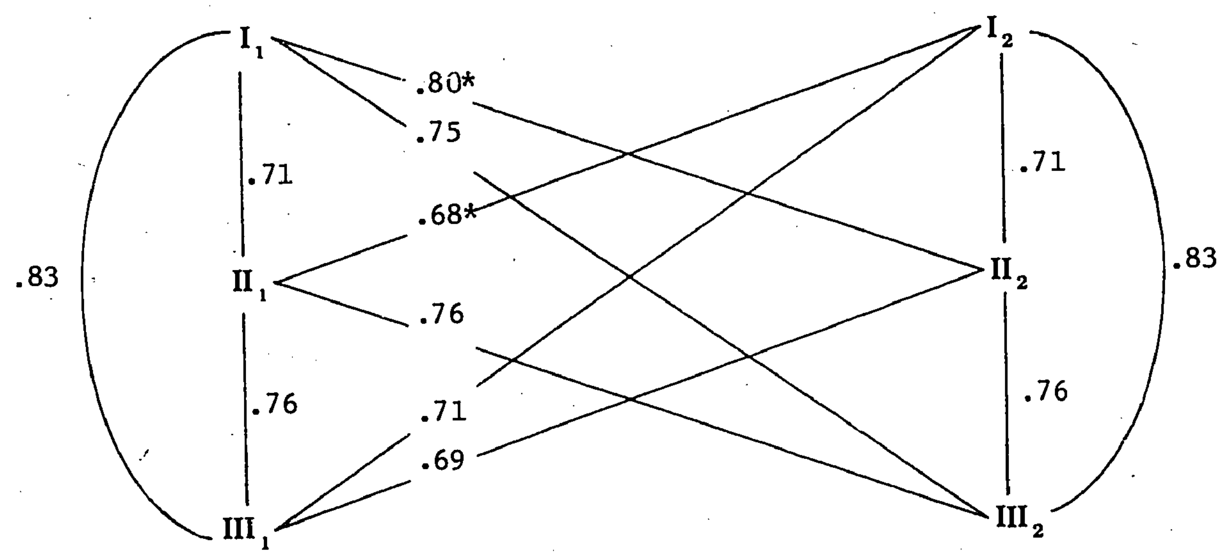
$K_{III}^2 = 0.75$

CLPC Results of Math CTBS Factor-based Scales
for Control Students' Post- and Follow-up Scores

RAW



CORRECTED

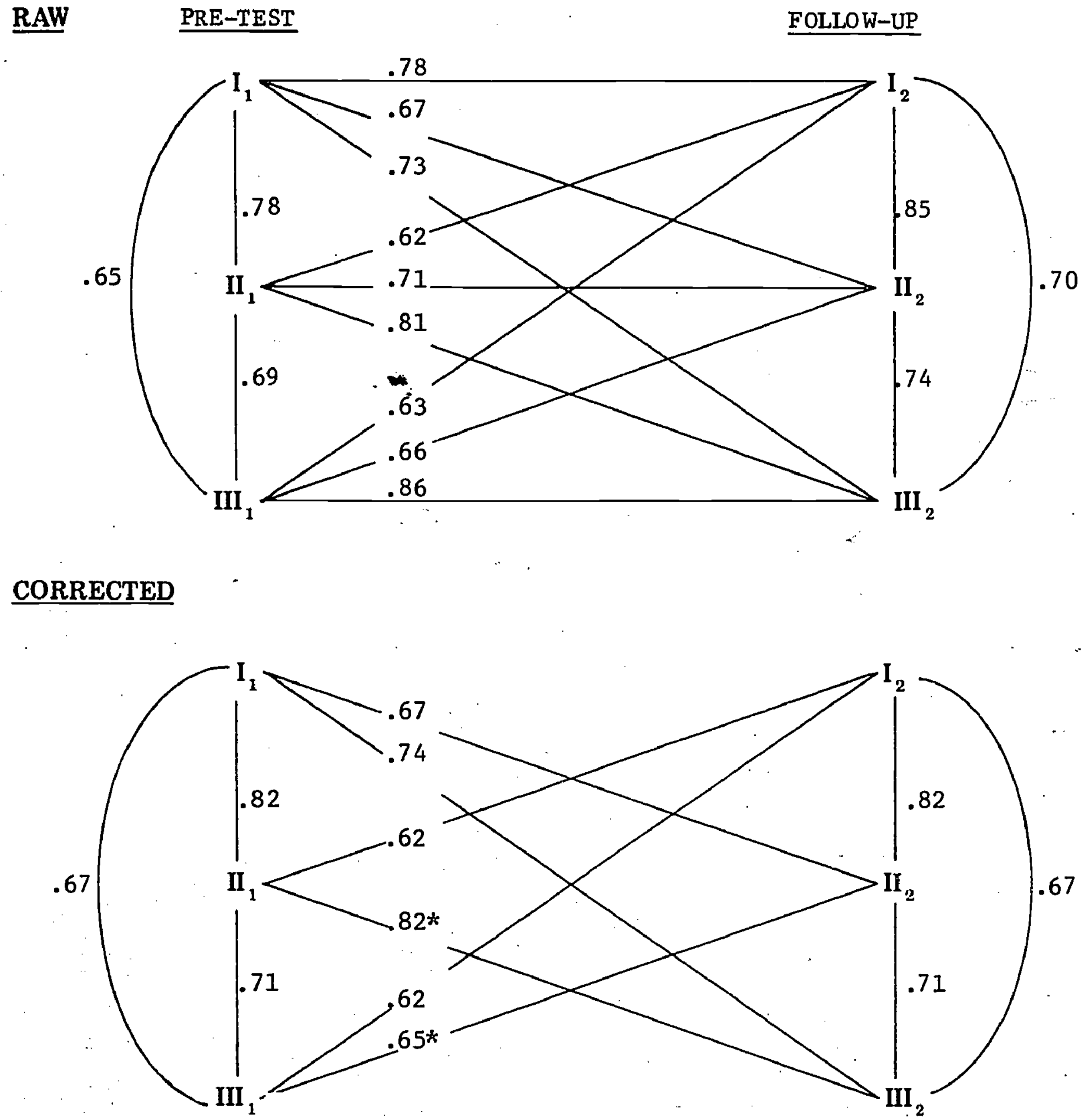


* Z = 1.28, p = .19

n = 28

$K_I^2 = 1.23$
$K_{II}^2 = 1.11$
$K_{III}^2 = 0.81$

CLPC Results of Math CTBS Factor-based Scales for Treatment Students' Pre- and Follow-up Scores



* $Z = 1.75$, $p = .08$

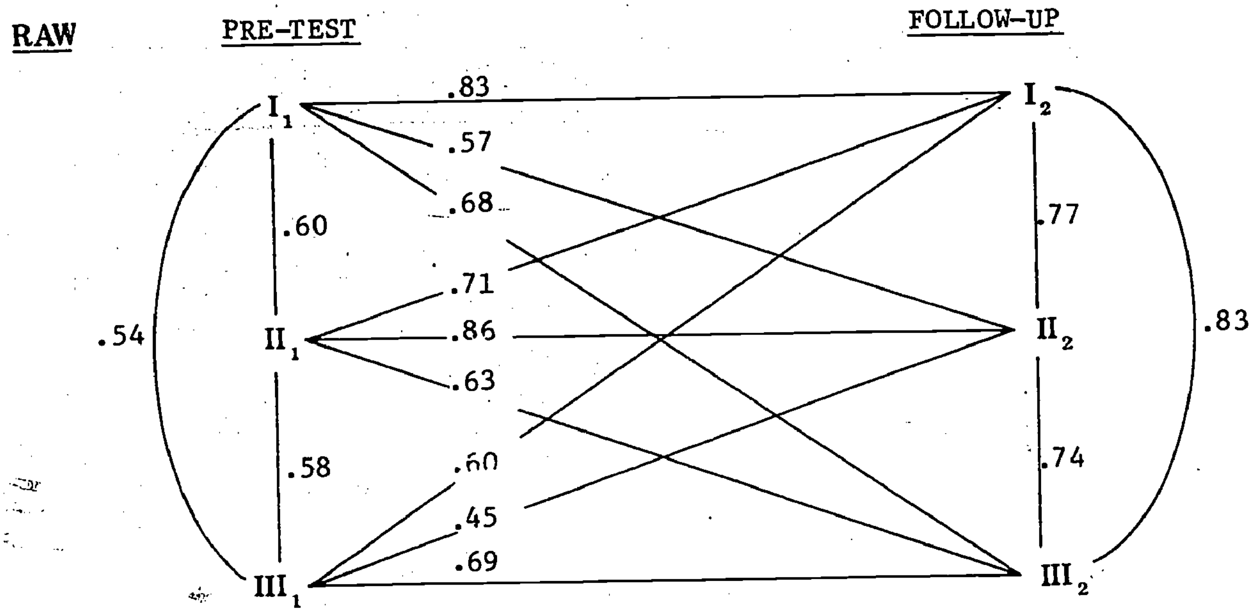
$n = 30$

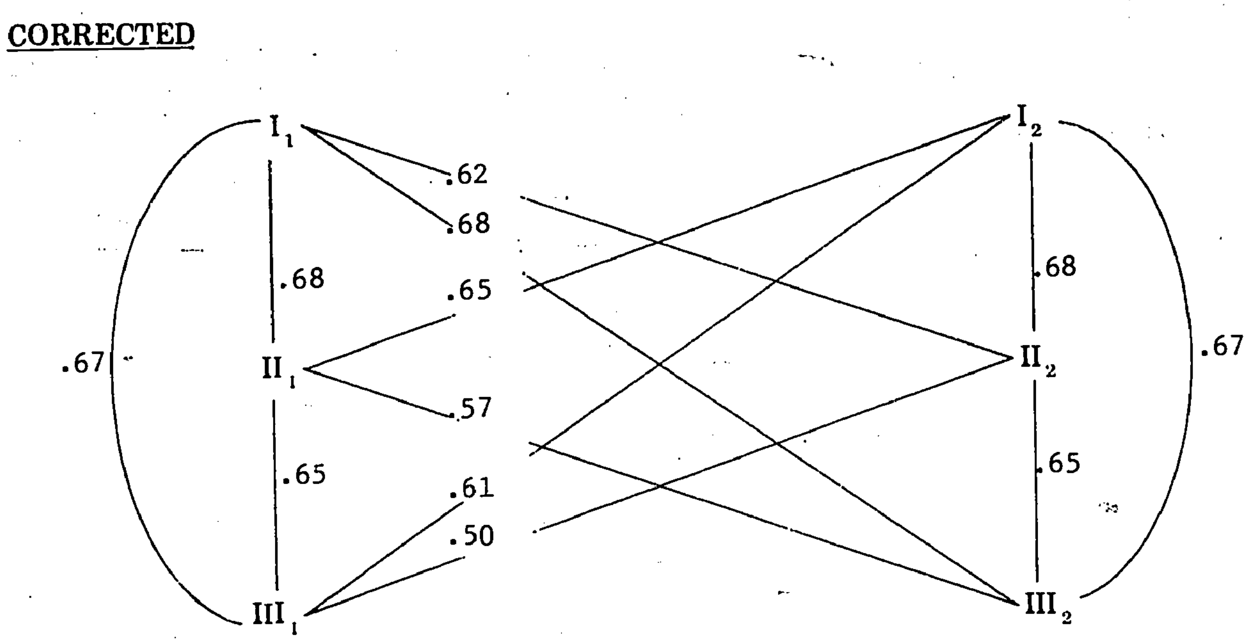
$K_{I}^{2} = 1.09$

$K_{II}^{2} = 1.09$

$K_{III}^{2} = 1.05$

CLPC Results of Math CTBS-based Scales for Control Students' Pre- and Follow-up Scores





n = 28

$K_I^2 = 1.52$

$K_{II}^2 = 1.06$

$K_{III}^2 = 1.56$

APPENDIX E

COMMISSIONED PAPER:
"RELATIONSHIPS BETWEEN DIDACTIC AND EXPERIENTIAL LEARNING"
BY DAVID P. AUSUBEL

Relationships Between Didactic and Experiential Learning*

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* Paper prepared for the Symposium on the Learning-in-Work Study of the National Center for Research in Vocational Education to be held at the National Institute of Education, Washington, D.C., October 17, 1980.

