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ABSTRACT

A study investigated the retention of mathematical and reading concepts of students enrolled in a learning-in-work environment (Experience-Based Career Education) and a traditional classroom learning environment on a measure of academic achievement using a twelve-month longitudinal design. The performance of twenty-seven students in each environment was evaluted using the Comprehensive Tests of Basic Skills, administered at the beginning and end of the junior year and at the beginning of the senior year. The learning interval was designated as the time between pre- and post-testing, and the retention interval as the time between post- and follow-up testing. The results indicated differences in both reading vs. math skills and in traditional vs. learning-in-work environments, with the greatest amount of fluctuation being in the math scores of the two groups. While the groups were equivalent at the beginning of the year, the students in the traditional environment increased their math performance by the end of the year, while the learning-in-work students' math scores decreased during the same time period. The groups subsequently reversed this direction of change over the summer, with the traditional students' math scores showing a decrease, while the learning-in-work students showed an increase in math scores. An interference/assimilation model is proposed to interpret the findings. (Author/MEK)

RETENTION OF CONCEPTS RESULTING FROM LEARNING BY EXPERIENCE

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

Research and Development Series No. 200

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An Interim Report on a Project Conducted

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

National Institute of Education

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FOREWORD

Learning-in-work is an integral part of Experience-Based Career Education Programs, internships, cooperative and work-experience programs, and on-the-job components of vocational education. Since the early 1970s, 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 as they result from 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. Recognition is due Tim Wentling, Professor of Vocational Technical Education at the University of Illinois, for his assistance with the collection of the student test data.

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 of the technical information document from which this report is derived and for their recommendations and suggestions: to Joe Grannis, Associate Professor of Education, Teachers College, Columbia University; Mary Malone, Dean of College of Education, Rutgers University; and Tom Miller, Research Specialist, the National Center for Research in Vocational Education.

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Recognition is due Richard Miguel, Program Director, for the direction 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
The National Center for Research
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 differences in both reading vs. math skills and in traditional vs. learning-in-work environments. An interference/assimilation model was proposed to interpret the findings.

This preliminary investigation is the first of a two-year effort. In the interest of parsimony and the wise use of resources, this report was prepared for dissemination to interested researchers and program designers. For the selected few who may be interested, the larger document (175p) containing the technical information and appendices, is available for inspection at the National Center. Finally, Appendix A of this report contains the Table of Contents, List of Figures, and List of Tables of the technical information and appendices document.

PROBLEM

Since the early 1970s, there has been an effort to expand students' educational opportunities to include a variety of "real-world" experiences in the workplace to complement the traditional classroom learning environment (Crowe and Adams, 1979). An example of a learning-in-work program is the Experience-Based Career Education (EBCE) program.

Briefly, the EBCE model is an academically-oriented, community-based program: students spend one day per week at the learning center with a learning coordinator, who supervises and directs the learning activities of the students; four days per week are spent at a community (work) site under the guidance and supervision of a resource person (worksite mentor). Students work at three to twelve sites per school year, depending on their career interests and academic needs. The program offers twenty-eight EBCE courses that are related to traditional subject matter disciplines. Students choose EBCE courses as a function of their assessment of (1) *career* interests and aptitudes (e.g., EBCE courses and occupations are related through the *Dictionary of Occupational Titles* worker trait groups) and (2) *academic* needs and interests (e.g., EBCE courses and traditional subject matter concepts are related through an instructional matrix that sets the parameters for designing the learning activities).

Under the EBCE model, academic development is accomplished through the use of an activity sheet. The activity sheets are designed to guide students' learning through a series of learning activities that relate subject matter concepts and career objectives to experiences at the work site. After concluding work on the activity sheets, students are evaluated by the learning coordinator and then plan future learning experiences.

The EBCE 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.

Given that past research using only a pre-test/post-test control group design has detected few statistical differences in students' achievements (Crowe and Adams, 1979; Crowe and Walker, 1977), it was of interest in the present investigation to test the assumption that demonstrable changes in student performance may occur after participation in the program. Thus, a retention model design was proposed using repeated measures whereby the learning interval was the time students participated in the learning environment (nine months) and the retention interval was the summer recess (three months). In view of previous research on environmental contingencies as determinants of learning and retention (see Gagne, 1978, for a review), it was predicted that students' exposure to different types of learning environments would affect performance on standardized tests of academic ability (i.e., CTBS). The study was exploratory in nature and examined performance in two learning environments longitudinally in order to detect changes in the retention of academic performance which would result from participation in one of the two environments during the learning interval.

