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ABSTRACT

Relationships between cognitive and affective learner characteristics or "aptitudes" and mathematics achievement for sixth-graders in three instructional treatments in one school district were examined. Aptitude-treatment interaction (ATI) analyses were performed to test for differential prediction of achievement outcomes among treatments, using each aptitude as a single predictor. Multiple regression analyses were also run using aptitude, treatment, and aptitude x treatment interaction variables as predictors. Initial results with single predictors suggest a fairly consistent direction of differences among treatment slopes. This study provides an example of the ATI approach within a specific school setting in an evaluation context. (Author/BW)

INDIVIDUAL DIFFERENCES AND MATHEMATICS ACHIEVEMENT: AN INVESTIGATION OF APTITUDE-TREATMENT INTERACTIONS IN AN EVALUATION OF THREE INSTRUCTIONAL APPROACHES

by
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INDIVIDUAL DIFFERENCES AND MATHEMATICS ACHIEVEMENT: AN INVESTIGATION OF APTITUDE-TREATMENT INTERACTIONS IN AN EVALUATION OF THREE INSTRUCTIONAL APPROACHES[1]

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In the past, evaluations of instructional approaches have often attempted to determine which instructional method is best for all students. However, learner characteristics are important inputs which also relatc to educational outcomes. Thus, the analysis of aptitude-treatment interactions which focuses on the hypothesis that individual differences in learner characteristics (considered "aptitudes") interact with instructional methods to produce differential outcomes (Berliner and Cahen, 1973; Snow, 1974; Cronbach and Snow, in press), is a promising technique for evaluating instructional programs. Although aptitude-treatment interaction (ATI) analyses are well suited for providing data to educators for making decisions about optimizing learning for individual students, evaluations of educational programs have generally not utilized an approach like this (Webster and Mendro, 1974). This study provides an example of the use of the ATI approach in a specific context (Cronbach, 1975)--an evaluation of different mathematics instructional approaches in a school district.

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Briefly, in the simplest case, the ATI approach compares the regression line relating a learner aptitude (or characteristic) to a learning outcome under one instructional treatment with the regression line for a competing treatment. If the regression lines cross, the interpretation is that students at one end of the aptitude (ability or other learner characteristic) continuum learn better under one treatment, whereas students at the other end of the continuum perform better in the opposite or competing treatment. The occurrence of such aptitude-treatment interactions might have implications for differential placement of students under different teaching methods for optimum learning.

The importance of focusing on a variety of variables when examining educational settings is pointed out by Randhawa and Fu (1973):

> Since classroom learning environment is an interaction phenomenon, it is important that the developmental history of each member of the group, personality variables, cognitive variables, socioeconomic status, sex, and other variables which would seem to interact with the behaviors of the participants of a certain environment be taken into account (p. 318).

The importance of using multiple measures for student traits and outcomes has also been stressed in both educational research and evaluation literature (Snow, 1974; Cooley, 1971; Astin and Panos, 1971; Messick, 1970).

Past research has shown relationships between achievement and attitudes and personality variables, as well as ability level. For example, Cattell and Butcher (1968) stated that: "It seems very likely that children's school achievement, even in the sense of standardized achievement tests..., is connected with their patterns of personality factors and of interests and attitudes" (p. 152). They added that it is known that general intelligence is predictive of achievement and that it needs to be determined whether personality variables add to the prediction of achievement over and above what is predicted by intelligence. Characteristics of students, as inputs, then, are generally considered to be related to student outcomes. In addition to ability and previous achievement, social-psychological and personality characteristics such as self-esteem, learning style, and belief in internal or external control of reinforcements in the learning situation are often considered to be important variables relating to students' achievement.

Many studies have shown significant and positive relationships between self-concept and achievement in upper elementary students (Purkey, 1970; Sears, 1963; Campbell, 1967; Bledsoe, 1967; Williams and Cole, 1968). A child's belief that he, rather than someone else, is responsible for his own learning performance, has also been shown to be related to academic achievement. Lefcourt (1972), in reviewing locus of control research, concluded that the overwhelming majority of studies show a positive relationship between internality (internal locus of control) and academic behavior.

In a study comparing children of teachers who were more oriented toward responding to individual students with children whose teachers tended to initiate more interactions with the whole class, ATI's occurred when regressing posttest achievement (in this case, verbal) on self-concept, as well as on locus of control. In both cases, students higher on the aptitude variable (self-concept or locus of control) had higher achievement in the more individualized treatment (Sears et al., 1972). Thus, the two variables may have important implications for determining optimal teaching methods for different children.

Field dependence-independence, one dimension of cognitive style, denotes clusters of characteristics, both cognitive and personal, that are broad in scope (Witkin and Moore, 1974). Cognitive style refers to a person's typical ways of processing information and tends to function across a variety of content areas (Witkin and Moore, 1974). Relatively field independent persons perceive analytically, while field-dependent persons tend to perceive globally. It has been suggested that field independent persons tend to do better than field dependent persons in non-language tasks (Cohen, 1969; Witkin and Moore, 1974). Thus, this personal characteristic may have particular implications for mathematics instruction.

Self-concept, locus of control, and field dependence-independence, then, in addition to ability and previous achievement level, represent possible important learner characteristics which might interact with type of instruction to produce differential outcomes. These variables may have an influence upon how well students respond to teaching methods differing in instructional groupings and degree of self-direction required. This study focused on these variables in relation to achievement in different methods of mathematics instruction.

This study was part of a larger evaluation study designed to explore relationships among learner characteristics, instructional treatments, classroom environment and cognitive and affective outcomes in both mathematics and reading at the sixth grade level in one school district. This effort was part of an external evaluation of a federally funded five-year project in the school district of 8,000 K-12 students, in a partly suburban, partly semi-rural area with a primarily working class population.

The purpose of this paper is to focus on part of this larger study and to examine the relationships between the cognitive and affective learner characteristics mentioned above (IQ, previous achievement, self-concept, locus of control, and the cognitive style of field dependence-independence) and the cognitive outcomes of mathematics achievement in three different sixth grade mathematics instructional treatments, varying in degree of individualization, which were utilized in one school district. This study was also designed to examine patterns of achievement in various areas of arithmetic skills, not only in overall arithmetic achievement.

Although standardized achievement tests provide only gross measures of differences between groups, it was felt that an examination of patterns of achievement in particular areas of arithmetic skills (the different subtests contained in the CTBS), as well as total arithmetic achievement, might yield more discriminating information in evaluating effects of differing methods of mathematics instruction.

The study included IPI (Individually Prescribed Instruction) as one of the treatments, as it was the most widely used individualized instructional approach in the district during the project. A mathematics management and support system correlating objectives with various published curricula was developed in the district during the project and, at the time of this study, was being implemented in some of the schools; thus, it was included as one of the treatments. Another treatment was a more traditional approach centering on the use of a basal text and was selected for its representation of typical instruction in the district prior to a greater emphasis on individualization of instruction during the five year project.