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Introduction: Historical Context of the Learning-in-Work Approach to the Acquisition and Retention of Knowledge

By way of introduction, it might be useful, in assessing, in attempting to explain, and in suggesting new perspectives for validating and extending the preliminary research findings of the Learning-in-Work Research Program of The National Center for Research in Vocational Education, to identify briefly the more significant trends in pedagogic theory and practice to which this research program is historically related. This is more than a mere academic exercise. For by placing this research in its historical context we can also hopefully identify the crucial variables involved in such learning, focus on, and take into consideration relevant available explanatory hypotheses, as well as generate psychologically tenable new hypotheses, and suggest new aspects of research strategy that profits from both the strengths and weaknesses of the research methodologies associated historically with these related psychoeducational movements.

First, it is important to recognize that experiential learning is indisputably based on the first pedagogic strategy evolved in the course of cultural evolution. Further, it is still very much alive today as a significant component of formal, vocational, and professional education. In such professions as medicine, dentistry, law, accounting, nursing, teaching, social work, engineering, etc., the apprenticeship system of instruction not only originated first but also co-existed later with formal professional schools until relatively recently as an alternative means of entry into the profession. The importance of practical, naturalistic experience in formal, traditional schooling has also been recognized more recently in both college and high school work-study programs, in career-oriented education, and in ever-expanding internship programs in government, industry, and in various social agencies and institutions. A still more recent development has been the training of paraprofessionals in such areas as medicine, dentistry, nursing, and teaching that places relatively greater emphasis on the experiential as opposed to the formal theoretical aspects of training.

In all of these pedagogic developments involving the acquisition of manual, social, and intellectual work skills, perhaps the chief pedagogic problem has been the relationship between the traditional theoretical classroom component and the practical, experiential or naturalistic component in terms of relative emphasis, timing, proximateness of relevance, correlation, and transfer.

Closely related to vocational and professional education have been such educational movements as the "social utility" and "life adjustment." Apart from the philosophical dictum that the only knowledge worth acquiring is that which enhances adaptation to practical problems of living, the pedagogic rationale has been an emphasis on the presumed motivational advantages of clear and perceptible relevance to current problems of personal and social adjustment. The theme of relevance, of course, more recently became the battle cry of the student revolt in the late Sixties and early Seventies.

A third significant educational trend in experiential learning was the growth of the Progressive Education movement with its emphasis on "learning by doing" in "real-life" settings, on direct, concrete experience, on incidental or non-deliberate learning, on student participation in educational planning and evaluation, on the existing interests and endogenous motivation of pupils, on autonomous discovery and problem-solving, on student-centered teaching, and on the avoidance of contrived or structured practice and drill. Many of these ideas were borrowed from or were elaborations on the original predeterministic notions of child development advanced by such educational philosophers as Rousseau, Froebel, and Pestalozzi. The original project and activity approaches of Progressive Education were the forerunners of such later movements as learning by discovery; "process," inquiry, and "heuristics of discovery" approaches to science education; and "teaching for creativity and independent thinking."

The principal pedagogic difficulties generated by these various movements stemming from Progressive Education were the unwarranted identification of meaningful learning with self-discovery and direct, concrete experience; the confounding of the rote-meaningful and reception-discovery dimensions of learning; the unwarranted and gratuitous stigmatizing of expository instruction as both necessarily leading to rote learning and as authoritarian; the unrealistic denigration of structured and contrived learning experience, practice, and non-endogenous interests and motivations; and the neglect of the facilitating and integrative influence of abstract verbal concepts and principles in the acquisition and retention of knowledge and in problem-solving.

The Fifties and early Sixties of this century were the heyday of the curriculum reform movements, particularly in mathematics and the natural sciences. These curriculum movements emphasized, for the first time in thirty years, that a given discipline consists of a hierarchically organized body of knowledge; that certain key explanatory ideas have organizing and integrative properties in effectively transmitting this body of knowledge to pupils; and that the subject-matter content taught to pupils must reflect the most valid, up-to-date, and cogent thought prevailing in the discipline (Bruner, 1960; Finlay, 1959, 1960).

The curriculum reform movements foundered, however, because the relationship between didactic and experiential instruction was still not adequately understood (undue emphasis was still placed on the role of autonomous problem-solving or discovery and of direct, concrete experience in meaningful learning and retention); because they were not based on pedagogic principles derived from a comprehensive and self-consistent theory of meaningful learning and retention; because their subject matter materials were overly difficult and complex, due to insufficient pretesting for learnability and inattention to the presence of necessary background knowledge in pupils' existing cognitive structures; and because the effectiveness of the programs were inadequately evaluated and validated (for reasons to be discussed below).

Concomitantly with the rise and fall of the curricular reform movements, but completely ignored by them, a cognitive theory of meaningful learning and retention (Ausubel, 1958, 1960, 1963, 1968; Ausubel, Robbins and Blake, 1957) was being evolved which specified the nature and conditions of meaningful learning and retention as processes distinct from their rote counterparts; clearly differentiated between the orthogonal rote-meaningful and reception-discovery dimensions of learning; specified the cognitive structure and other cognitive (i.e., practice, instructional material, level of intellectual development, and intellectual ability, cognitive style), social, motivational, and affective variables influencing meaningful learning and retention; developed general pedagogic principles (e.g., progressive differentiation, integrative reconciliation) consistent with this theory and pedagogic devices (e.g., advance organizers) consistent with the principles; specified the relationship between the respective didactic and experiential aspects and roles of learning for different grade levels, levels of subject matter sophistication, and levels of professional or vocational objectives; and differentiated between the major categories of meaningful learning (representational, concept, propositional).

Lastly, experiential learning was significantly influenced by the individualized instruction movement which recognized the importance of taking into account individual differences in general, as well as more specific and immediately prior, cognitive structure, intellectual ability, cognitive style, motivational, personality, affective, and social variables in the programming, sequencing, and pacing of learning experience. The possibility of handling the complex logistics of individualized learning experience for these multiple variables first became realistically realizable with the development of sophisticated and economically feasible computer-assisted instructional technology and with the growing acceptance of the evaluation and measurement concepts of "mastery learning" and criterion-referenced measures.

Theoretical Aspects of the Relationships between Didactic and Experiential Learning

In discussing relationships between didactic and experiential learning, it is important at the outset to distinguish between two kinds of knowledge that can be learned both didactically and experientially, namely, (1) "applied" knowledge that has more or less immediate practical relevance and applicability to the world of work (i.e., vocational and professional knowledge) and (2) "pure" knowledge which is acquired as an end in itself just for the sake of knowing or better understanding personally significant physical, biological, behavioral, and social phenomena in one's environment.

Naturally these two kinds of knowledge are not dichotomous. Much "pure" knowledge, for example, ultimately has relevance for and applicability to practical mechanical, biological, educational, and social problems. However, the original motivation and intent for its discovery or learning are not necessarily utilitarian; and its applicability to or relevance for such problems is more remote, thus requiring the consideration of additional variables relative to the particular problem situation and objective in question; the generation of new theoretical principles at an applied level of generality and relevance; and the performance of additional research in the applied setting or framework. I am making this distinction explicit in order to emphasize that in this paper I am dealing only with applied knowledge intended to be learned and used in a vocational or professional context.

Reception-Discovery and Rote-Meaningful Dimensions of Learning

It is also necessary to point out explicitly that just as pure, as well as applied, knowledge can be acquired in experiential settings, such settings include both discovery and reception learning, each of which, in turn, may be rote or meaningful depending on the conditions under which the learning occurs. Both types of learning (i.e., reception and discovery) may be said to be meaningful (1) if the student employs a meaningful learning set (a disposition to relate new learning material nonarbitrarily and substantively (nonverbatimly) to his existing structure of knowledge) and (2) if the learning task itself is potentially meaningful [(a) if it itself can be nonarbitrarily (i.e., plausibly or sensibly) and substantively (i.e., nonverbatimly) related to any appropriate cognitive structure (i.e., manifests "logical meaning") and (b) if the particular learner's existing cognitive structure contains relevant anchoring ideas to which the new learning material can be so related.]

Thus, the acquisition of new meanings is an idiosyncratic product of the interaction between new logically meaningful material (e.g., subject matter) and relevant existing ideas in a particular learner's cognitive structure when the latter individual manifests a meaningful learning set. In reception learning the principal content of the material to be learned is presented to the learner in more or less final form and he needs only to integrate it into his cognitive structure for purposes of retention and transfer to new learning experience. In meaningful discovery learning on the other hand, the principal content of what is to be learned (i.e., a new successful problem-solving proposition) must first be discovered by transforming (applying, restructuring, reorganizing, reintegrating, analyzing, synthesizing) relevant background knowledge (previously acquired concepts, facts, and principles) in such a way as to constitute a means to the end specified in a problem-setting proposition. The disposition to discover an insightful means-end relationship constitutes the meaningful learning set in meaningful discovery learning or problem-solving. Once an acceptable problem-solving proposition is discovered, it is then internalized in precisely the same way as in reception learning.