METHOD

Subjects

Juniors from a suburban school district in Minnesota were selected to participate in the study. This district was chosen by virtue of having both a traditional learning environment (classroom instruction) and learning-in-work environment (EBCE program) in operation. Twenty-seven students who volunteered for the EBCE program were successfully followed over the observation period. Eleven students in the original EBCE sample of thirty-eight were dropped due to missing data at one or more of the subsequent testings. Control students in a traditional environment were selected at random from a pool of students to match the EBCE students on sex, school membership, and GPA. Twenty-seven control students were successfully followed over the observation period, while fifteen students were lost due to missing test data.

Measures

The CTBS Expanded Edition, Level 4, Form S was used at all testings. Of the total test battery, Test 2 (Reading Comprehension) and Test 7 (Mathematics Concepts and Applications) were selected for administration due to constraints on testing. The math test was scored to provide six scales, and the reading test, five scales.

An additional scale to measure student perceptions of the complexity of the learning environment was developed (Learning Environment Questionnaire, LEQ). This scale was composed of thirteen items measuring the degree to which students perceived the environment as providing feedback, offering a variety of tasks, and giving direction to complete tasks.

Students were interviewed by the researchers during May to gather further information on the instructional processes in the learning environments.

Procedure

The CTBS tests were administered on three occasions: pre-test, September, 1978; post-test, May, 1979; and follow-up test, September, 1979. The tests were group-administered to students in a school setting and were computer-scored by the experimenters. The LEQ was given at the second testing, and interview data was gathered the week of the post-test.

RESULTS

Analytic Strategy

Since the purpose of the present preliminary investigation was to identify areas for future in-depth examination of the data, analysis of variance techniques were used to evaluate the results of the reading and math CTBS scores. Given that the sample size was relatively small, an attempt was made in all analyses to use the smallest number of variables possible to allow higher statistical power to detect effects which may have been present. Accordingly, variables which demonstrated insignificant effects in higher-order designs were deleted from subsequent analyses in an attempt to decrease Type II errors of inference.

Three-Factor Analyses

Repeated-measures analysis of variance (ANOVA) tests were performed on the results of the math scales (scale 1 – content dimension, concepts; scale 2 – content dimension, application; scale 3 – process dimension, recognition; scale 4 – process dimension, translation; scale 5 – process dimension, interpretation; and scale 6 – process dimension, analysis). These scales constituted the dependent variables for each analysis. Independent variables were as follows: test – observations at T_1, T_2, and T_3 functioned as the repeated measure; program – EBCE or treatment (T) group, traditional learners or control (C); and math instruction option – math class taken as a junior, no-math class taken as a junior. The resultant design was defined as a 2 (programs) x 2 (math—no-math) x 3 (tests) factorial.

Results of these analyses are summarized in Table 1, which reveals significant main effects for tests on math scale 3 and significant tests by program interactions for scales 2, 3, and 5. No effects were seen for the math—no-math variable, which was therefore dropped from subsequent analyses ($p < .05$ reported for all analyses).

Two-Factor Analyses

Analyses of CTBS scores (math and reading) were then performed using a 2 (programs) x 3 (tests) design to allow increased power in detecting effects. The dependent variables for the reading comprehension analyses consisted of the following five scales: scale 1 – content dimension, reading comprehension; scale 2 – process dimension, recognition; scale 3 – process dimension, translation; scale 4 – process dimension, interpretation; and scale 5 – process dimension, analysis. Results of the repeated measures ANOVAs, analyses of simple effects, and LSD tests between means are reported in Table 2. Main effects for program were absent in all analyses; main effects for tests were seen in reading, scale 1 and 4; interactions of programs by tests were seen in math scales 2, 3, and 5 and reading scale 5. These results are plotted in Figures 1 and 2 with scores expressed in raw units, standard deviation scores (SD), and grade equivalents (GE) when available. Figure 1 presents the results of the math concepts analysis while Figure 2 presents the results of the reading concepts analysis.

LEQ

Comparisons of the responses to the LEQ items for treatment and control students are reported in Tables 3 and 4 and were analyzed via t tests.