Method

Subjects

Data were collected on 165 sixth grade students for the mathematics sample in three schools using the three different methods of mathematics instruction. Students with missing data on any of the variables of interest to this study were eliminated from analyses, leaving a total of 124 subjects in the final sample: 37 in the basal text treatment (whole group instruction), 45 in the mathematics management treatment (combining individual, small group, and large group instruction), and 42 in the IPI treatment (individualized instruction).

Instrumentation

Arithmetic achievement was measured with the Comprehensive Test of Basic Skills (CTBS), developed by the California Test Bureau (CTB, 1970). Level 2, form R, was administered at the fifth grade in spring 1974 and Level 3, form Q, at the sixth grade in spring 1975 for this sample. The Arithmetic test has three subtests, Computation, Concepts, and Applications, and a Total score. Expanded standard scores can be used for comparisons among grades, growth between grades, and ascertaining trends within individuals, groups, or schools (CTB, 1970).

Academic aptitude was measured with the Short-Form Test of Academic Aptitude (SFTAA), also developed by the California Test Bureau and used in conjunction with the Comprehensive Test of Basic Skills. It consists of four item types: Vocabulary, Analogies, Sequences, and Memory. Language, Non-Language, and Total IQ scores are derived from the test: the Non-Language score, used in this study, is based on the Analogies and Sequences items.

The Sears Self-Concept Inventory (SCI) was the self-concept measure used in this study. It is a 48-item inventory asking children to compare themselves on each item with others their own age. The inventory is revised from an original instrument of 100 statements (Sears, 1963). The revised instrument yields a total score and nine subscale scores for theoretically integrated subareas of self-concept: physical ability, social relations with same sex, attractive appearance, social virtues, happy qualities, work habits, divergent mental ability, convergent mental ability, and school subjects (Sears, 1966; Sears et al., 1972; Marx, forthcoming). The last four subscales can be combined into an academic self-concept scale (Marx and Winne, 1974; Marx, forthcoming), which was used in the present study.

The Intellectual Achievement Responsibility Questionnaire (IAR) was used in the study as a measure of internal-external control of reinforcements (locus of control) in intellectual-academic situations (Crandall, Katkovsky, and Crandall, 1965). It is composed of 34 forced-choice items which pose either a positive (success) or negative (failure) achievement experience. Each item (stem) is followed by two alternative responses, one explaining occurrence of the situation due to oneself (internal) and the other due to someone else's behavior (external). The total internal control score was used in the present study, but the instrument also yields two subscale scores, I+ (internal responsibility for success) and I- (internal responsibility for failure).

Field dependence-independence, or analytic ability, was measured with the Group Embedded Figures Test (GEFT), an adaptation of the original individually administered Embedded Figures Test (Witkin et al., 1971). It is an 18-item group administered paper and pencil test. The task is to determine where a designated simple geometric figure is embedded in a complex design for each item and to trace it. Those who can do this successfully are field-independent.

Procedures

Classrooms in three schools were selected as providing three representative sixth grade mathematics instructional treatments employed within the school district. Schools were selected on the basis of districtwide observations in classrooms during the 1973-74 school year and followup interviews with principals and teachers to verify treatments used during 1974-75, the year of this study. Classroom observations were conducted during the course of this study for documenting classroom activities in the different treatments, but will not be detailed in this report. The three mathematics treatments studied were: Treatment One, traditional whole class instruction based on a basal textbook; Treatment Two, a locally-developed mathematics management system which correlated instructional objectives with various published curricula and which utilized a combination of individual, small group, and large group instruction; and Treatment Three, Individually Prescribed Instruction (IPI), which was one of the major programs implemented in the district in its attempt to individualize instruction.

The CTBS was routinely administered by the school district in the spring of each year. Spring 1974 scores were used as pretest measures, and spring 1975 scores were used as the posttests for this study. The IQ scores were taken from the district's administration of the SFTAA in spring 1974. This test was administered by the district every other year during the five-year project. The other measures described were group-administered in the classrooms by the authors.

Method of Analysis

Data were submitted to regression analyses to test for ATI's. First, using single aptitude variables (pretest achievement, IQ, self-concept, locus of control, and field dependence-independence) to predict the criterion variables (posttest achievement), slopes were tested for homogeneity of within-class regressions (Winer, 1971); the Johnson-Neyman technique was applied in the case of significant differences among regression slopes to determine critical regions of significance (Kerlinger and Pedhazur, 1973). Second, a multiple regression approach was then used, in which the various aptitude variables were forced into the regression equation first, followed by treatment variables and aptitude X treatment interaction variables to assess the relative contributions of each, as well as the cumulative effect of all variables, in predicting the criterion achievement variables.

Results

Basic descriptive statistics for the three treatments on the several variables are shown in Table 1. There were significant differences among groups on the posttest and pretest achievement measures and on the GEFT (field

Table 1
Means and Standard Deviations for
Three Mathematics Treatments

	Treatment One[a] (n = 37)		Treatment Two (n = 45)		Treatment Three (n = 42)	
	$\overline{X}$	S. D.	$\overline{X}$	S. D.	$\overline{X}$	S. D.
Posttest Achievement						
TOTAL	500.03	65.67	446.78	59.19	437.79	52.95
COMPUTATION	510.30	71.78	437.96	54.73	430.05	55.64
CONCEPTS	496.43	66.87	466.89	64.60	454.33	58.85
APPLICATIONS	505.24	68.85	467.93	70.25	457.91	65.04
Pretest Achievement						
TOTAL	467.43	52.82	436.71	51.96	410.07	47.23
COMPUTATION	453.92	43.52	425.36	48.58	391.10	46.65
CONCEPTS	495.92	71.81	460.24	58.37	444.86	54.75
APPLICATIONS	484.11	72.82	449.89	72.84	437.81	63.95
Other Student Aptitudes						
SFTAA (IQ)	107.24	14.89	100.56	14.80	100.57	13.36
GEFT	12.03	5.19	9.60	4.94	8.55	4.13
SCI-ACADEMIC	3.22	.63	3.08	.83	3.48	.76
IAR-TOTAL	24.00	4.47	22.98	3.52	23.48	4.74

[a]Treatment One is the basal text treatment; Treatment Two is the math management treatment; and Treatment Three is the IPI treatment.

dependence-independence), but not on IQ, academic self concept, or internal locus of control. The general regression model will adjust for differences among groups where they exist and does not require random assignment to groups when the results are not generalized beyond the sample itself or a similarly distributed sample (Cohen, 1968). For an evaluation study such as this, the population of interest is the one examined or one very similar to it; e.g., other students in the same district. As in most field-based evaluation studies, treatments in this study were composed of intact, not randomly assigned, groups. ATI analyses, utilizing the regression model, provide potentially fruitful information by examining differential outcomes for subjects differing on some designated aptitude variable. The results of the two methods of analyzing aptitude-treatment interactions will be reported here: first, simple bivariate regression analyses examining a series of relationships between single predictor variables (aptitudes) and single criterion variables (achievement); and, second, multiple regression analyses assessing the effects of several aptitude variables, treatment variables, and then interactions of aptitudes with treatments on the predicted criterion variables.