Just as reception learning was stigmatized in the past as rote, by definition, discovery learning was similarly held to be meaningful by definition. Thus, for at least thirty years (approximately 1930-1960), mathematics and science at the high school, college, graduate, and professional school levels were taught almost exclusively by paper-and-pencil and laboratory problem-solving exercises, inasmuch as expository teaching and explication were axiomatically regarded as necessarily leading to rote learning outcomes, and problem-solving approaches were similarly regarded as necessarily leading to meaningful learning. The disastrous upshot of these pedagogic attitudes was that an entire generation of students "learned" science and mathematics by memorizing solutions to "type problems," by substituting specific numerical values for unknowns in memorized formulas and equations, and by performing "cookbook" laboratory exercises and manipulations of symbols without understanding what they were doing or why, and, hence, without acquiring any of the basic concept or propositional meanings in these disciplines (despite solving successfully an acceptable percentage of the test problems involving these concepts and principles).

Thus, although a certain minimal degree of problem-solving experience is obviously necessary for learning the methodology for a given discipline (i.e., for understanding how knowledge is discovered in that discipline) and also for learning how to deal with, and overcome, difficulties in the application of didactically acquired concepts and principles to practical vocational or professional problems, it obviously accomplishes neither objective unless the conditions of meaningful discovery learning are satisfied.

Further, problem-solving experience is much too time-consuming to be used as a primary means of learning the basic subject-matter content of any discipline, pure or applied. If students had to rediscover by themselves the major portion of the substantive content of a given discipline, they would obviously not have sufficient time to acquire more than just the rudimentary aspects of that discipline and, thus, would be incapable of solving even the relatively simple and routine practical vocational or professional problems involving the application of its theoretical content.

Two additional disadvantages of the discovery approach to acquiring the substantive concepts and principles of a given discipline, even under guided or contrived discovery conditions, are (1) that it requires greater intellectual ability to rediscover these concepts and principles than to understand them in a reception learning context and (2) that, in any case, even those students who are capable of such rediscovery require much more time to do so than would be the case if this substantive content were presented to them. It is evident, therefore, that inasmuch as abstract and general knowledge can be applied only if and after it is discovered, fewer students will have such knowledge available to apply, and only after varying periods of discovery time have elapsed, in comparison to their fellows who are exposed to effective expository instruction. The latter students, therefore, can acquire a much larger total body of abstract knowledge relevant for application to problem-solving situations in an equivalent period of instructional time. A much larger proportion of these students are also successful in acquiring such knowledge; and this knowledge, additionally, is available for application much sooner.

Relative Transferability of Substantive and Procedural Knowledge

Even if discovery enthusiasts concede the greater efficacy of reception vis-a-vis discovery learning for acquiring the abstract, substantive content of a discipline, they are prone to insist that procedural knowledge, or knowledge of how to solve problems or how to discover new knowledge, gained through problem-solving experience, is more significant for solving the practical, vocational, or professional problems in an applied discipline than is relevant, substantive knowledge. This point of view has spawned such approaches to science education as "process," "inquiry," "heuristics of discovery," and "junior scientist" models.

The rapid rate of obsolescence in science is also often offered as a rationale for these latter approaches. Since the content of what is taught today will be obsolescent in fifteen years, the argument runs, students should be taught the process rather than the content of science. Actually, the rate of obsolescence in science is grossly exaggerated. Although the specifics of science do change rapidly, basic principles tend to manifest impressive longevity; and it is more the case that their validity is not negated or superseded by, but rather subsumed under, new and more inclusive or sophisticated conceptualizations.

This argument is also strikingly reminiscent of the objection small boys frequently offer to washing their faces daily, namely, that they will only get dirty the next day. Obsolescence of knowledge is a fact of life that must always be kept in mind, but this does not render futile the assimilation of the current content of knowledge or counsel exclusive attention to the process whereby knowledge is discovered. As will be pointed out below, the availability in learners' cognitive structures of broad, over-arching explanatory concepts and principles in a given discipline is the most important single variable determining the outcome of both meaningful reception and meaningful discovery learning.

A related argument in this context invokes the allegedly rapid rate of forgetting of school learning. Actually, however, when potentially meaningful subject-matter is optimally programmed in accordance with such pedagogic principles as progressive differentiation, integrative reconciliation, sequential dependency, differential practice schedules, overlearning, consolidation, individualization of instruction, immediate and explanatory corrective feedback proximateness of relevance, etc., meaningful reception learning in classroom settings, contrary to prevailing educational opinion, exhibits impressive longevity--even over a period of years (Tyler, 1930, 1934; Ward and Davis, 1938). Further, both these long-term classroom studies, as well as more traditional laboratory-type research (e.g., Meyer and McConkie, 1973; Mandler and Johnson, 1977; Brown and Smiley, 1977) indicate that the relative memorial longevity of concepts in meaningful text tends to vary positively as a function of their relative salience and level of abstraction.

An important line of research investigation (e.g., Ring and Novak, 1971; Saugstad, 1955) has demonstrated that in solving less novel and less difficult application problems, the degree of prior problem-solving experience per se contributes much less to variance in problem-solving outcome than does the availability, clarity, and stability in cognitive structure of the particular concepts and principles that are relevant for the solution of the problem in question. Apart from certain general intra-disciplinary problem-solving capabilities, such as facility in hypothesis formulation and testing, in the general strategy of efficient application, in identifying fruitful approaches that minimize costly risk and unnecessary cognitive strain, in using systematic and economic methods of inquiry, and in maintaining a flexible and meaningful learning set, general training in problem-solving approaches or strategies manifests relatively little generality over different intra-disciplinary problem categories (Crutchfield, 1966; Parnes and Meadow, 1959), in addition to being discipline-specific. Typically, it also exhibits the circumscribed intra-problem learning-to-learn transfer effects characteristic of Harlow's (1949) original research on discrimination problem-solving.

Additional supportive evidence of the powerful transfer effects of abstract verbal knowledge on problem-solving, even in motor, perceptual, and puzzle-type problems, is provided by such transfer studies as French (1954), Hendrickson and Schroeder (1941), Hilgard et al. (1953), Judd (1902), Katona (1940), Overing and Travers (1966), and Scandura (1966). It should also be appreciated that since some general effects of problem-solving experience listed above are transferable within a given discipline, knowledge of scientific method acquired through discovery experience with one class of problems is generalizable to other intradisciplinary problem areas. Knowledge of scientific method, therefore, need not be acquired from problem-solving experience with every substantive concept and principle within a discipline. It can be transferred not only from verbally expressed methodological generalizations derived from prior laboratory experience but also from the exposition of purely presented methodological principles as well.

With respect to the application of non-experientially or didactically-acquired classroom knowledge, however, whether substantive or methodological, even though such principles are highly transferable to particular classes of practical vocational problems, the capability of handling a given problem class efficiently is greatly enhanced by intensive problem-solving experiences in coping with its distinctive features in an applied setting.

In the case of more difficult and novel problems that are not ordinarily susceptible to simple application or to limited modification of relevant substantive and methodological content in cognitive structure by means of rational thinking processes, a complex of such cognitive-personality traits as perseverance, resourcefulness, flexibility, originality, problem sensitivity, venturesomeness, and improvising ability appears to determine most of the variance in problem-solving outcome. Common experience indicates that such traits are relatively rare--as rare as talented practitioners in any vocational or professional area, both most likely generally determined, for the most part, and not very teachable. For example, there are very few genuinely good diagnosticians in medicine who can cope successfully with the rare non-garden variety of diagnostic.

problems. These relatively rare individuals--perhaps one physician in a thousand--are also identifiable quite early in their medical careers, before they have had a great deal of clinical experience. Their colleagues who lack these traits, on the other hand, do not improve appreciably in diagnostic ability over the years, irrespective of how much experience, instruction, and supervision they may have in diagnosis. Clinical experience, or instruction, in other words is a minimally necessary but not a very significant or sufficient factor in producing good diagnosticians in medicine.

Thus, for both the less and more difficult variety of vocational or professional problem-solving, it seems to make more sense, in terms of transferability to problem-solving ability, for the school to focus on the more efficient and meaningful transmission of subject-matter content that constitutes most of the raw material from which problem solutions are derived (by both the more mediocre and the more talented problem solver) than to concentrate on teaching problem-solving skills or traits that both are genically less generously distributed in the population and are also less teachable. And what is true about exceptional degrees of problem-solving capability is even more true about creativity--i.e., the discovery of uniquely significant and original new knowledge as opposed to the application of existing knowledge to particularly difficult practical problems requiring exceptional inferential, eliminative, analytic, or synthetic reasoning skills, in addition to the specific cognitive and personality traits mentioned above.

Natural ("Real Life," Experiential) versus Structured Settings

How important is it that substantive or procedural knowledge be acquired and practiced in natural ("real-life" or experiential) settings? Enthusiastic supporters of discovery learning, beginning with the Progressive Education or "Learning by Doing" school of thought, as we have already seen, take a rather extreme position on this issue, advocating (1) the use of unstructured and uncontrived learning situations; (2) direct kinds of experience, in a concrete manipulative sense; (3) unintentional or nondeliberate learning effort with respect to the component skills involved in a total performance context; (4) learning by autonomous, unguided discovery; and (5) exposure to diversified rather than repetitive experience. It is important at the outset, however, to point out that advocates of experiential or naturalistic learning need not necessarily take an all-or-none position on any of these five issues and that all possible degrees of didactic, classroom, or reception learning can be used successfully within the general framework of experiential or career-oriented education.

It is true, of course, (providing that all other factors are equal) that learning is enhanced when its relevance for later use is perceived as immediate and proximate; when practice, application feedback, and reinforcement are contemporaneous with learning and directly accompany the learning phase of component and homogeneous ideational elements rather than follow the completion of a total heterogeneous package of didactically transmitted content after an interval of months or years; and when the conditions of practice closely resemble the conditions under which the skill or knowledge in question will eventually be used. Such learning is also less likely to be monotonous or to be forgotten because of long intervals of disuse and is more likely to benefit from higher levels of personal interest (ego involvement) and motivation. Wholly natural settings, however, rarely provide the learning and practice conditions that are both necessary and optimal for efficient learning.

Generally speaking, it is only in the later stages of learning in vocational or professional education, after each component substantive and procedural skill has been mastered in structural practice sessions, that naturalistic "dress rehearsals" become feasible. In the first place, wholly naturalistic settings deprive the learner of the facilitative effects of abstract didactic knowledge (acquired rapidly through optimally organized reception learning) on the later learning of more highly differentiated substantive or procedural materials and on later problem-solving.

Second, uncontrived and unstructured (i.e., "real-life") learning experiences typically fail to include a sufficient number of properly spaced reviews and problem applications as well as adequate opportunity for differential corrective practice, clarification, and confirmation of particularly difficult components. Third, unstructured practice does not receive the benefit of skilled pedagogic selection, presentation, and organization of instructional materials; of careful sequencing, spacing, and gradation of difficulty; and of optimal balancing of intra-task repetition and intra- and inter-task variability. Fourth, most learning effort is enhanced by deliberate rather than incidental intention to learn.