TABLE 1

Summary of Program By Math, No-Math, By Tests

Sources of Variance

Math Scale:		Program (T vs. C)	Math, No-Math	Program X Math, No-Math	Tests (T_1, T_2, T_3)	Tests X Program	Tests X Math, No-Math	Tests X Program X Math, No-Math
Content: Concepts	1				X_1			
Content: Application	2					X_2		
Process: Recognition	3				X_2	X_2		
Process: Translation	4							
Process: Interpretation	5					X_2		
Process: Analysis	6							

$X_1 = p < .10$
$X_2 = p < .05$

TABLE 2

Summary of Program By Tests

		MAIN EFFECT & INTERACTION: Program (T vs. C)	MAIN EFFECT & INTERACTION: Tests (T_1, T_2, T_3)	MAIN EFFECT & INTERACTION: Program X Tests	SIMPLE EFFECTS: Program @ T1 Pre-test	SIMPLE EFFECTS: Program @ T2 Post-test	SIMPLE EFFECTS: Program @ T3 Follow-up	COMPARISONS OF MEANS (LSD, p = .05): T1 vs. T2	COMPARISONS OF MEANS (LSD, p = .05): T2 vs. T3	COMPARISONS OF MEANS (LSD, p = .05): 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

FIGURE 1

Student Performance on Math Scales for Three Testings

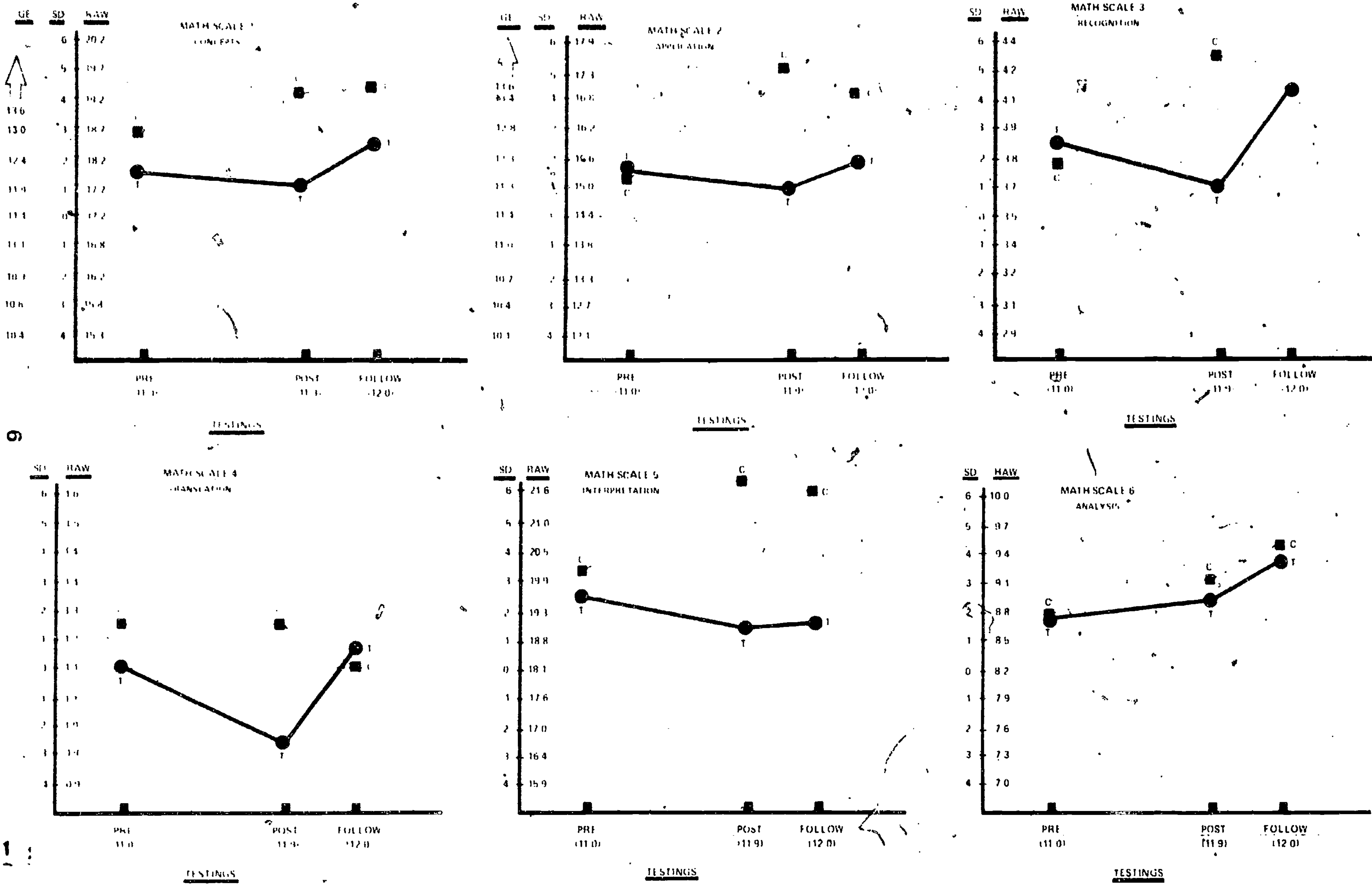


FIGURE 2

Student Performance on Reading Comprehension Scales for Three Testings

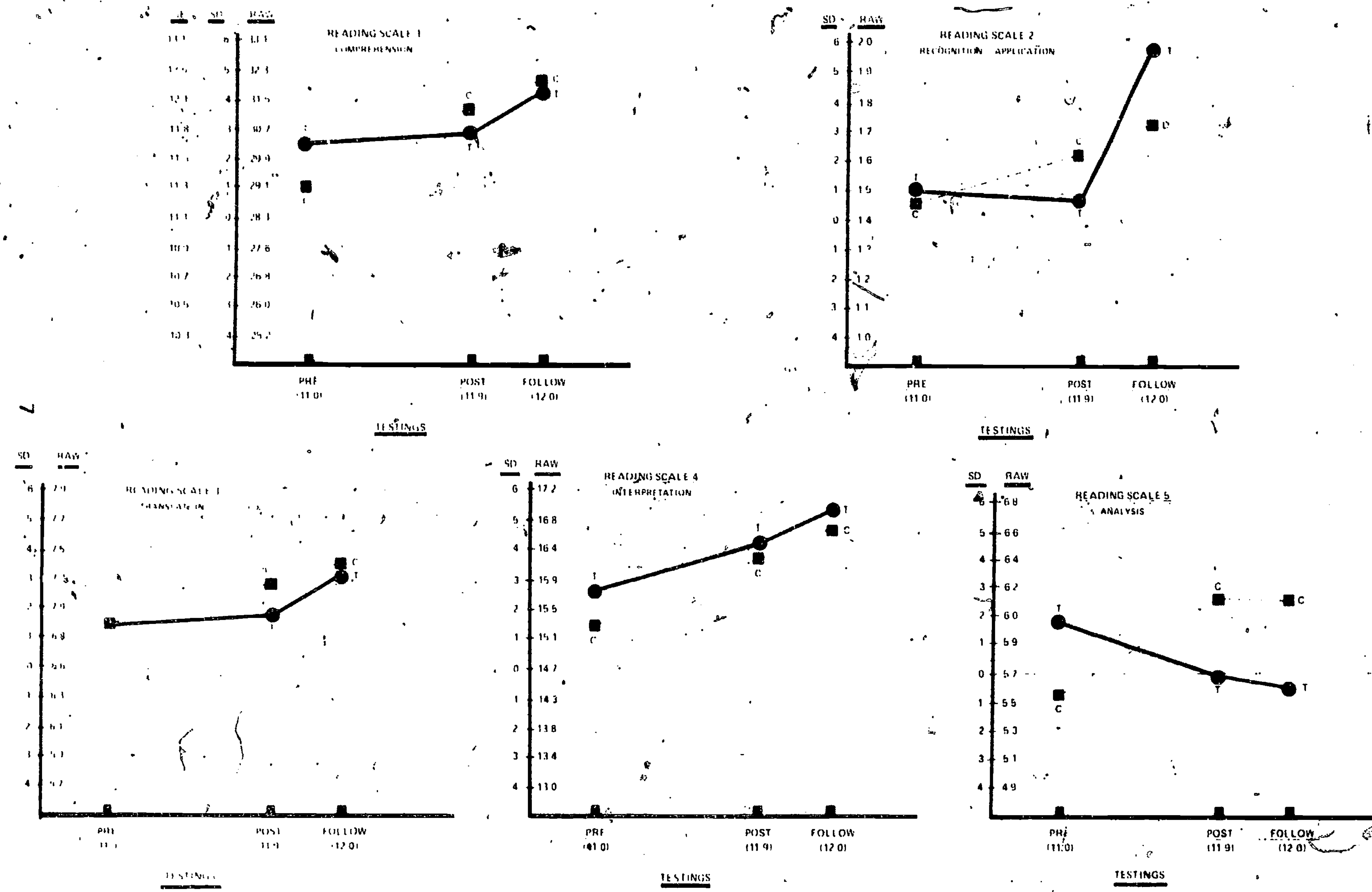


TABLE 3

t-TEST ANALYSIS FOR SCALE 1 OF LEQ

LEARNING ENVIRONMENT QUESTIONNAIRE

Hypothesized Scale 1
Environmental Complexity

ITEM	Group (a)	No. of Cases	Mean	Standard Deviation	t Value (b)	Degrees Freedom	Two Tail Probability
1 In my school program I felt encouraged to find things out for myself	C	41	3.78	.76	4.11	77	.0001
In the EBCE program I felt encouraged to find things out for myself	T	38	4.50	.80			
4 In my school program I was able to ask many questions about the work	C	41	3.76	.99	4.96	77	.0001
In the EBCE program I was able to ask many questions about the work	T	38	4.66	.53			