Bivariate Regression ATI Analyses

Results will be reported first for the bivariate regression analyses in which single aptitude variables were used to predict posttest performance on the four arithmetic achievement measures used in this study: CTBS Arithmetic Total and the three subtests of Computation, Concepts, and Applications.

Predicting Posttest Arithmetic Total. Regression slopes of the three treatments for posttest Arithmetic Total regressed on pretest Arithmetic Total, and each of the other aptitude variables, were tested for homogeneity of within-class regressions. For Arithmetic Total on pretest Total, there was a significant difference among the three slopes. These results are shown in Table 2, and the regression lines are pictured in Figure 1. Tests of pairs of slopes yielded a significant difference ($p < .05$) between Treatment Three, IPI, and Treatment One, basal text, and a difference nearly as significant ($p < .06$) between Treatment Three and Treatment Two, the math management group. The basal text and math management treatments each had more positive slopes than the IPI treatment.

The Johnson-Neyman technique was applied to determine the regions of critical significance. As shown in Figure 1, Comparing Treatment One with Treatment Three, the region of critical difference occurred for X (pretest Total) greater than 475.4. Students above this score at pretest ($n_1 = 18$, $n_3 = 5$) scored significantly higher at posttest in Treatment One (basal text) than in Treatment Three (IPI). However, for Treatment Two and Treatment Three, the region of critical difference was X less than 422.6 ($n_2 = 17$, $n_3 = 26$), with students having the low pretest scores achieving significantly higher on posttest Arithmetic Total in IPI than in the math management treatment.

Regressing posttest Arithmetic Total on each of the other aptitudes (non-language IQ, field dependence-independence, academic self-concept, internal locus of control) yielded somewhat similar patterns, with the basal text whole class treatment in all cases having the most positive slope. When field

Table 2
Treatment Regressions Predicting Posttest Arithmetic Achievement Total on Pretest Arithmetic Total

Group	a	b[a]	r
Treatment One (n = 37)	-13.76	1.099	.88
Treatment Two (n = 45)	-3.46	1.031	.91
Treatment Three (n = 42)	131.74	.746	.67

[a]Overall F for homogeneity of within-class regression = 3.14, $p < .05$ (df = 2, 118).

$F_{1 \text{ vs } 3} = 4.56$, $p < .05$ (df = 1, 75)

$F_{2 \text{ vs } 3} = 3.78$, $p < .06$ (df = 1, 83)

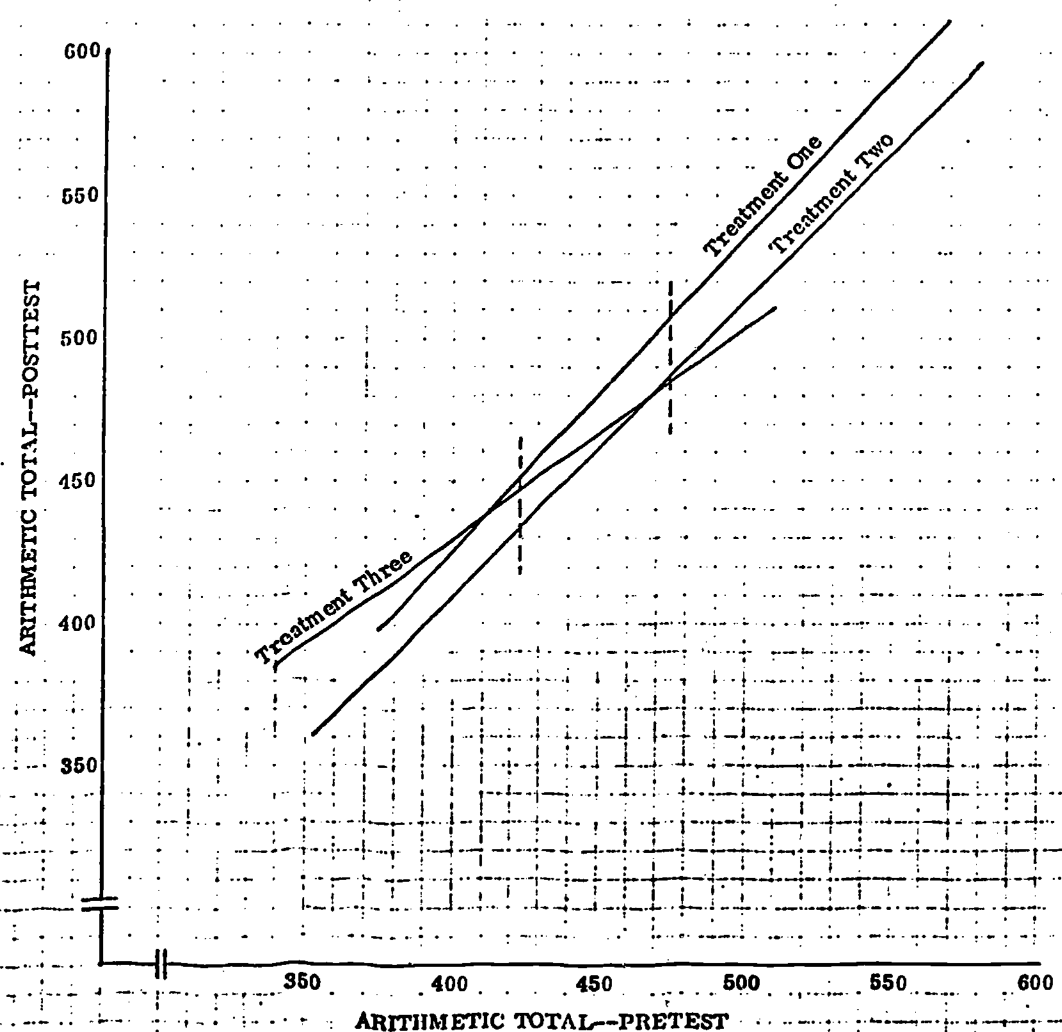

FIGURE 1. Posttest Arithmetic Total regressed on pretest Arithmetic Total for each treatment. Johnson-Neyman regions of significance are shown with vertical dashed lines. For X (pretest) > 475.2, $Y_1 > Y_3$, $p < .05$ ($n_1 = 18$, $n_3 = 5$). For X < 422.6, $Y_3 > Y_2$, $p < .06$ ($n_2 = 17$, $n_3 = 26$).

dependence and locus of control predicted total achievement, the IPI slope was slightly more positive than the math management slope. No differences among slopes in any of these comparisons were significant, however.