Fifth, the important principle of initial simplification of difficult learning tasks for unsophisticated pupils runs counter to the doctrine of wholly naturalistic or unstructured learning. Exposing unsophisticated learners to all of the complexities of natural, "unarranged," data in the laboratory, or of subtle distinctions and qualifications in advanced instructional materials, is the surest way of confusing and overwhelming them. The use of artificial "crutches" and gradation of difficulty, the division of complex tasks into separate component units, and slowing down the rate of presentation are common forms of initial simplification of learning tasks.

Lastly, many features of experiential learning programs were based on the extrapolation to older children, adolescents, and adults of the proposition that the pre-school and primary school child perceive the world in relatively concrete and intuitive terms. It is true that the young child requires considerable direct experience with multiple tangible exemplars to formulate a concept and with many concrete instances of a given set of relationships, before he or she can comprehend abstract generalizations. Thus an attempt was made to teach factual information and intellectual skills through the medium of direct, manipulative experience in natural settings rather than through verbal expositions.

In older pupils, however, once a sufficient number of basic abstract concepts and transactional terms are acquired and once the skill of comprehending and manipulating abstractions without the benefit of concrete-empirical props is mastered in one or more subject matter areas, new concepts can be acquired from verbally presented definitions rather than from direct experience, and new propositions can also be understood without any reference to concrete exemplars of their component terms. At this stage of intellectual development, therefore, direct concrete experience is typically helpful only in the beginning phase of exposure to a completely new and unfamiliar discipline. Thus in the secondary school and beyond, it may be desirable to reverse both the sequential relationship and the relative proportions between abstract concepts and concrete data.

All of these considerations suggest that various combinations of didactic and experiential instruction will be more effective in professional and vocational education than reliance on purely experiential learning. Most of the first year or year and one-half of medical education, for example, might be spent in learning the more general, explanatory, and interprative concepts and principles of the basic medical sciences (such as anatomy, physiology, pathology, bacteriology, and pharmacology) with only illustrative reference to more detailed content in these fields; and as, pointed out above, such highly abstract, general, and salient ideas are highly resistive to forgetting. More specialized and highly differentiated details in these areas could then be profitably postponed until the student receives training in the specialized clinical areas of medicine. At this latter time he would not only be better able to appreciate their relevance for medical practice, and thus be more highly motivated to learn and retain them, but would also have less time and opportunity to forget them during the interim when no opportunity for application exists.

In addition, instead of learning the entire detailed content of each basic science in one total package and then applying individual segments piecemeal and haphazardly one or more years later, he would have the opportunity to apply each individual segment clinically as he learns it didactically, and, thus, simultaneously to receive immediate and proximate feedback after didactic instruction in each particular segment as he comes to it.

In training paraprofessionals, in contrast to professionals, greater relative emphasis would be placed on the experiential as opposed to the didactic component of instruction. For example, since a physician's assistant deals with less complex aspects of diagnosis and therapy than the physician himself, he/she has less need for high-level theoretical sophistication and needs only to learn those more general aspects of theory that are immediately and proximately relevant for relatively simple, practical considerations. It has been demonstrated, for example, that when a mere summary of the underlying physiology and pathology of the endocrinology of pubescence is presented immediately before the clinical disorders, the latter material is learned just as well as when a much more detailed discussion of the physiology and pathology of the endocrinology of pubescence is learned, reviewed, and consolidated by several weekly readings prior to the learning of the clinical materials (Ausubel and Youssef, 1966). Paraprofessionals in medicine can thus be trained much more rapidly than physicians by dispensing with much of the more tangential and less salient aspects of pre-medical and pre-clinical medical science education.

Explanation of Preliminary Findings of Learning-in-Work Research Program

The Importance of Long-Term Retention Measures

The methodological decision of the Center researchers to use a long-term retention dimension in ascertaining and evaluating the relative efficacy of experiential versus traditional classroom learning environments was extremely crucial because, as the researchers point out, the traditional pre-test/post-test control group design "may restrict the time required for differences to emerge" (Crowe and Harvey, 1980, p.7). Over short-term retention intervals, comparative test scores for the two groups are misleading because rote retention (e.g., short-term cramming) may be confounded with the meaningful retention that is more likely to be an outcome of experiential "hands on" learning, thereby obscuring one of the principal advantages of the latter approach to learning. Also, over the long haul, the artifactual test disadvantages for the learning-in-work group of using a test instrument designed to measure the learning outcomes of traditional classroom teaching are much more likely to be attenuated.

The methodological advantages of long-term retention designs, however, are in my opinion, largely negated in this context by the researchers' explanation of forgetting in terms of retroactive and proactive interference, principally the former, that tend to have explanatory value for rote rather than for the kinds of meaningful learning and retention that supposedly characterize experiential learning environments. A theory of meaningful learning as the acquisition of new meanings (resulting from the interaction between potentially meaningful material and relevant subsumers or anchoring ideas in cognitive structure), accounts for forgetting in terms of the gradual loss of dissociability of these new meanings from the more general and less qualified meaningful import of the more stable anchoring ideas that subsume them. The functional incorporation of these newly learned meanings into a network of relevant anchoring ideas in cognitive structure obviously tends to protect them from the proactive and retroactive interfering effects of similar but conflictive stimuli or responses that are so damaging in the rote learning and retention of discrete units of learning material because in the latter instance they are not nonarbitrarily and nonverbatimly relatable to relevant ideas in the learner's existing structure of knowledge.

Most research on forgetting[1] suggests that retroactive or proactive interference occurs in the forgetting of potentially meaningful learning material only when verbatim recall of the latter is required or when the learner employs a rote learning set. When it does occur in meaningful learning and retention, it is <u>not</u> a reflection of pairing similar stimuli with different responses--because students are not typically taught different answers to the same question in classroom learning--but rather because the interpolated or previously learned material engenders cognitive confusion, ambiguity, or loss of discriminability between the anchoring ideas and the new meanings derived from and stored in relation to them. In fact, interpolated material that enhances these latter effects tends to induce retroactive <u>facilitation</u> (Ausubel, Robbins, and Blake, 1957; Ausubel, Stager, and Gaite, 1968) despite the negative influence of similarity short of identity. We shall return to this problem later in discussing the retroactive interference explanation of the experimental findings.

Another theoretical difficulty in interpreting long-term measures of retention in experiential and other kinds of learning is the use of such notions as "long- and short-term memory" as explanatory rather than as the descriptive concepts they really are. These terms merely describe the temporal, limiting parameters and sequences involved in the processing and storage of information rather than explain the underlying psychological processes or mechanisms involved. Thus, for example, meaningful learning processes have much more explanatory value for long-term memory than vice versa.

Finally, we must consider the theoretical confusion engendered by using and differentiating between such phenomena as knowledge and comprehension in terms of Bloom's purely arbitrary and theoretically inconsistent taxonomy of educational objectives. By defining knowledge as simply "the recalling of factual information," the essential characteristic of knowledge as meaningfully acquired information is completely obscured; and in defining comprehension as "understanding information without relating it to other information," the very process underlying comprehension or understanding, namely, relating new potential meanings to already existing knowledge in some sensible fashion, is similarly ignored, as well as the distinction between understanding <u>previously</u> acquired (perception) and <u>new</u> meanings (cognitive learning).

Meaningful retention scores can also <u>never</u> exceed learning scores (except for the phenomenon of reminiscence occurring within several days following immediate testing for meaningful learning) in the absence of intervening practice, transfer, or rehearsal. For this reason the occurrence of an <u>increasing</u> slope of the retention curve in the learning-in-work group, immersed in a similarly interfering work environment over the summer recess (when no active efforts were made to integrate the summer work experience with subject matter knowledge), suggests that it may be artifactual, i.e., reflective of sampling, experimental or test error. This is especially true when we consider (1) that this same work experience during the academic year, accompanied by concomitant integration with school knowledge in mathematics, yields a learning curve with a <u>negative</u> slope and (2) that there is no difference between the "math" and "no math" subgroups with respect to this declining learning curve, as there should have been if retroactive interference were operative during the learning period.

Additionally, interpreting meaningful versus rote learning curves, it is necessary to appreciate that the superiority of meaningful over rote retention is not simply due to the fact that, as the Center researchers suggest, "there is more information available to retrieve, since meaningful material is learned better originally" (Crowe and Harvey, 1980, p.35). Unlike the occurrence of superior <u>rote</u> retention under conditions of superior rote learning, where <u>all</u> of the increased retention is attributable to the increased learning (Postman and Rau, 1957), the <u>same</u> conditions responsible for superior <u>meaningful</u> learning also continue to operate during the retention interval and, thus, to enhance retention <u>independently</u> of their effect on learning.

Hence, if such factors as greater meaningfulness or greater frequency, salience, and immediacy of feedback in the learning-in-work environment eventuate in greater learning, they will also independently induce greater retention as well, over and above that attributable to superior learning, with resulting divergence of the retention curves for the two learning environment groups, after completion of learning phase of the learning-retention curve.

The Retroactive Interference Explanation

It is theoretically and empirically improbable, in my opinion, both on the theoretical grounds considered above and in the face of the overall weight of the research evidence against a retroactive interference model of meaningful forgetting (at least with respect to the simpler stimulus generalization or stimulus or response competition versions of this model) that one can account for the findings of the Center study in terms of an R.I. paradigm of forgetting which is theoretically and empirically credible only in instances of rote learning and forgetting. The R.I. explanation also does not fit the implausible finding of an increasing slope of the retention curve over the summer recess for the learning-in-work group--even assuming the "unlearning," "integration," and "fading effects" of the interference of the rules for learning to learn in a work environment with the rules for learning to learn in a school environment (Crowe & Harvey, 1980, pp.138-41). The type of interference that is typically involved in an R.I. paradigm is reflective of similarity of stimulus or response content in simple and discrete S-S or S-R rote associations or of the perseveration of unadaptive learning sets in apparently similar but nevertheless conflicting problem situations.

It therefore seems somewhat far-fetched to suppose that mere shifting from the rules of learning to learn in a school environment to corresponding rules in a work environment would generate sufficient interference to result in impaired responses to test items designed to measure learning in the former environment. This is especially the case when one considers the compensatory advantages in meaningfulness and in the various dimensions of reinforcement through feedback provided by the work environment. At the very most one might reasonably anticipate a relatively slower rate of learning as a result of the shift in the learning environment rather than an apparent decrement in learning score. Seemingly more plausible explanations, therefore, would be (1) the anologically relatively poorer scores to be expected of students enrolled in one of the new mathematics or science curricula[2] on tests designed to measure knowledge of the traditional curriculum (i.e., test disadvantage) and (2) the artifactually higher scores that are possible on a rote memory basis (over a short retention interval) when the same traditional measuring instruments are used to measure learning outcomes for students continuing to learn in a traditional as opposed to those who are shifted to a new and unfamiliar learning environment. This would explain both the artifactually higher learning scores of the traditional group over the short learning (cramming)-testing interval in May as well as the actual steeper decrement in retention for this same traditional group over the long summer recess retention interval. The test disadvantage explanation, however, could not account for the increasing slope of the retention curve in the learning-in-work group, because the same test disadvantage applies in the post-summer follow-up test as in the May post-test.