7 In my school program I had opportunities to try things out for myself	C	41	3.78	1.04	4.29	77	.0001
In the EBCE program I had opportunities to try things out for myself	T	38	4.66	.75			
10 In my school program I was encouraged to come up with my own ideas	C	41	3.68	1.01	3.47	77	.0009
In the EBCE program I was encouraged to come up with my own ideas	T	38	[illegible]	.79			
3 The teachers taught me what I needed to know	C	41	3.56	.87	(c) 2.59	77	.0115
The resource person taught me what I needed to know	T	38	4.02	.72			
The learning coordinator taught me what I needed to know	T	38	3.74	.76	(d) .96	77	.3424
6 The teachers described the way they wanted me to do my work	C	41	3.76	.80	(c) .53	77	.5968
The resource persons described the way they wanted me to do my work	T	38	3.82	1.06			
The learning coordinators described the way they wanted me to do my work	T	38	3.29	1.16	(d) 2.09	77	.0395
9 The teachers gave me the right way to do the work	C	41	3.49	.93	(c) 3.33	77	.0013
The resource person gave me the right way to do the work	T	38	4.13	.77			
The learning coordinator gave me the right way to do the work	T	38	3.71	.96	(d) 1.05	77	.2961
12 The teachers showed me what they required me to do	C	41	3.93	.92	(c) .54	77	.5915
The resource persons showed me what they required me to do	T	38	4.03	1.05			
The learning coordinators showed me what they required me to do	T	38	3.97	1.02	(d) .26	77	.7964

(a) C Control students in traditional learning environment
T Treatment students in learning in work environment

(b) t Test calculated for students who had both pre and post test scores

(c) t Test comparing teachers of controls to resource persons of treatment students

(d) t Test comparing teachers of control students to learning coordinators of treatment students