Predicting Posttest Computation. The general patterns of regressions predicting posttest Computation were exactly the same as for Arithmetic Total. The regressions of posttest Computation on pretest Computation for each treatment are shown in Table 3 and Figure 2. The test for homogeneity of within-class regression again yielded differences among treatments, nearly significant at the .05 level ($p < .06$). Comparisons of pairs of slopes showed that the basal text treatment again had a significantly more positive slope than IPI. The Johnson-Neyman technique showed that the region of critical significance occurred for X (pretest Computation) greater than 445.7 ($n_1 = 19$ and $n_3 = 6$), with posttest achievement significantly higher in the basal text group than in IPI for those above this pretest level. Results of the F-tests for homogeneity of regression yielded trends of differences in two other comparisons: Treatment One had a more positive slope than Treatment Two, and Treatment Two's slope was more positive than Treatment Three's (both at $p < .20$).

As for Arithmetic Total, there were no significant differences among slopes of the three treatments on the other comparisons, although the trend of the values of the regression coefficients was Treatment One > Treatment Two > Treatment Three, except for field dependence and locus of control as predictors, where Treatment Three again had only slightly more positive slopes than Treatment Two.

Table 3
Bivariate Regressions Predicting Posttest Computation Achievement on Pretest Computation

Group	a	b[a]	r
Treatment One (n = 37)	-35.84	1.203	.73
Treatment Two (n = 45)	44.28	.93	.82
Treatment Three (n = 42)	167.22	.67	.56

[a]Overall F for homogeneity of within-class regression = 2.99, $p < .06$ (df = 2,118).

$F_{1 \text{ vs } 3} = 4.72$, $p < .05$ (df = 1, 75)

$F_{2 \text{ vs } 3} = 2.03$, $p < .20$ (df = 1, 83)

$F_{1 \text{ vs } 2} = 1.91$, $p < .20$ (df = 1, 78)

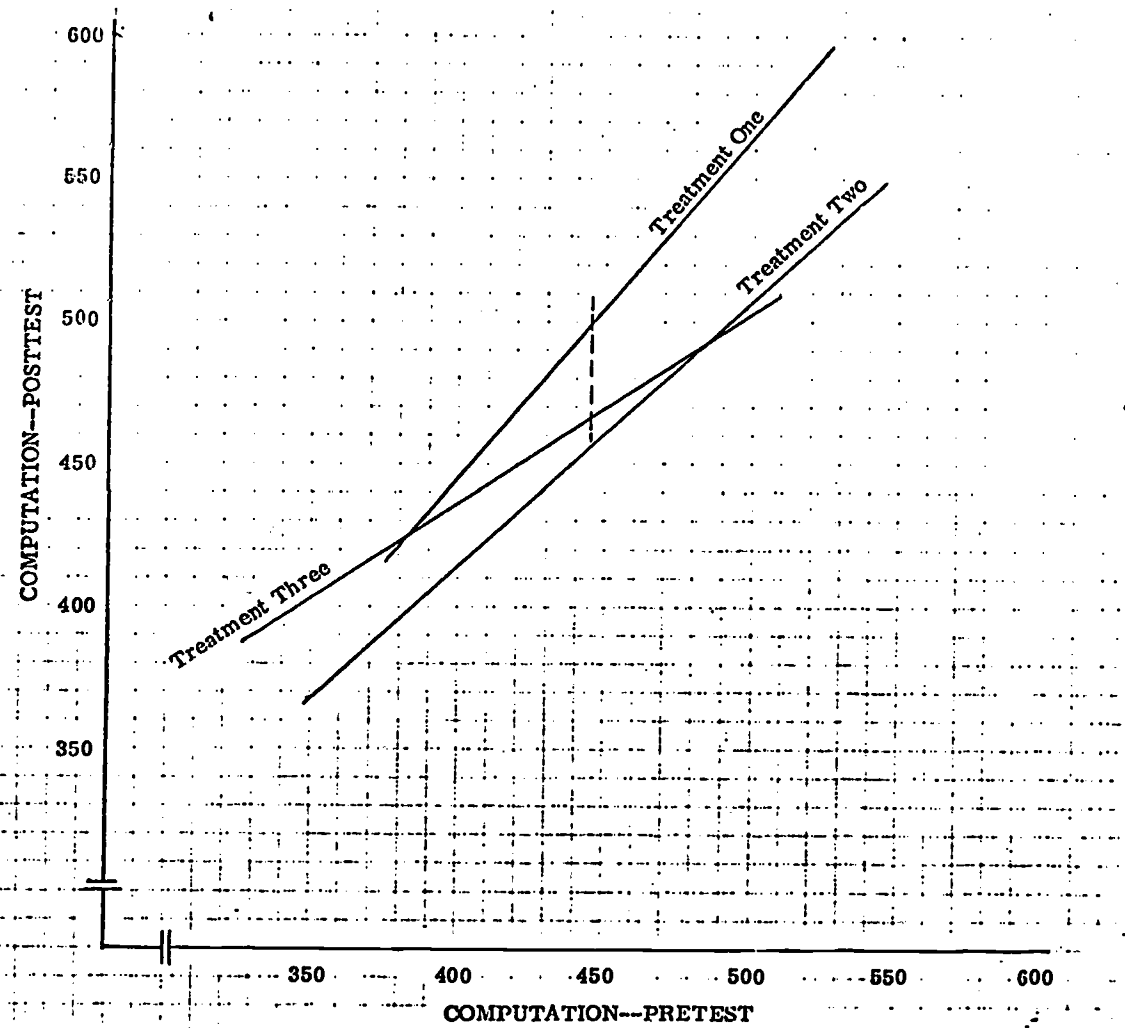

FIGURE 2. Posttest Computation regressed on pretest Computation for each treatment. Johnson-Neyman region of significance is shown with vertical dashed lines. For X (pretest) > 445.7, $Y_1 > Y_3$, $p < .05$ ($n_1 = 19$, $n_3 = 6$).

Predicting Posttest Concepts and Applications. Patterns of regression slopes predicting posttest Concepts and Applications were very similar to those for Arithmetic Total and Computation, but no significant differences among slopes occurred for any comparisons, including those with pretest achievement measures as predictors.

Multiple Regression Analyses

Another set of four analyses was performed, utilizing a more complete multiple regression ATI model. These analyses examined the contributions of student aptitude variables, treatment variables, and finally, aptitude X treatment interaction variables in a hierarchical procedure.

Aptitude scores (pretest achievement, field independence, self-concept, and locus of control) were transformed into deviation scores so that each subject's score on a variable was a deviation from the grand mean for that variable (Cronbach and Snow, forthcoming). Two variables for treatment codes were constructed, using vectors with effect coding as described by Kerlinger and Pedhazur (1973). Subjects in Treatment One, the basal text whole class approach, were coded 1 and 0 for the two vectors; S's in Treatment Two, the mathematics management approach, were given codes of 0 and 1; and S's in Treatment Three, IPI, were coded -1 and -1. Thus, treatment vector 1 represented the effect of Treatment One, whereas vector 2 represented the effect of Treatment Two (Kerlinger and Pedhazur, 1973).