However, the inadequacy of the test disadvantage explanation of the latter finding is discounted somewhat by the strong possibility that it is reflective of error, rather than genuine treatment variance, and would probably not be replicated with a larger and more representative sample and under better-controlled experimental conditions. As pointed out above, the maximum effect that could be theoretically expected from a continuing learning-in-work environment is a more gradually declining retention curve, vis-a-vis the traditional learning groups, rather than an apparent increase in retention after the long summer recess interval during which no obvious practice, rehearsal, or transfer effects are operative.

Greater Meaningfulness and More Effective Reinforcement of Learning-in-Work Environment

As indicated earlier, learning-in-work environments are more likely to result in meaningful learning and retention for several reasons. Most important, the very fact that the knowledge is acquired in relation to particular, naturalistic problem-solving situations and is also performed "hands on" invests the learning with both greater proximate relevance and vividness. Such learnings are also easier to learn because the problem situation provides immediate, perceptible exemplification of the concepts or principles involved.

As emphasized above, although actual application is both necessary and helpful in learning to apply didactically acquired knowledge in "real life" vocational situations and is probably more meaningful when acquired in such learning environments, this explanatory generalization must be qualified by at least three important considerations. First, it does not imply that the didactic knowledge itself, that is, the knowledge to be applied, must necessarily be the product of either autonomous discovery learning or of inductive problem-solving experience. Even within the general context of a learning-in-work environment, the underlying concepts and principles can be taught most effectively by expository teaching methods and acquired most efficiently through meaningful reception learning. In practice, this consideration is followed by most vocational training programs, both civilian and military, including the Center learning study. That is, classroom instruction is utilized as an integral part of the general experiential learning setting. Research[3] has also shown that a guided discovery approach is more successful in applying general principles to particular problems than either completely autonomous discovery or completely guided problem solving.

Second, educators in learning-in-work settings must be disabused of the deeply rooted belief in our educational folk lore that practical problem-solving experience in an experiential learning environment necessarily and inevitably leads to meaningful learning and retention. Actually it is quite commonly the case that on-the-job trainees simply imitate their preceptors blindly or memorize procedural steps in problem solving without having the faintest idea of what they are doing and why. Such experiential problem-solving experience is obviously just as rote as rote memorization of scientific formulas or of geometrical theorems, without understanding the principles involved, and is equally not transferable either to related problems or even to the same problem couched in slightly different language. What over-enthusiastic proponents of "learning by doing" apparently overlook is that one does not learn anything by doing unless one understands what one is doing and why.

Still a third misconception, often attributed to John Dewey, but actually advanced and popularized by some of his more overzealous disciples, is the notion that knowledge gained through direct exposure to <u>concrete</u> experience is invariably more meaningful and transferable than when acquired through <u>abstract</u> verbal instruction in the classroom. This idea may often be true, but for reasons that have nothing to do with the abstractness or concreteness of the learning experience <u>per se</u>, once learners have either developed generally beyond the concrete stage of logical operations or, if generally beyond this stage, are no longer confronted by the initial task of learning the vocabulary of an entirely new discipline. It is rather a reflection of the fact that knowledge acquired in "real-life" learning environments has greater proximate, immediate, perceptible, and personalized relevance than the same knowledge acquired in a classroom, is typically more individualized, and also does not need to be transferred to the context in which it will ultimately be used. Counterbalancing these advantages, however, are such factors as the fact that structured classroom learning can profit more from initial simplification and progressive gradation in difficulty as well as from skillful pedagogic programming, sequencing, pacing, and consolidation, and is also typically characterized by more systematic and differential practice schedules.

Reinforcement interpretations of the greater learning and retention to be expected in learning-in-work situations are probably valid insofar as they invoke such dimensions of reinforcement (feedback) as frequency, immediacy, completeness, relevance, vividness, and individualization. We have already discounted the importance of the abstract-concrete dimension. In addition, reinforcement is probably more effective when provided immediately through application experience after each component segment of a course or curriculum than when all didactic instruction is given first in one large block of time comprising months or years and is then followed by practical application in "real-life" situations in a comparably large block of time, as is typically the case in such professions as medicine, dentistry, law, etc. All of the reinforcement dimensions of frequency, immediacy, and proximateness of relevance favor the latter experiential over the former traditional type of professional education. Furthermore, the former organization of the curriculum provides greater motivation to learn and less forgetting when the practical relevance of each didactic segment for professional practice is perceived and applied immediately than when practical naturalistic experience is mostly provided after the completion of all preclinical courses. For this reason we have advocated the deferral of all detailed, anatomical, physiological, pathological, and pharmacological instruction in medical schools until such time as relevant clinical specialty courses and actual naturalistic problem-solving experiences are provided (Ausubel, 1980).

From a theoretical standpoint it is also important to recognize that reinforcement in meaningful learning and retention does not operate in accordance with the law of effect, whereby the (habit) strength or probability of recurrence of a response (instrumental or rote) to a particular stimulus, or simply of an emitted response, is a function of the satisfying consequences of the response in question. Knowledge of results, or the effectiveness of feedback regarding the success or failure of the learning effort, serves as cognitive reinforcement (by providing confirmation, clarification, and correction) and also enhances the existing motivation energizing this effort (i.e., by increasing attention, self-confidence, perseverance, etc.).

Even in instrumental, operant, and rote learning, the habit or availability strength explanation of reinforcement is not very convincing. More credible, and also more congruent with innately (genically) determined hierarchies of probabilities of instrumental responses when a given drive state is operative, is the explanation that reinforcement, under instrumental or rote learning conditions, increases acquired response probability by lowering response or perceptual thresholds rather than by increasing habit or availability strength. This explanation is also more consistent with fluctuations in response probability in the opposite direction (repression, blocking, or response competition and "learning shock"); with such disinhibition phenomena as reminiscence and increased recall under hypnosis; and with the differential availability of rote or anecdotal memories in recognition versus recall criteria of retention (Ausubel, 1968, pp.104-05; 384-86; 391-93).

In meaningful learning and retention, however, since new meanings are invariably part of a larger subsystem of ideas in the learner's structure of knowledge, rather than discrete and isolated S-R connections, it is theoretically improbable, as well as empirically undemonstrable, that satisfying effects of feedback can lower thresholds of availability. It is much more likely that motivational and effective factors (anxiety or guilt; negative attitudinal bias) negatively influence the retrieval of learned meanings by raising thresholds of availability (repression) than that positive attitudinal bias lowers thresholds of availability. Meaningful retention, as pointed out above, is also influenced by the same cognitive structure variables that influence meaningful learning and then continue to affect retention in the same direction during the retention interval.

Finally, it seems theoretically unwarranted, in my opinion, to suppose that the perception of greater task complexity or of greater internal versus external control by members of the learning-in-work group is reflective of higher intrinsic motivation. Intrinsic motivation, by definition, connotes motivation to learn as an end in itself, i.e., for the satisfaction of knowing, understanding, or being able to master the challenge of problem situations rather than for some utilitarian, career-oriented, or ego-enhancing purpose. Hence, there is no good reason for believing that learning by problem solving for career-oriented purposes in an experiential, naturalistic setting is inherently any more intrinsically motivated or any less energized by ego-enhancement considerations than rote or meaningful reception learning for the purpose of obtaining high grades in a traditional classroom setting. In both cases the type of motivation--intrinsic or extrinsic--that is primarily operative can only be ascertained by motivational and personality analysis of the particular learner in the particular learning environment rather than by formal membership in a particular learning environment group or by the reception versus the discovery approach to learning used in that learning environment.

Suggested Changes in Research Design and Objectives

Apart from such obvious methodological changes as increasing the size and representativeness of the sample, random assignment of subjects to experimental and control groups, and eliminating or counterbalancing, as far as possible, test disadvantage for both groups, perhaps the two most important changes that are required in research design are (1) overcoming the massive Hawthorne effect and (2) avoiding the imprecision and ambiguity inherent in constituting experimental and control groups in terms of such global and unspecifiable terms as "traditional" and "learning-in-work." Not only are these latter criteria vague and susceptible to almost infinite variability, but the precise independent variables responsible for obtained differences between the two groups in learning and retention outcomes are also neither specified nor controlled and their relative contributions to the differences in outcomes are indeterminable. It will be recalled that the curriculum reform movements largely foundered for similar irremediable defects in measurement and evaluation involving (1) identification of the large number of independent variables involved and their respective indeterminable relative effects on learning and retention outcomes and (2) the virtual impossibility of controlling for the massive Hawthorne effect under such experimental circumstances. Both difficulties could be simultaneously overcome, in my opinion, by adopting a multivariate instead of a global and unspecified experimental-control group research design.

Such a multivariate research design would presumably be capable of identifying and measuring precisely both the learning and retention effects attributable to a host of independent variables and the various interactions between them, as well as of differentiating between different levels of learning, retention, transfer, and problem-solving outcomes appropriate for vocational, paraprofessional, and professional training, respectively. In no other way, also, would it be possible to control for such highly conspicuous Hawthorne effects resulting from the use of a learning-in-work versus a traditional classroom research design.

In very brief outline form, the following main categories of independent variables should be systematically varied in different multivariate research design studies: (1) <u>Cognitive Structure</u>: availability, proximateness of relevance, clarity, stability, and discriminability of anchoring ideas; use of expository and comparative advance organizers; progressive differentiation, integrative reconciliation, sequential dependency, and consolidation in programming subject matter; availability of relevant background ideas in students' cognitive structures versus teaching of problem-solving strategies in both "application" and "reorganization of background knowledge" types of problem solving; level of total subject matter sophistication; cohesiveness and integrativeness of subject matter in learner's structure of knowledge. (2) Aptitude: general intelligence; primary mental abilities; dimensions of cognitive style affecting both reception and discovery learning (e.g., particularizing-generalizing trends, divergent versus convergent thinking ability, integrativeness versus compartmentalization of knowledge, preference for complexity versus simplicity), cognitive and personality determinants of creativity. (3) Motivational: intrinsic versus extrinsic; task-oriented versus ego-oriented; cognitive drive; affiliative drive; level of achievement motivation. (4) Personality: satellizer versus non-satellizer; dogmatism; closed- versus openmindness; tolerance for ambiguity; test and personality anxiety; locus of control; inner- versus outer-directedness. (5) Overall developmental stage of cognitive functioning. (6) Task or Treatment Variables (practice and instructional materials): frequency of practice; distribution of practice; difficulty and quantity of learning material; pacing; individualization; linear versus differential practice schedules; mastery learning; learning set and warm-up variables; homogeneity versus heterogeneity of learning tasks; single-context versus multicontextual concept and rule learning; structured versus incidental learning; different mixes of didactic and experiential learning in terms of proportion, relative emphasis, sequency, whole versus part didactic-application strategy; naturalistic versus contrived learning settings; transfer versus direct practice; verbalization of insight; abstract versus concrete exemplification of concepts and principles. (7) Reinforcement: completeness, frequency, immediacy, invariable versus intermittent; corrective versus confirmatory. This listing, of course, is intended to be illustrative rather than exhaustive in nature.