TABLE 4
t-TEST ANALYSIS FOR SCALE 2 OF LEQ

LEARNING ENVIRONMENT QUESTIONNAIRE
Hypothesized Scale 2
Environmental Control

ITEM	Group (a)	No. of Cases	Mean	Standard Deviation	t Value (b)	Degrees Freedom	Two-Tail Probability
2. I was able to tell by myself if I was doing a good job.	C	41	3.73	.74	2.36	77	.0207
I was able to tell by myself if I was doing a good job.	T	38	4.18	.96			
5. The results of what I did had meaning. I felt the results were important.	C	41	3.66	.91	3.45	77	.0009
The results of what I did had meaning. I felt the results were important.	T	38	4.34	.88			
8. The work that I did offered me many different things to do.	C	41	3.56	.56	4.81	77	.0001
The work that I did offered me many different things to do.	T	38	4.45	1.00			
11. The teachers provided me opportunities to do meaningful work or solve problems.	C	41	3.63	.73	(c) 4.11	77	.0001
The resource person provided me opportunities to do meaningful work or solve problems.	T	38	4.32	.74			
The learning coordinator provided me opportunities to do meaningful work or solve problems.	T	38	4.31	.77	(d) 4,01	77	.0001
13. The teachers encouraged me to decide for myself how I was going to do my work.	C	41	3.68	1.01	(c) .23	77	.8196
The resource person encouraged me to decide for myself how I was going to do my work.	T	38	3.74	1.08			
The learning coordinator encouraged me to decide for myself how I was going to do my work.	T	38	3.84	1.10	(d) .66	77	.5054

(a) C = Control students in traditional learning environment
T = Treatment students in learning-in-work environment

(b) t Test calculated for students who had both pre- and post-test scores

(c) t-Test comparing teachers of controls to resource persons of treatment students.