Aptitude X treatment interaction variables were created by multiplying each treatment vector by the respective aptitude deviation score (Cronbach and

Snow, forthcoming; Kerlinger and Pedhazur, 1973; Cohen, 1968); thus, for example, there were two ATI variables for pretest achievement, one representing an interaction showing the effect of Treatment One (coded 1 in vector 1) and the other an interaction showing the effect of Treatment Two (coded 1 in vector 2).

All three treatments had similar slopes when posttest scores were regressed on IQ. Since non-language IQ had strong correlations with the pretest achievement scores (.60 with Computation, .74 with Concepts, .65 with Applications, and .72 for Total), two methods were used to deal with this problem of multicollinearity. The first method was the creation of a combined achievement and IQ variable by adding the z-scores of IQ and the respective pretest achievement measure. However, this method tended to attenuate any pretest achievement X treatment interactions that existed, due to no differences among treatments when predicting posttest achievement with IQ. The second method used, and the one to be reported in the remainder of this paper, eliminated IQ from the aptitude variables and used the pretest achievement measure in place of the two. This method tended to maximize the possibility of detecting ATI effects.

Following a hierarchical regression model, the respective pretest achievement variable was forced into the equation first, followed by the other aptitude variables (field dependence-independence, academic self-concept, internal locus of control); next the two treatment variables were forced into the equation to assess their effects once the aptitude variables were in; finally, the eight ATI variables were forced into the equation in predetermined order (treatment vector 1 code X aptitude 1--pretest achievement, treatment vector 2 code

X aptitude 1, ... , up to treatment vector 2 code X aptitude 4--locus of control). Table 4 shows the hierarchical model used and serves as a reference list of the variables.

The overall multiple regression equations elicited final partial regression coefficients for each variable (including treatment and ATI variables) over all S's (n = 124). From the overall equations, regression equations were then constructed for each treatment (Kerlinger and Pedhazur, 1973). The constant for each treatment was derived from the overall constant, adjusted by the values of that group's treatment vector codes multiplied by the vectors' unstandardized regression coefficients in the final equation [e.g., constant for Treatment One = overall a + 1 (b_{TRT1}) + 0 (b_{TRT2})]. The aptitude regression coefficient for a treatment was likewise derived from the overall regression coefficient for that aptitude, adjusted by the products of its treatment vector codes and the regression coefficients of the two corresponding ATI variables [e.g., Treatment One's regression coefficient for pretest Arithmetic Total = overall b for TOTAL + 1 ($b_{TOTALXT1}$) + ($b_{TOTALXT2}$)]. Individual treatment regression equations, then, included the aptitudes only, as the treatment and ATI effects were reflected in the aptitude regression coefficients and constants.

Predicting Posttest Arithmetic Total. As shown in Table 5, the pretest achievement measure accounted for nearly 72 percent of the total variance in predicting posttest total score ($p < .001$). The field dependence-independence measure (GEFT) accounted for an additional 1.7 percent ($p < .01$). The two variables accounted for 73.5 percent of the variance in predicting the posttest, with the remaining variables in the full regression model accounting for an

Table 4
Hierarchical Regression Model

Variable Name	Abbreviation
Aptitude Variables[a]	
1. Pretest achievement (for each posttest achievement measure, the corresponding pretest score was used)--CTBS	
Arithmetic Total	TOTAL
Computation	COMPU
Concepts	CONC
Applications	APPL
2. Field Dependence-Independence (Group Embedded Figures Test)	GEFT
3. Academic Self-Concept (Sears Self-Concept Inventory)	SCACAD
4. Internal Locus of Control (Intellectual Achievement Responsibility Questionnaire)	ITOTAL
Treatment Variables[b]	
5. Treatment Vector 1 Code	TRT1
6. Treatment Vector 2 Code	TRT2
ATI Variables[c]	
7. Pretest Achievement X Treatment Vector 1 Code	
Arithmetic Total X Treatment Vector 1 Code	TOTALXT1
Computation X Treatment Vector 1 Code	COMPXT1
Concepts X Treatment Vector 1 Code	CONCXT1
Applications X Treatment Vector 1 Code	APPLXT1
8. Pretest Achievement Vector 2 Code	
Arithmetic Total X Treatment Vector 2 Code	TOTALXT2
Computation X Treatment Vector 2 Code	COMPXT2
Concepts X Treatment Vector 2 Code	CONCXT2
Applications X Treatment Vector 2 Code	APPLXT2
9. Field-Dependence-Independence X Treatment Vector Code 1	GEFTXT1

Variable Name	Abbreviation
10. Field Dependence-Independence X Treatment Vector 2 Code	GEFTXT2
11. Academic Self-Concept X Treatment Vector 1 Code	SCACXT1
12. Academic Self-Concept X Treatment Vector 2 Code	SCACXT2
13. Internal Locus of Control X Treatment Vector 1 Code	ITOTXT1
14. Internal Locus of Control X Treatment Vector 2 Code	ITOTXT2

[a]Aptitude scores are deviations of S's scores from grand mean

[b]Treatment codes form two vectors of effect coding (Kerlinger and Pedhazur, 1973). (Treatment One S's had 1 and 0 for the vector scores; Treatment Two S's had 0 and 1; Treatment Three S's had -1 and -1.)

[c]ATI variables are formed by multiplying the aptitude (deviation) scores by coded treatment vector scores.

Table 5
Multiple Regression ATI Analysis Predicting
Posttest Arithmetic Total Achievement

Variable[a]	R^2	R^2 Increase	r	b[b]	F to Enter
Aptitude Variables					
TOTAL-PRETEST	.718	.718	.85	.901	310.22***
GEFT	.735	.017	.63	1.899	7.66**
SCACAD	.735	.000	.15	-5.578	.01
ITOTAL	.735	.001	.12	.195	.35
Treatment Variables					
TRT1	.736	.001	.38	6.064	.30
TRT2	.736	.020	.05	-9.126	9.66**
ATI Variables					
TOTALXT1	.765	.009	.19	.227	4.47*
TOTALXT2	.767	.002	.09	.095	.80
GEFTXT1	.771	.005	.15	- .934	2.28#
GEFTXT2	.775	.003	.03	-1.289	1.74
SCACXT1	.776	.001	.12	-9.740	.45
SCACXT2	.779	.003	.10	6.971	1.54
ITOTXT1	.779	.000	.11	.051	.05
ITOTXT2	.779	.000	-.01	.248	.05

Constant 456.722

[a]full variable names are listed in Table 4
[b]unstandardized regression coefficient

*$p < .05$
**$p < .01$
***$p < .001$
#$p < .15$

Individual Treatment Regression Equations:

$$Y_1' = 462.786 + 1.128(\text{TOTAL}) + .965(\text{GEFT}) - 15.319(\text{SCACAD}) + .246(\text{ITOTAL})$$

$$Y_2' = 447.596 + .996(\text{TOTAL}) + .610(\text{GEFT}) + 1.393(\text{SCACAD}) + .443(\text{ITOTAL})$$

$$Y_3' = 459.784 + .580(\text{TOTAL}) + 4.12(\text{GEFT}) - 2.809(\text{SCACAD}) - .103(\text{ITOTAL})$$

additional 4.4 percent of the variance. The achievement X treatment vector 1 ATI variable added significantly to the prediction. Treatment vector 2 accounted for a significant treatment effect, but there was no ATI effect for this treatment vector X pretest achievement. There was a trend of an ATI effect indicated for GEFT and treatment vector 1.