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Footnotes

1 For a review of studies in this area see Ausubel (1968 pp.115-18; 1977, pp.171-72).

2 For references demonstrating lower final post-test scores for students enrolled in new mathematics or science curricula on tests measuring knowledge of the traditional curriculum material and the opposite effect for students enrolled in traditional curricula on post-tests measuring knowledge of the new curriculum content, see Ausubel (1968 pp.357-58). The latter effect, of course, is largely just as reflective of test disadvantage for the traditionally instructed students as the former effect is reflective of test disadvantage for the innovatively instructed students (since, additionally, there is strong reason to believe that much of the material in these new curricula were rotely rather than meaningfully learned because it was too difficult in terms of the students' existing degree of subject-matter sophistication latter explanation. This would be somewhat more true, for example, of the BSCS (Ausubel, 1966) than of the PSC (Finlay, 1959, 1960) or UICSM (Beberman, 1958) curricula.

3 For a summary of research in this area see Ausubel (1968, pp.302-05).

APPENDIX F

COMMISSIONED PAPER:
"AN ANALYSIS OF RETENTION OF CONCEPTS RESULTING FROM LEARNING BY EXPERIENCE"
BY HENRY C. ELLIS

An Analysis of Retention of Concepts Resulting from Learning by Experience

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Paper presented at National Institute of Education Conference, National Center for Research in Vocational Education held at the American Council on Education, October 17, 1980, Washington, D.C.

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This paper is an examination of the report entitled Retention of Concepts Resulting from Learning by Experience by M.R. Crow and R.J. Harvey. The approach of the paper is to critically examine the results and the theoretical model proposed to account for the findings, to examine proposed alternatives, to suggest new interpretations, to suggest new research possibilities, and to propose ways of improving the current research design.

Comments on Theoretical Interpretations: Interference

The principal surprising result of this study was the loss in math test performance over the nine months' instructional interval for the learning-in-work-environment students coupled with a gain in performance for this group over the three-months' retention interval. The modest loss in math test performance during the instructional interval is perhaps not too surprising; however, the gain in math performance during the retention interval does represent an anomaly and is certainly an unanticipated finding.

In contrast, the gain in math performance during the instructional period followed by forgetting during the retention interval is consistent with previous findings on traditional classroom groups.

The authors propose an interference/assimilation model to account for the anomalous findings. The basic issue is to interpret, consistently, the decrease in math test performance during the instructional interval and the increase during the retention interval for the learning-in-work-environment students. Retroactive interference is used to account for the loss during the instructional period. Here it is assumed that students in the learning-in-work environment were acquiring new skills and concepts (during instruction) which interfere with prior learning acquired in a traditional formal school environment. This interpretation is quite reasonable and logically follows from viewing the instructional sequence as a retroactive interference paradigm.

But this interpretation leaves out one important feature of this paradigm. It is also quite possible that the loss (forgetting) that occurs during the instructional interval is due to other more non-specific interference. The design does not have a control that is comparable to one found in the typical laboratory study of retroactive interference. Usually, a control group which learns some "unrelated task" is compared with the experimental (treatment) group. Thus any loss in performance can be actually attributed to the treatment itself. But a comparable control does not exist here, which can be appreciated by considering the following question: Specifically, what would happen to a hypothetical control group that engaged in some wholly unrelated activity during the retention interval? (Otherwise they are tested at all three times.) If they showed a loss comparable to the learning-in-work group, then the forgetting shown by the learning-in-work group could not be attributed to learning specific interfering rules or concepts.

Of course, it does not seem practical to have such a control. But it is important to consider this issue. If the presumed interference is more general and not specific to the features of the work environment, then research focusing only on specific interference could be misleading.

An alternative way to approach this issue is to make the radical assumption of <u>no interference</u>. Assume that the skills and knowledges learned in the learning-in-work environment have no interfering effects on prior school learning. In effect, assume that these represent two reasonably independent systems of skills and knowledges, and that they neither interfere nor aid each other. How then would one account for the loss in math performance of the learning-in-work group?

A reasonable candidate is simply that the learning-in-work students receive insufficient practice on their math skills to maintain the level of knowledge they had nine months earlier. Forgetting occurs but is not due to interference specific to the skills learned in the work environment.

I will add that I prefer the <u>specific interference</u> interpretation proposed in the report. However, I believe that it is important to consider and reject these alternatives before accepting the specific interference hypothesis. The point is that you would be ill-advised to pursue an extensive research program based on interference assumptions without considering the alternatives.

Finally, it might be worthwhile to consider designing a small-scale laboratory study of interference in learning math concepts using an analogue study. The basic design would first teach students some new math concepts, then split the students into three groups, one a control learning new math, the second an experimental group learning something like what the learning-in-work students learn, and a third learning some unrelated task, followed by a retention test of the initially learned math concepts. Unless you could demonstrate interference in this laboratory setting, you would have much less confidence in pursuing this interpretation. Offhand, I am unaware of any studies on interference in retention of math concepts but a survey of this literature may show some support.

Theoretical Interpretations: Assimilation

The second explanatory construct proposed is assimilation of information. The assumption is that during the summer retention interval the learning-in-work students assimilated the new rules and concepts learned during the instructional period with existing knowledge structures. This assimilation led to a new cognitive structure which provided for enhanced performance on the retention test.

This interpretation is intuitively appealing but is faced with at least two difficulties. First, the account is not terribly parsimonious. One could simply follow through with the retroactive interference argument, and use the fact that the amount of retroactive inhibition tends to decrease as the time interval between the second-task learning and the test of retention increases. Simply as an empirical finding (cf. Underwood, 1948), known to occur over short periods, this progressive decrease in retroactive interference would account for the improved performance on the retention test. Moreover, continued improvement at later testings would not necessarily support an assimilation argument. I have no objection to the assimilation argument per se, but it may not be necessary.

A second problem with the assimilation interpretation is the implicit assumption that it begins and/or is most active during the summer session. It is necessary to make this assumption to account for the pattern of learning/retention findings. But it could be argued that assimilation starts much earlier, maybe after two to five months of instruction. More generally, whenever one has to postulate two processes (in this case, interference and assimilation) which generate a U-shaped function, it is difficult to evaluate the interpretation. Unless one can independently specify when the process of assimilation begins, there is no way to predict with accuracy when retention should improve.

Criterion Task: The CTBS

As noted in the major report, the question of content validity of the CTBS may be seriously raised. The appropriateness of the test as an instrument for evaluating the effects of nontraditional learning can be questioned. The criterion issue is frequently complicated by other issues. If all educational innovation is to be evaluated by scholastic achievement tests, then one will frequently, I suspect, be unable to show much effect of novel educational environments. Alternative tests which sample problem-solving skills, ability to generalize to new situations, etc. may be more appropriate for evaluation purposes. At best I would suggest the use of several other measures beyond the CTBS.

Indeed, if there are genuine albeit subtle effects due to learning-in-work environments, it will be necessary to consider a range of instruments that might tap these effects.

Implications of Learning-in-Work Environments: Generation Effect and Variability Effect

In principle, there are several features of any idealized learning-in-work environment which should produce reasonable gains in achievement. The EBCE approach should benefit students for the reasons cited in the report, but it should also benefit students for at least two additional reasons.

There are two features of the EBCE program which are directly relevant to contemporary psychological research in human memory. One feature is that in the EBCE program students learn to generate many of their own solutions to problems. Recently, Slamecka and Graf (1978) have provided evidence for what they call the generation effect in recall. The basic finding in a series of experiments is that if subjects have to generate an answer rather than simply remember one, recall is substantially improved. Jacoby (1978) has presented similar findings. He reports that if subjects have to solve a problem rather than remember a solution, recall is enhanced. These findings appear consistent with the older notion of learning-by-discovery and it would appear that the opportunities for discovery learning are substantially greater in the learning-in-work environment.

It would appear that a fruitful approach would be to examine the EBCE program in detail to see to what extent generation or discovery principles are present. Moreover, these could be introduced as part of the program package. Because of the renewed interest in the generation effect in memory, I would recommend an examination of this process and that experimentation dealing with it be introduced in the EBCE program.

A second feature of the EBCE program is that it provides for a variety of experiences not found in the traditional classroom. Classic studies (e.g., Duncan, 1958; Morrisett and Hovland, 1959) have demonstrated the importance of task variety in both transfer and problem solving. In both studies, performance improved as a function of increased variation in the tasks. Recent studies have also shown the importance of stimulus variability in memory (cf., Dukes and Bevan, 1967; Ellis, Parente, and Walker, 1974; Ellis, Parente, Grah, and Spiering, 1975; Cosden, Ellis, and Feeney, 1979). In all of the studies by Ellis and his colleagues, subjects were presented with a perceptual grouping task consisting of letter strings which masked the meaningful structure of the material. (When properly grouped, the letters combined into words or sentences.) The letters were presented in constant or varied groupings, and subjects recalled the varied groupings more frequently. The superiority of varied input is known as the variability effect in recall. In other words, seeing the information to be remembered in varied fashion aided recall because subjects were more likely to chunk the information into meaningful groupings.

It would also appear fruitful to examine the EBCE program from the perspective of determining the range of varied tasks or stimuli present. In addition, it would be potentially useful to design a program with some predetermined built-in variability.

More generally, it is proposed that two basic elements, at least theoretically, of the EBCE program are opportunities for discovery and task or stimulus variation. Research designed to directly examine these two features in the context of learning-in-work environments should be potentially fruitful. If these elements are truly present, then benefits should result.

Implications of Learning-in-Work Environments: Depth of Processing and Cognitive Effort

Two fairly recent developments in human memory may have broad implications for this research. One is the depth of processing framework and the other is the notion of cognitive effort. An important idea in human memory is the depth or levels of processing concept. In its original form, the basic notion was based on the premise that a series of analyzers, varying along a continuum from structural to semantic analysis, is employed in processing an item for storage in memory (Craik and Lockhart, 1972). Expansion of this idea was later made by inclusion of elaboration and breadth of processing (Craik and Tulving, 1975) and distinctiveness (cf. Cermak and Craik, 1979). Although there are logical problems with the concept (e.g., Nelson, 1977; Baddeley, 1978), the notion may have some usefulness here. One possibility is that students in the learning-in-work environment fail to process the information they have learned at the same depth as the controls. Another is that more semantic conceptual processing occurs later during the summer period. (This latter is not unlike the assimilation construct.)