(d) t-Test comparing teachers of controls to learning coordinators of treatment students.

Summer Activities

Students reported their summer activities on the third questionnaire, which were then classified as follows: part-time paid employment – 11 EBCE, 16 control; full-time paid employment – 9 EBCE, 5 control; "other" – 5 EBCE, 3 control; and summer school plus part-time paid employment – 2 EBCE, 3 control. Results of chi-square analysis on the 2 (treatment–control) x 4 (summer activity classes) frequency matrix ($X^2 = 4.2$, df = 4, $p = 0.38$) indicated no significant association between these factors.

DISCUSSION

LEQ and Interviews

While the researchers recognize that the LEQ is currently in a developmental stage, the results of both the LEQ and the interviews with students were seen to indicate that students in the alternative (learning-in-work) environment perceived: (1) a greater chance to find things out on their own (autonomy); (2) more support from instructors for developing their own ideas; (3) more feedback on their performance (self-generated); (4) more variety in their learning tasks; and (5) more meaning in their activities. Overall these are similar characteristics to those identified by research on learning and retention of material (Gagne, 1978) that lead to increased performance on learning tasks. It was concluded from these data that the learning-in-work environment does contribute to conditions favorable for academic learning and retention.

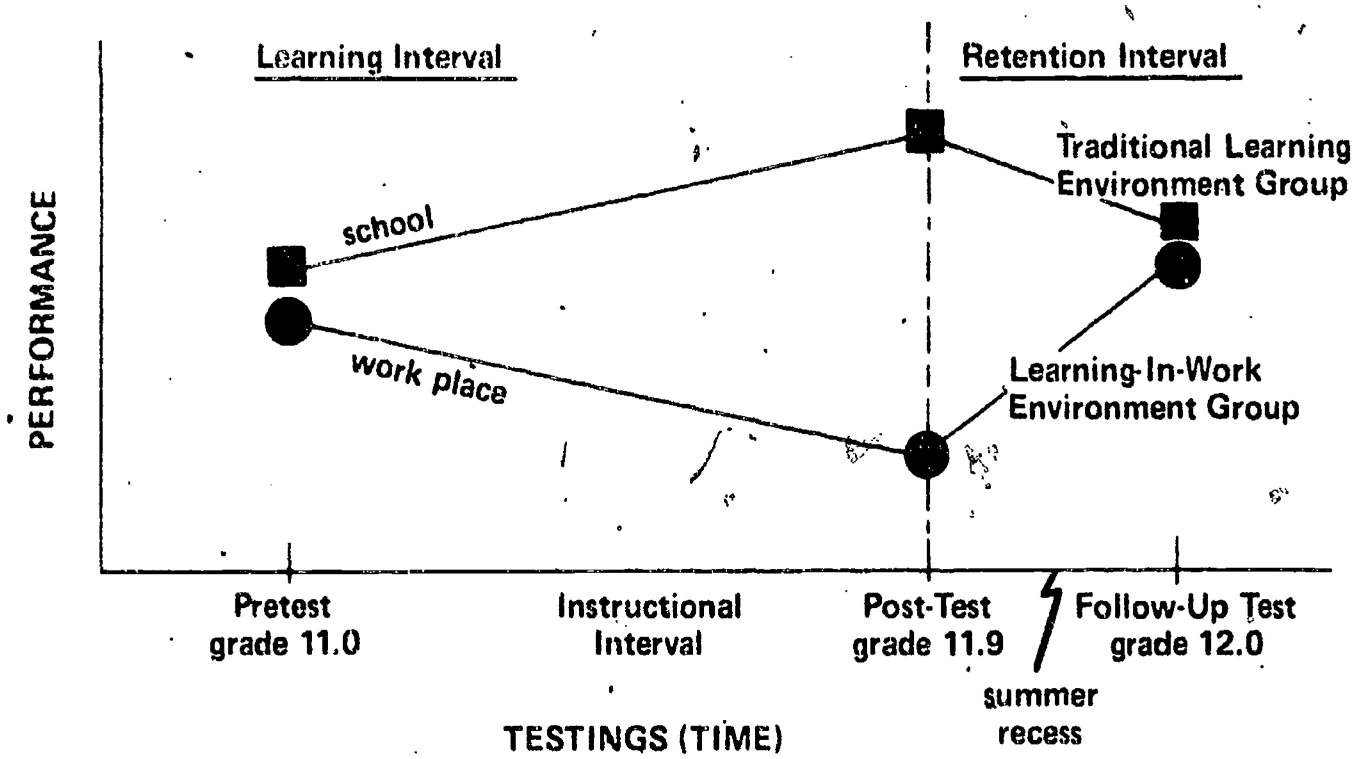
CTBS Scales: Reading Comprehension