Using the final treatment regression equations, regression planes of posttest achievement on the two variables of pretest achievement and field independence for the three treatments were plotted in a three-dimensional space to examine the interactions. Students who were high on pretest achievement (whether highly field independent or dependent) had higher achievement in Treatment One and Treatment Two than in Treatment Three, while those low on pretest achievement performed better in IPI than the other treatments (this reflects the relationship found in the earlier bivariate ATI analysis). The GEFT X treatment interaction trend appeared to be in effect mainly for students with low pretest achievement. While low pretest students did better, in general, in Treatment Three, whether field dependent or independent, students with both low pretest achievement and low field independence did nearly equally well in all treatments, whereas students who were low pretest achievers and highly field independent did much better in IPI than in the other two treatments. Thus, high field independence tended to enhance total arithmetic achievement for students in IPI, especially low achieving students, but had less effect for students in the other two treatments. In the individualized work of IPI, it may be that analytic ability (as represented by the GEFT) may help the low achieving student structure his own learning environment, persist in his tasks, and understand the non-language type of operations in the mathematics subject matter. The low analytic, low achieving student may have more problems either in structuring his own learning environment or in dealing with the subject matter on his own.

Predicting Posttest Computation. Results of the multiple regression analysis predicting posttest Computation was somewhat similar to that for Arithmetic Total. Table 6 shows that, as before, pretest achievement and field dependence-independence were significant predictors ($p < .001$ for both). In this case, GEFT accounted for an additional 7.5 percent of the variance in predicting posttest Computation beyond that already accounted for by the pretest achievement variable. These two variables together accounted for 62.4 percent of the variance in the prediction. The remaining variables accounted for an additional 8.9 percent of the variance--the most of the four analyses. Both treatment vectors also yielded significant effects (affecting the constants of the individual regression equations) in predicting posttest Computation. As in the case of Arithmetic Total, there was a significant ATI effect for pretest achievement X treatment vector 1 (showing the effect of Treatment One). In addition, an ATI effect for GEFT X treatment vector 2 approached significance ($p < .10$). Again these results appear to reflect those found in the bivariate regression approach.

Again, individual treatment regression equations were used to plot treatment regression planes of posttest Computation achievement on pretest Computation and field independence. The achievement X treatment interaction appeared more pronounced for students with high field independence, in which case students with low pretest achievement did better in Treatment Three (IPI). Performance

Table 6
Multiple Regression ATI Analysis Predicting
Posttest Computation Achievement

Variable[a]	R^2	R^2 Increase	r	b[b]	F to Enter
Aptitude Variables					
COMPU	.548	.548	.74	.715	48.16***
GEFT	.624	.075	.62	4.094	24.25***
SCACAD	.629	.005	.19	4.957	1.54
ITOTAL	.632	.003	.12	.311	1.07
Treatment Variables					
TRT1	.646	.014	.45	20.037	4.60*
TRT2	.686	.040	.04	-16.991	14.94***
ATI Variables					
COMPXT1	.697	.011	.15	.187	4.14*
COMPXT2	.697	.000	-.00	.107	.00
GEFTXT1	.699	.002	.14	-.208	.89
GEFTXT2	.706	.007	-.02	-1.975	2.84#
SCACXT1	.707	.000	.08	-.037	.10
SCACXT2	.708	.001	.05	-5.502	.53
ITOTXT1	.712	.003	.10	1.640	1.33
ITOTXT2	.713	.001	-.04	-.857	.41

Constant 452.838

[a]full variable names are listed in Table 4
[b]unstandardized regression coefficient

*p <.05
**p < .01
***p < .001
#p <.10

Individual treatment regression equations:

$$Y_1' = 472.875 + .902(\text{COMPU}) + 3.886(\text{GEFT}) + 4.919(\text{SCACAD}) + 1.951(\text{ITOTAL})$$

$$Y_2' = 435.847 + .823(\text{COMPU}) + 2.119(\text{GEFT}) - .545(\text{SCACAD}) - .546(\text{ITOTAL})$$

$$Y_3' = 449.793 + .421(\text{COMPU}) + 6.277(\text{GEFT}) + 10.496(\text{SCACAD}) - .472(\text{ITOTAL})$$

was highest in traditional math for those with high pretest achievement and high field independence. The GEFT X treatment interaction trend again appeared most pronounced for students with low pretest achievement: as in Total achievement, although IPI students were always higher, low achieving, field dependent students in IPI had posttest performance about equal to that for similar students in the other two treatments, whereas more field independent, low achieving students did best in IPI. As for Arithmetic Total, a high degree of analytic ability (field independence) may, to some degree, compensate for low achievement in IPI and allow those students to be more independent and task oriented and to be able to structure their own learning to a greater degree than less analytic low achieving students.

Predicting Posttest Concepts and Applications. As shown in Table 7, there were three significant predictors of posttest Concepts. The pretest measure and GEFT predicted most of the variance (57.7 percent) as in all the predictions. Remaining variables added only 3.4 percent to the variance. The only other significant predictor was an ATI variable, Academic Self-Concept X treatment vector 2. representing the effect of Treatment Two (coded 1 in that vector). Using individual treatment regression equations to plot treatment regression planes for posttest Concepts on pretest Concepts and self-concept showed that for students with high pretest Concepts achievement, those with high self-concepts performed better in Treatment Two (math management), while those with low self-concepts performed better in traditional math. Low achieving students at pretest achieved better in IPI than in the competing two treatments at most levels of self-concept. While low prior achieving students with high self-concept did better in math management than in traditional math; the reverse

Table 7
Multiple Regression ATI Analysis Predicting
Posttest Concepts Achievement