The other concept is cognitive effort. Recent studies have shown that retention of information is a function of the degree of cognitive effort present during study (Tyler, Hertel, McCallum, and Ellis, 1979; Eysenck and Eysenck, 1979). Tyler et al. define cognitive or mental effort as the amount of the available processing capacity of the limited-capacity central processor utilized in performing an information-processing task. Although the implications of this concept are not fully apparent, it is proposed that it be discussed by the panel. One possibility is that subjects in the learning-in-work do not process the material as intensely as the controls.

Implications of Learning-in-Work Environments: Individual Differences

The role of individual differences, while not neglected in this study, is an area which could be explored in greater depth. The domain of personality factors, cognitive styles, mood-emotional states, and motivational variables should be carefully considered in future research on learning-in-work settings. The use of any of these factors would serve the double advantage of increasing the precision of any experiment when used, say, as a levels factor, and would provide information in its own right. Renewed interest in individual differences is attested by the fact that the entire issue of the December 1979 issue of the Journal of Research in Personality was devoted to research on individual differences in human learning and memory (e.g., Battig, 1979; Cosden, Ellis, and Feeney, 1979; Eysenck, 1979; MacLeod, 1979; and Schwartz, 1979).

Instructional Considerations

The only point I wish to consider here is the instructional balance in the ECBE program. Is four days of in-work training and one day of classroom training the optimal balance? Would a two-three day combination (or some other) be better?

Transfer Considerations

Another way of viewing the research is to consider the learning sequences from the viewpoint of a transfer paradigm. This is not antithetical to interference considerations but represents merely another aspect of the sequence. Examination of figure 38 (p. 139) of the model will make this clear. Events A and B represent two successive tasks in which transfer effects of A to B may occur. Ten years of learning in a formal school environment (A) should continue to transfer positively to more of the same. In contrast, transfer to the activities in a work setting may be negligible or yield even negative effects.

I would like to discuss any possible implications of this perspective.

Design Considerations

In this section I will briefly comment on a few design considerations. The emphasis will be on how to improve research design for future studies.

1. The authors are aware that a basic problem in the design is that subjects in the EBCE conditions were not randomly assigned. Rather, students selected this program. This is understandable since it would be extremely difficult to have arranged for random assignment. Although subjects were matched on sex, school membership, and GPA, I suspect that there were motivational differences between the groups. I would suggest that some matching on motivational and/or personality factors be considered in future studies.

2. Most statisticians, I suspect, would argue that multivariate analysis of variance would be appropriate (rather than univariate analyses) since multiple dependent variables were used.

3. I did not see any correction for the number of statistical tests conducted. Given that at least 131 tests of significance were run (42 in table 1, 99 reported in table 2), the question of some adjustment is raised.

4. I think future studies should more directly attempt to get the student to integrate what is learned in the work environment with academic skills and knowledge.

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APPENDIX G

COMMISSIONED PAPER:
"FORGETTING: SOME PERSPECTIVES"
BY BENTON J. UNDERWOOD

Forgetting: Some Perspectives

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Paper prepared for the Symposium on the Learning-in-Work Study of the National Center for Research in Vocational Education to be held at the American Council on Education, October 17, 1980, in cooperation with the National Institute of Education.

G-3

Forgetting: Some Perspectives

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Forgetting is the failure to recall or recognize events which could be recalled or recognized at some earlier point in time. No psychologist is needed to tell us that forgetting can be very distressing, painful, and sometimes lethal. It is difficult to see why forgetting has not been gradually eliminated by evolutionary forces over the milleniums. But it has not been eliminated and we must accept forgetting as a fundamental characteristic of living organisms and a phenomenon to be understood.

There are some general issues that must be identified initially before we get into the examination of data which must guide our thinking about forgetting. These issues are at various levels of discourse, are not clearly and systematically related, and therefore will simply be numbered to reflect this.

General Issues

1. Laboratory research on forgetting is nearly 100 years old, its beginning commonly being identified with Ebbinghaus about 1885. Some may feel that few advances have been made since Ebbinghaus, but I believe that most of the points to be made in this paper tend to deny this. The conceptions of memory and forgetting, and the empirical facts which are most important today, are simply different from those about which Ebbinghaus wrote.

2. Forgetting cannot be studied in isolation from learning because forgetting is probably in some way (not yet understood) determined by the nature of the learning codes. Learning of a given task establishes a memory which is generally accepted to consist of more than one type of information. Thus, when learning is viewed as information processing, the process of learning consists of establishing memories which may consist of several different types of information. Thus, a memory might include temporal information telling when the memory was established; it might include frequency information, affective information, conceptual information, associative information and so on. These various types of information are sometimes spoken of as memory attributes. If a collection of these attributes is

what constitutes a memory--is what results from learning--then conceptions of forgetting must sooner or later deal with the loss of these attributes over time. At the present time very little progress has been made with respect to this.

3. Different models of memory emphasize different aspects of the learning-forgetting system. We may examine two such models by way of illustration. The first model assumes a system with limited capacity, and further assumes that forgetting is adaptive. Given a finite capacity, to establish new memories may require that some of the old memories have to be "dumped." This model has been illustrated in a story that surely must be familiar to some. A young biologist was named president of a small liberal arts college. Actually, as a biologist he had specialized in fish, hence he was an ichthyologist. He decided it would be a good idea to learn student's names so that he could greet them when he met them on the campus. He went about his task with great vigor and success until he determined that he would have to give up the idea because he found that each time he learned the name of a student, he lost the name of a fish. One could muster some evidence for a limited capacity model if a short-term memory system was all that was involved, but for long-term memory the model seems quite separated from reality. We cannot really note any practical limits on the capacity of the long-term memory system.

A second model is based on a most surprising assumption, the assumption that there is no forgetting. Nothing that is learned is ever forgotten is the basis of this model. Memories, it would be said, do fade but do not disappear into nothingness. On the face of it, this seems to be an absurd assumption, and it may be, but the fact is that some respected investigators have accepted the assumption as a working hypothesis. Of course the obvious question which such a model evokes is what it is that we call forgetting. The fact that forgetting occurs appears so obvious that it seems ridiculous to assume otherwise. The trick to overcome this problem is embedded in a further assumption of the model that what we call forgetting is really a retrieval failure, and if we look long and hard enough we will find retrieval cues which will allow us to recover all memories that have ever been established.

Several comments should be made about this model. First, given this model, research takes a different direction from that traditionally taken because the search will be for an understanding of retrieval cues. Second, there is simply no way to prove that there is no forgetting. Of course, this is not critical for the model; much could be learned about the learning-memory system by using this model and whether there is truth in it or not is not a heavy burden to carry. Third, some interesting data arise from some of the research that comes from emphasizing the importance of retrieval cues. For example, a study was done recently at the University of California at San Diego in which observers, several years removed from high school graduation, were asked to recall the names of high school classmates. The subjects worked at this task for ten hours--an hour a day for ten days. The important finding, for our purposes, was that even during the tenth hour these subjects were still recalling new names. That is, they were recalling names they had not recalled earlier but that, according to the yearbooks from the high schools, indeed belonged to members of the class in question.

Fourth, the more classical model of forgetting certainly does not deny the importance of retrieval cues, but it might ask not only how memories are at least momentarily forgotten but also how it is that the retrieval cues are forgotten. It has always seemed to me that there is no way to avoid the issue that there is a phenomenon that is called forgetting that involves the loss of "something," and it is our task to try to understand how this loss occurs. That is the perspective with which I will proceed with this paper.

4. We must face the fact that most of our systematic data on forgetting have come from experiments in which word lists have been used. I frequently hear the criticism that most of our work has used nonsense syllables as the units of study. In relatively recent times, say, from 1960, it is a rare experiment in which nonsense syllables have been used in the study of forgetting. Nevertheless, most experiments have used work lists, and the question may be raised as to how generalizable such results are. It can be stated that most of the phenomena which will be described later have been found at various levels of material complexity. For example, retroactive inhibition (an interference phenomenon) has been found with sentences and with paragraphs as the units of study. Heavy interference can be produced with hierarchically ordered conceptual systems. Nevertheless, I do not know the degree to which a finding might be applicable to school subjects, such as mathematics and reading. I am not acquainted with any systematic work on the retention of school subjects. There are many, many problems attending such research although there are certainly some issues that could be attached with benefit. As it is, we can only assume that the laws or principles of forgetting which have evolved from work with relatively simple materials have some pertinence to the forgetting of school subjects.

5. The role of reinforcement has probably been over-emphasized as a factor in learning, at least for the young adult subject. There have been many studies in which incentive variation has been shown to have no influence on learning. There are, furthermore, studies which show that immediate knowledge of

results (so-called immediate reinforcement) is inferior to delayed knowledge. The implication of these remarks is that in the study of forgetting one finds essentially no role for the idea of reinforcement. Indeed, it is quite possible to have subjects learn as much incidentally as they learn intentionally. Since the subjects are not trying to learn in the incidental conditions, it is difficult to see how any very direct forms of reinforcement can be implicated.

6. Two measures of learning and memory are commonly used, recall and recognition. There is now a substantial body of evidence that indicates that under normal circumstances these two indices of memory reflect differences in the nature of the attributes (types of information) in memory used by the subjects on the memory test. Having noted this, we must then say that most of the evidence we have on forgetting over long intervals is based on the recall measures, so that of necessity we will be dealing with recall as an index of memory.

One can always raise questions about any response measure in any area of investigation. Usually we want the response measure to reflect the essence of the behavior in which we are interested. However, there are other requirements we impose on the response measure, most notably it must be objective and capable of being quantified. An observer of our subjects as they engage in the various steps of an experiment sometimes sees the subjects doing things that seem to reflect directly the behavior of interest. However, when we look at the response measure we are using we find that nothing happened to support the observations. I remember when the people at Yale were first working on frustration and aggression before World War II. In one experiment they kept their subjects awake all night and frequently treated them in beastly ways during the night, e.g., they promised the subjects a fine meal but this food never arrived. Periodically during the night the investigators took objective measures which they presumed could reflect increasing aggression as the night wore on. None of these measures showed any effects of the treatment. However, the experimenters were sure behavior had changed during the night. They pointed to a picture drawn by one of the subjects, a picture which showed a man being hanged on the gallows, and this man was labeled "psychologist." The picture was taken to indicate clear evidence of aggression whereas this aggression was not picked up at all by the objective ratings scales that had been used. The point to be made is that we must think carefully about our response measures. The recall measure seems to be a sensitive one, for studying forgetting, and one which is ecologically valid and quite objective, but we should not use it unthinkingly in all situations.

The Simple Case

We will now evaluate the evidence with regard to the simple case of forgetting. Ideally, the simple case consists of a naive subject who is given a single task to learn, and then retention is taken after a day for one group, and after a week for another group. The usual finding is a forgetting curve with the amount forgotten over 24 hours being at a somewhat faster rate than that which occurs between one day and one week. The first question we need to ask is what variables will change the rate of forgetting; what variables accelerate it.