The effect of these two environments on standardized scholastic achievement performance was evaluated by the ANOVAs on the CTBS data. Results of reading scores indicated that, in general, both groups demonstrated equal performance that increased linearly for reading scales 1-4 over the learning interval (pre-test to post-test) and over the retention interval (post-test to follow-up). Significant mean increases were seen only for reading scales 1 and 4, comparing pre-test to follow-up. Groups did not differ significantly (T vs. C) at any observation, on any reading scale, indicating a similar level of performance on these measures.

CTBS Scales: Mathematics Concepts and Application

Inspection of the math scores reveals a different pattern for the groups. Three of the six math scales (2, 3, and 5) revealed significant interactions of program (T vs. C) by Tests, indicating significantly nonparallel learning/retention functions. Additionally, the two groups differed significantly at the end of the school year but were nonsignificantly different at the start of their junior year and at the start of their senior year. Thus, groups were equivalent at the point where they were split into different learning environments, but the students in the traditional learning environment *increased* in performance up to the end of the year, while the learning-in-work students showed a *decrease* in performance on the post-test. This effect was manifest in scales 3 and 5 at

FIGURE 3
Composite of Math Scale Functions



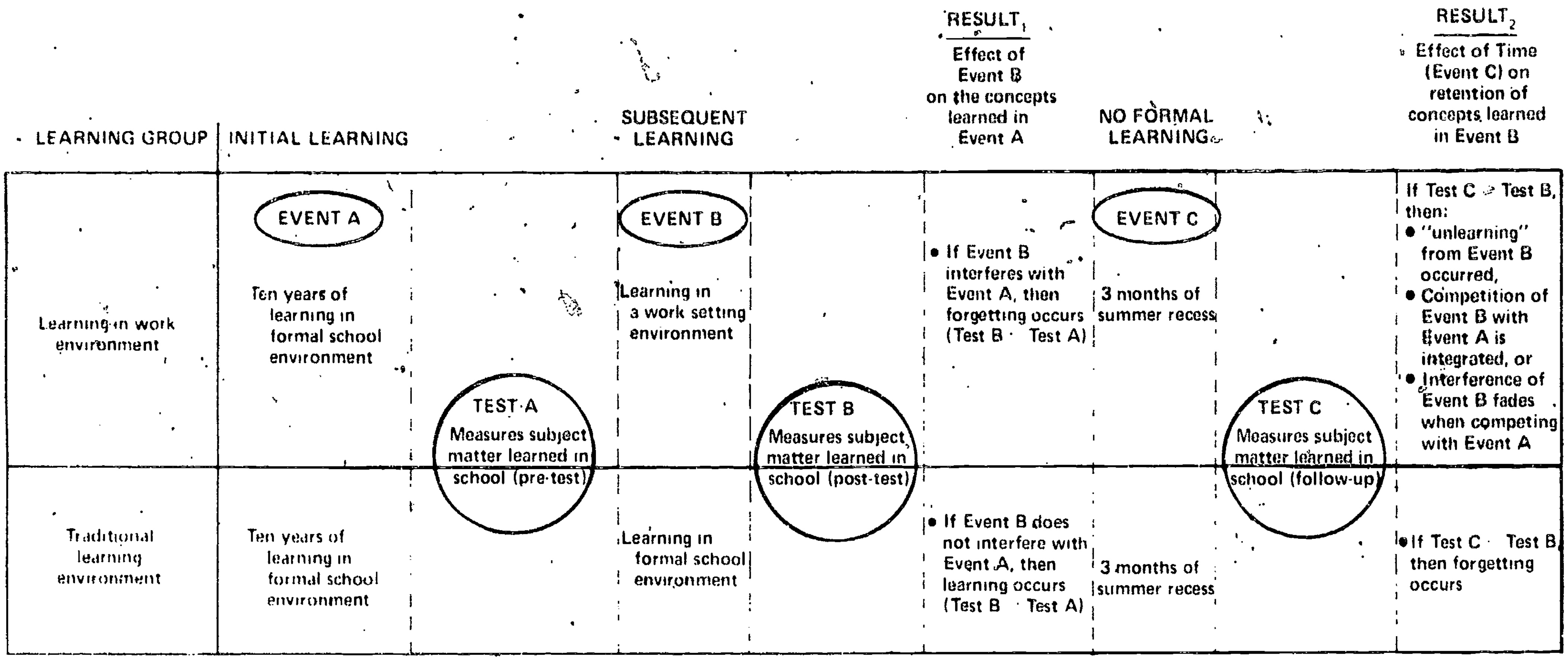
$p < .05$, while scales 1, 2, and 4 showed trends in this direction. The groups subsequently reversed this direction of change over the summer: the students in the traditional learning environment *decreased* from post- to follow-up test, while learning-in-work students *increased* over the summer. The overall composite form of this relationship across math tests is depicted in Figure 3.