Variable[a]	R^2	R^2 Increase	r	b[b]	F to Enter
Aptitude Variables					
CONC	.559	.559	.75	.669	154.57**
GEFT	.577	.018	.57	2.349	5.24*
SCACAD	.578	.001	.10	-4.734	.20
ITOTAL	.578	.000	.10	.436	.00
Treatment Variables					
TRT1	.578	.000	.26	-2.851	.00
TRT2	.578	.000	.08	2.544	.01
ATI Variables					
CONCXT1	.581	.003	.20	.139	.83
CONCXT2	.582	.001	.07	.037	.27
GEFTXT1	.586	.004	.12	-1.179	1.07
GEFTXT2	.586	.001	.03	-.567	.16
SCACXT1	.586	.000	.10	-11.969	.00
SCACXT2	.602	.016	.12	15.774	4.43*
ITOTXT1	.603	.000	.12	-.943	.07
ITOTXT2	.611	.008	.04	2.266	2.38

Constant 472.023

[a]full variable names are listed in Table 4
[b]unstandardized regression coefficient

*$p < .05$
**$p < .001$

Individual treatment regression equations:

$$Y_1' = 469.172 + .808(\text{CONC}) + 1.171(\text{GEFT}) - 16.703(\text{SCACAD}) - .508(\text{ITOTAL})$$

$$Y_2' = 474.568 + .706(\text{CONC}) + 1.782(\text{GEFT}) + 11.041(\text{SCACAD}) + 2.702(\text{ITOTAL})$$

$$Y_3' = 472.329 + .494(\text{CONC}) + 4.094(\text{GEFT}) - 8.538(\text{SCACAD}) - .887(\text{ITOTAL})$$

was true for those with low self-concepts. Thus, high academic self-concept appears to have enhanced achievement in the math management treatment and to have decreased performance in traditional math. Perhaps students with high academic self-concept respond better to instruction which operates in a variety of instructional modes, such as different groupings and materials. They may feel comfortable, secure, and more free to develop in this type of situation, whereas they might feel restricted in a more structured whole class traditional approach with less flexibility. Low self-concept students, on the other hand, may have their conceptual achievement somewhat enhanced when they feel the security of a more structured learning situation.

In predicting posttest Applications (see Table 8), the only significant predictors were pretest achievement and GEFT. These two variables together accounted for 50.7 percent of the variance in predicting the posttest score. The remaining variables in the full regression model accounted for only 2.3 percent additional variance, the least of the four regression analyses.

Summary and Discussion

The evaluation study reported here has demonstrated the existence of aptitude X treatment interactions influencing some areas of mathematics achievement in this sample. Mathematics achievement measures examined were three subtests (Computation, Concepts, and Applications) and Total score on the CTBS. Using student prior achievement to predict posttest achievement, similar patterns occurred for all posttest measures, with significant differences among treatment slopes for Total and Computation scores.

Table 8
Multiple Regression ATI Analysis Predicting
Posttest Applications Achievement

Variable[a]	R^2	R^2 Increase	r	b[b]	F to Enter
Aptitude Variables					
APPL	.482	.482	.69	.616	113.60**
GEFT	.507	.025	.52	2.208	6.07*
SCACAD	.507	.000	.11	-6.520	.09
ITOTAL	.507	.000	.07	-.410	.01
Treatment Variables					
TRT1	.511	.004	.27	5.411	.98
TRT2	.513	.002	.05	-2.555	.40
ATI Variables					
APPLXT1	.517	.004	.15	.216	1.04
APPLXT2	.517	.000	.11	-.042	.01
GEFTXT1	.523	.006	.11	-1.823	1.47
GEFTXT2	.524	.000	.06	-.077	.01
SCACXT1	.526	.002	.12	-13.999	.54
SCACXT2	.530	.004	.12	8.595	.99
ITOTXT1	.530	.000	.11	.169	.01
ITOTXT2	.530	.000	-.01	-.094	.00

Constant 474.969

[a]full variable names are listed in Table 4
[b]unstandardized regression coefficient

*$p < .05$
**$p < .001$

Individual treatment regression equation:

$$Y_1' = 480.380 + .831(APPL) + .385(GEFT) - 20.519(SCACAD) - .240(ITOTAL)$$

$$Y_2' = 472.414 + .574(APPL) + 2.131(GEFT) + 2.439(SCACAD) - .504(ITOTAL)$$

$$Y_3' = 472.114 + .442(APPL) + 4.108(GEFT) - 1.480(SCACAD) - .485(ITOTAL)$$

On both of these measures, students in the basal text whole class treatment had significantly more positive slopes than students in IPI. The region of significance was for those at the higher ranges of pretest achievement. Although the two regression lines crossed, making the interaction disordinal, there were too few cases in the basal text treatment below that point to cause significant differences in that range. Thus, for this particular sample, those students in mid-range to low-range on pretest achievement (Total and Computation), achieved about the same at posttest on those measures in either treatment. However, at the higher levels of pretest achievement, students in the basal text, whole class treatment achieved significantly better at posttest than those in IPI. Maguire (1971) reported teachers' general perceptions that IPI mathematics was better suited to the "above average" and "average" student than most mathematics programs; from interviews with teachers, he also reported their feelings that IPI provides well for "below average" students in upper elementary grades. Results from the present study did not support the former opinion in this sample, but did suggest that below average students tended to gain more in IPI than in a competing treatment. Maguire also reported analyses in which control schools (matching IPI schools on location and SES; type of mathematics instruction was not specified) had higher adjusted mean achievement than IPI schools in the third and sixth grades; the present study generally supports this finding at the sixth grade, but only for higher prior achieving students. There was no interaction in that study between ability level and type of instruction. The present study did not yield a significant interaction of ability level and posttest achievement, but did yield an interaction between prior achievement (substantially correlated with ability) and type of instruction.

On Arithmetic Total, there was a disordinal interaction for posttest regressed on pretest, when comparing IPI and the math management treatments. IPI students with low prior achievement performed significantly better at posttest than did students with comparable prior achievement in the math management treatment. Students who had middle or high prior achievement performed as well at posttest in one treatment as in the other. A similar interaction occurred for the Computation subtest, but differences were not significant.

For Concepts and Applications achievement, it appeared to make little difference in this sample what treatments students were assigned to in relation to prior achievement; students at all levels of pretest achievement achieved about as well in any of the three instructional methods.

In all four multiple regression equations the pretest achievement variable, as expected, was the single most highly significant predictor, accounting for a range from a low of 48 percent (for Applications) to a high of 72 percent (for Arithmetic Total) of the variance in predicting the posttest scores, leaving relatively little variance to be accounted for by other variables; however, this may reflect reality, and even given this situation, certain other variables also contributed significantly to the variance. Field dependence-independence was a significant predictor in all equations even after the large effect of pretest achievement was accounted for, providing confirming evidence that field independent students perform better than field dependent students on mathematics tasks. In the case of the prediction of posttest Computation, GEFT accounted for an additional 7.5

percent of the variance (an increase of .075 in R^2). No other aptitude variables by themselves were significant predictors in any of the four equations.