Not infrequently we hear experimental psychologists justifying their lack of progress as being due to the fact that behavior is so complex. It is said that a large number of variables influence behavior and these variables frequently interact. This situation is not present in the case of the simple retention paradigm. Evidence from the early years of research clearly showed that. Recently, in an attempt to bring this matter up to date, I studied the research published during the past ten years and I found that the generalization still held: Very few independent variables influence the rate at which forgetting occurs in the above-described simple paradigm. Let me first indicate some of the variables which do not influence forgetting.

Irrelevant Variables

All task variables can be included in this category. By a task variable I mean any systematic variation in the nature of the units used in the task. For example, various forms of meaningfulness represent task variables. We might, for example, compare the forgetting of a list of nonsense syllables with the forgetting of a list of common words. We observe a marked difference in the rate at which the two lists are learned, but given that the same level of learning is achieved for the two types of materials, forgetting rates do not differ. That the usual person has believed otherwise indicates that there is a confusion between learning rate and forgetting rate. Other task variables, which may influence learning markedly, have also been shown to have no influence on forgetting. For example, intra-list similarity, whether formal, conceptual, or meaningful similarity, will produce some marked differences in learning, but again, rate of forgetting does not differ.

A list can be structured so that three different conceptual levels are present, and their presence facilitates the learning as compared to the case where the same items are unstructured. Still, the forgetting of the two tasks will not differ. A relatively recent development is known as depth-of-processing procedures. The idea is that amount learned of a given task will depend upon the depth to which the items are processed. If the subjects were asked to cross out vowels in the words in a list the depth is shallow; if they are asked to rate the pleasantness of the words the depth is said to be substantial. The data show that recall is higher for the group given the rating task than those given the cross-out task. Nevertheless, if learning of the two tasks is taken to the same level, forgetting will not differ. There have been studies using sentences and the same words randomized in a string. Differences in retention are not observed. Various forms of mnemonic systems have been used to facilitate learning but there is consistent evidence showing that long-term memory is uninfluenced.

Finally, we should note that individual differences in rate of forgetting, if they exist at all, are very small in magnitude. A number of studies have shown that the rate at which a given list is learned by a group of subjects does not correlate with retention after twenty-four hours. This could mean that the variance added to forgetting by individual differences is minimal. However, the most convincing evidence on this matter comes from studies in which a group of subjects are given a constant number of trials to learn, with recall taken after twenty-four hours. Such studies show a high correlation between the number of correct responses on the last learning trial and the number of items correctly recalled. These high correlations indicate that the level of learning achieved dominated the amount recalled; hence, individual differences in the rate of forgetting must have been minimal.

Relevant Variables

It is much simpler to identify the independent variables, which do influence rates of forgetting, than those that do not. An obvious relevant variable, implied in the discussion just above, is the level or degree of learning achieved before the retention interval. The higher the degree of learning the better the long-term retention. It has long been assumed that overlearning led to better retention because overlearning simply was an extension of the degree-of-learning variable beyond the point at which all items had been first gotten correctly. However, this principle will probably need to be modified somewhat. According to unpublished work which I have heard about, if the task is a simple one overlearning will not facilitate retention; it will do so only if the task is a difficult one.

Perhaps one of the most potent variable involved in retention is spoken of as spaced practice. Suppose, for example, that one group of subjects is given two learning trials a day for five days (spaced practice) while another group is given all ten trials at a single sitting (massed practice). The recall of the group given spaced practice will be far better than that of that group given massed practice. These operations clearly have counterparts in the idea of cramming before an examination versus spaced study. If the test is given immediately after cramming, there is no reason why performance should not be high. However, it is the long-term retention measures that would be expected to differ, with the spaced practice being far better than the massed.

As a third variable I may mention a recent discovery which seems to indicate a further factor which influences long-term retention. If the subject is given two or three tasks to learn simultaneously, the retention of each list is better than if learned alone. In simultaneous learning the overall list of words consists of three distinguishable different classes of words which are simply randomized in the overall study list, but each class of items is tested separately. Not all possible artifacts have been ruled out of this paradigm but it now seems that the finding will hold up. We do not know just where this research will lead but the acquisition of several tasks simultaneously has ecological validity in that in school as well as in other situations we deal with several tasks more or less simultaneously.

We come to the fourth variable that is known to influence the rate of forgetting of the simple case; this fourth variable is the learning of interfering tasks. Both empirically and theoretically the forgetting produced for the target task by the learning of other tasks is of central importance. A large proportion of the work on long-term memory involves the study of the effect of interference from other tasks on the rate of forgetting, and innumerable studies in the past twenty years have examined the influence of interference in short-term memory paradigms.

Finally, there is the fifth variable that influences long-term retention, namely the length of the retention interval. To summarize, the five variables which must be considered relevant variables for forgetting are level of learning, spaced practice, number of simultaneous tasks, interfering tasks, and length of the retention interval.

Retroactive and Proactive Paradigms

Retroactive inhibition has been studied for about 80 years. To produce retroactive inhibition, a second task is inserted between the learning of the target list and its recall. Thus, the subject learns List T and then learns List X, before recall of List T is requested. The control group would learn and recall only List T. The difference in the recall of the two groups defines retroactive inhibition. Proactive inhibition, on the other hand, has had a relatively short history with very little work being done on the phenomenon until after World War II. In proactive inhibition the X List is learned prior to learning the T List, with the control again not having learned the X List. It can be seen that in the case of proactive interference an interval must occur between the learning and retention of the T List before any interference could be expected. Thus, length of the retention interval is an important variable determining the magnitude of proactive inhibition.

We must clearly understand the reasons for studying proactive and retroactive interference, and just how they may help us understand the causes of forgetting. The drosophila, or fruit fly, has been used extensively to study genetics. The major reason for this is that the fruit fly's life cycle is very brief and, therefore, biologists can study hereditary changes across many generations in a relatively short period of time. Nearly every discipline has its fruit fly; that is, nearly every discipline has developed ways of speeding up the study of its phenomena over the rate which occurs when nature simply runs her course. In the study of forgetting, retroactive and proactive inhibition are essentially our fruit flies. Many of us believe that interference is the major cause of forgetting. By the use of the two interference paradigms it is possible to speed up the processes which are assumed to occur in real life, and the magnitude of the interference phenomena can be amplified by these paradigms.

The facts of retroactive and proactive inhibition, as suggested above, led us to believe that the simple forgetting discussed earlier must be due to interference from tasks learned outside the laboratory, and that the forgetting of tasks learned outside of the laboratory is due to interference from other tasks learned outside of the laboratory. Because so much forgetting can be produced in the laboratory by the retroactive and proactive paradigms, theorists have been led to the conclusion that all forgetting results from interference. The forgetting of any task in real life probably results from a double whammy; it may be interfered with both by tasks learned earlier and by tasks learned later. Whatever you learn from what you read today will, over time, be put upon other events you have learned or experienced and by those things that you will subsequently learn or experience.

Mechanisms Underlying Interference

Interference always involves some incompatibility among response tendencies. Research which has studied the magnitude of the incompatibility has used various transfer paradigms, all of which have some representation in real life. Thus, there is the A-B, A-D paradigm in which paired-associate lists are used, and in which the stimulus terms in the two lists are identical, with the response terms being different. The A-B, C-B paradigm, on the other hand, has the same response terms in the two lists but the stimulus terms differ. It may be noted that this paradigm is the prototype for concept learning. There are other transfer paradigms, but they need not be enumerated here. It is apparent that the amount of interference is in some way related to similarity of the materials, and up to a point the higher the similarity the greater the incompatibility, hence the greater the interference at the time of recall.

A number of years ago it was suggested that retroactive inhibition involves more than competition among incompatible response tendencies at the time of recall. More specifically, it was proposed that with many interference paradigms, such as A-B, A-D, there is an unlearning or weakening or extinction of the A-B association during the learning of A-D. The technique which was evolved for testing this idea required the subjects to try to give both response terms to the stimulus terms after both lists had been learned. The time allowed for recalling both response terms was essentially unlimited. The idea was that with unpaced testing there would be no competition between the two response tendencies so that if the first-list responses could not be produced, it must be due to some factor other than competition, and thus was due to unlearning or extinction. Many experiments showed that something like unlearning must indeed have occurred. The subjects simply could not recall some of the first-list (A-B) response terms no matter how much time was given. This seemingly powerful analytical situation gradually began to disintegrate as studies began to show that the competition between the two response tendencies (A-B versus A-D) could occur even if there were no time pressures for the subject to respond. At the present time, therefore, it is doubtful that we should assume that a phenomenon such as unlearning is a part of the cause of the forgetting observed in the retroactive inhibition paradigm. Competition leading to interference remains as the only clear factor involved in forgetting.

In a very general sense, interference is an inverse function of the discriminability between tasks. Contemporary studies are being directed at factors which vary the discriminability of the potentially interfering tasks. In some cases, for example, it appears that a temporal discrimination is involved. In fact, there is appreciable evidence from both short-term memory studies and long-term memory studies that the loss of temporal discrimination is the primary cause of proactive interference. But this does not seem to be the case for retroactive inhibition. If the subject learns Task T, then Task X immediately, and then tries to recall Task T, there seems to be little confusion as to which list the recalled items belong, but still there is interference in that the subjects cannot recall some of the response terms. It was this fact which unlearning handled so nicely and we may eventually find that the concept of unlearning is still necessary. If so, it will require the invention of a test paradigm in which it is clear there is no competition.

The Theoretical Gap

The purpose for studying retroactive and proactive inhibition is that the outcomes of the experiments should direct us toward an understanding of the simple case of forgetting. However, there must be a theory which specifies how retroactive and proactive inhibition exhibit their influences in the simple case, and the theory must be capable of being tested. Such a theory had been proposed in great detail a number of years ago, with clear predictions flowing from the theory. Many tests have given little support to the theory. The basic idea that the simple case represents the forgetting produced by interference need not be discarded because of the failure of the one theory. A new transition theory is needed to close the gap between laboratory-produced interference and the case of simple forgetting. If not forthcoming, our fruit fly will not have accomplished completely what it was intended to accomplish.

It has sometimes been wondered how it is that we are able to carry on relatively organized and directed lives if interference is lurking around every corner ready to compete with each new thing we learn. There are a number of possible answers to this criticism. First, there is the possibility that in real life we do forget an enormous number of things we have learned. Try to remember in detail one's activities of the last ten hours. Try to remember many facts of history which at one time we knew "cold." Second, there are variables (which were listed earlier) which seem to inoculate memories against interference. Third, there may be various organizational structures into which new learning is "placed" and these structures may be easily discriminable from each other, hence the new memories may be discriminated by the structure from potentially interfering memories. Nevertheless, within a structure some interference must be expected. In short, it does not seem that a satisfactory theory of forgetting is going to be written if interference is omitted as a factor. It may turn out that it is not the only factor, but surely it must be a factor.

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