Interpretation

These findings were not predicted from previous research, which would suggest an increase for both groups during the instructional period, and a "forgetting" gradient over the summer (Ebbinghaus, 1885). Alternative *post hoc* explanations for these results were considered by the authors, which centered on uncontrolled effects of student selection for the learning-in-work program. While it was deemed possible that, due to nonrandom assignment of students to the EBCE program, subjects may have systematically differed on a variable that could interact with the repeated testings, this explanation was not favored in view of the lack of differences between groups at the start of the study. Additionally, a mechanism would be necessary to account for the unequal effect of such a confounded selection, such that it would have *no effect* at test 1, would produce a *significant decrement* at test 2, and would then *increase* performance for the EBCE students at the same time that controls (in the same environment) were *decreasing* over the summer. This necessarily unparsimonious approach was rejected in interpreting the results of the math performance.

A model was proposed to account for the unequal learning and retention of CTBS math skills, which emphasized two constructs: interference due to previous learning (retroactive interference) and assimilation of information. This model is displayed in Figure 4. On the basis of both interview and LEQ data, the researchers hypothesized that students in the learning-in-work environment were learning *different* things than the controls in a traditional setting. Specifically, it was postulated that EBCE students were learning new "rules" for learning how to learn or function in a work environment. These rules for learning how to learn were seen to be different than those typically measured by academic tests of achievement (e.g., CTBS). The paradigm is as follows: (1) students in both groups have similar learning histories up to the first testing, which emphasized traditional, nonapplied, use of math constructs; (2) students placed in the learning-in-work environment then were forced to *use* or *generate* constructs in an applied setting, and to generalize from abstract math concepts to applied math usage on the jobs; (3) traditionally learned math skills were not being practiced on the job, and new ways to use math were being learned which did not necessarily overlap with previous learning; (4) these new rules for learning were not assimilated into the previous math framework or structure learned in class, and constituted a retroactive inhibitor to the retrieval of the CTBS measured math skills which emerged as a function of dissimilarities for the two ways of learning math (measures at T_2); and (5) follow-up performance on CTBS was seen to depend on the extent to which new ways to use math were assimilated into the previous framework or structure of math knowledge. That is, CTBS performance should increase as a function of the degree to which students could relate the new rules for using math to the way math is measured by the CTBS.

FIGURE 4
Interpretation of Results From A Retroactive Design Perspective



Conversely, it was predicted that the use of a performance-based math test (content-valid for applied settings) would reveal that learning-in-work students were not "losing information" but were learning *new rules* for learning how to learn which were not manifest on the CTBS until they could be assimilated into the previously developed traditional structure for remembering math concepts. Accordingly, future research should measure the effects of different learning environments by employing classroom-based tests *plus* tests which are content-valid for measuring math skills as they exist in the work environment. This type of design would allow a powerful test of the model's predictions regarding performance on subject matter concepts in different learning environments, and could further illustrate the merit of hands-on learning as is offered by learning-in-work environments.

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APPENDIX A

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