Significant treatment effects occurred in predicting Arithmetic Total and Computation after all aptitude variables had entered the equations; thus, in these cases, treatment added a significant effect over and above the student aptitudes and was a significant factor accounting for posttest differences. In these two equations, as well, there were significant added contributions, beyond the effects of aptitudes and treatments, by pretest achievement X treatment interactions, which confounded the treatment effects according to initial achievement level. An additional ATI variable, GEFT X treatment interaction (which did not occur in the bivariate ATI analyses) approached a significant effect in these equations; high field independence tended to enhance the performance of low prior achieving students in IPI.

Academic self-concept interacted with treatment after all ability, treatment, and prior ATI variables were entered into the prediction equation for posttest Concepts. This result was such that, holding the effects of all variables in the equation constant, self-concept had a positive influence on achievement in the math management treatment, but tended to have a general negative influence in traditional math. Low prior achieving students generally did better in IPI than the other treatments regardless of self-concept. The last regression equation, predicting Applications achievement, had no significant treatment or ATI effects; the only significant predictors were the two aptitudes of pretest achievement and field dependence-independence; instructional method made no difference on achievement of arithmetic applications skills.

The results of this study show that students do have varying patterns of ability, achievement and personality traits which can interact in complex ways. Thus, categorizing students and assigning them to instructional methods on one dimension only may overlook some other important factors which may also influence outcomes.

However, for the particular sample in this evaluation study, pretest achievement appeared to be the single most salient aptitude interacting with treatment to influence achievement outcomes. There was evidence that students at higher pretest achievement levels achieved more on Computation and Arithmetic Total in traditional mathematics instruction than in IPI, and that students with lower pretest achievement scores achieved better in IPI. However, overall, students had highest achievement (posttest, as well as pretest) in traditional math and least in IPI.

There could be various reasons for these results. The different curricula utilized may give different amounts of emphasis to the various arithmetic skills tested in the different sections of the CTBS. Standardized tests, for example, may not adequately test the skills taught in IPI (Lindvall and Cox, 1970). In this particular school district, an earlier examination of content of the CTBS arithmetic tests and the skills of the IPI continuum showed that the Concepts and Computation sections were well represented in IPI, but Application items were not (District Evaluator, 1972). Since there were no ATI's in the present study for Applications, which was not deemed representative of IPI skills, but there was a significant ATI for Computation, determined to be representative of IPI, this explanation cannot account for all differences. Also, studies reported by Research for Better Schools (1971) showed that students in IPI math generally performed as well on various achievement measures as non-IPI students. For some measures, this study elicited results varying for different initial achievement levels.

A previous study of IPI math in a school in this school district, but not one included in the present analyses, showed that progress of selected students going from fifth to sixth grade was better for students in the IPI school than for students in comparable non-IPI schools on all CTBS subtests and total (District Superintendent, Project Director, and Evaluator, 1972). These results were based on group means, however, not on students' prior achievement levels. The present study showed some differences in achievement in general, as well as in growth predicted by pretest achievement on two of the measures, as previously discussed. Thus, even within a school district with a homogeneous student population, there may be individual school effects which influence outcomes. For example, in the sample in this study, although there were no statistically significant differences among groups on ability, the basal text treatment did have a higher mean IQ, as well as more students on the high end of the continuum on pretest achievement (and an initially higher mean achievement), whereas the IPI group had more at the lower end, which may have emphasized differences between groups at these ranges. Although there were not significant differences among groups on SES, it is known that the population in the IPI school attendance area is more mobile than at the other two schools. The school climates may reflect such differences and, in turn, influence achievement.

It may be that greater competition and a climate emphasizing achievement exist in the particular school utilizing the basal text approach, to which higher achieving students respond positively. Lower achieving students may respond better to the individual pace and to the established structure and continuity of method in IPI than to the changing structure and curricula in the math management instruction or to the faster pace of traditional instruction.

There may be other such interactions between student characteristics and methods. For example, there was evidence in this study that field independence, or analytic ability, tended to interact with treatment in producing post-test achievement. High analytic ability seemed to enhance Computation and Total achievement for low prior achieving students in IPI. Perhaps this ability allowed these students to structure their own individual learning and enabled them to be more task-oriented and to deal on their own with the numerical subject matter; low achieving students without this ability may not have been able to cope with the subject matter or individualized situation as well. High academic self-concept appeared to enhance Concepts achievement for students in math management and seemed to be somewhat detrimental to achievement in the other two treatments. Perhaps being in a learning situation with more variety (in curricula and groupings), and possibly less structure, high self-concept students may have had more emotional freedom and the self-confidence to thrive in dealing with conceptual aspects of mathematics. These students may have felt somewhat constricted and less motivated in the other two methods which were probably more structured, albeit in different ways (e.g., sequence and content in IPI, teacher direction in traditional math).

Two different levels and forms of CTBS were used as pretest and posttest measures in this study (due to the district administering form R in 1974 rather than form Q which it generally administered). Although CTB claims comparability among levels and forms of the test, there is some indication that forms Q and R may not be equivalent (District Evaluator, 1975). Patterns of achievement on the two forms may have been different enough to result in the regression effects achieved. However, since pretest and posttest correlations were high, indicating roughly equivalent positions of achievement for students when compared with their peers in the sample, one form reasonably can be used as an acceptable aptitude to predict performance on the other.

The results that were obtained in this study might be useful to educational decision makers in the district for optimum placement of students in different mathematics instructional treatments. The results could lead, in addition, to the examination of other variables which might account for differences in achievement, such as systematic school differences or other student individual differences.

The results obtained also suggest that, for this sample and for mathematics achievement, some of the variables investigated here are extraneous. A more parsimonious prediction model, at least for predicting Total and Computation achievement, might be based on only student pretest variables of achievement and field dependence-independence, the treatment variables, and the interactions of the two aptitudes with treatments. Such a model was tested, but not reported here, for predicting posttest Arithmetic Total and Computation, with both equations predicting the same amount of variance (within 1 percent) in the posttest as the full model equations reported here. A similar model using achievement and self-concept and their interactions with treatment for predicting Concepts achievement predicted nearly as much of the explained variance (within 3 percent) as the full model. Such refinement of the model might also lead to a refinement in generating future hypotheses to test.

The full model used in this analysis assessed the effects of several learner characteristics (or aptitudes), treatments, and interactions of treatments with the aptitudes. It is possible to extend the model further to assess effects of interactions of the various aptitudes ("trait-trait" interactions), if one wishes, as there may well be such interactions affecting outcomes of instruction. For example, it might be fruitful to explore achievement-field independence interactions in predicting mathematics achievement.

In conclusion, this study has provided an example of the application of ATI methodology in a specific field setting within an evaluation context to investigate individual differences and differential outcomes for different mathematics skills in various instructional methods. The model used in this research and evaluation study provides a useful method for a school system to evaluate instructional programs and their effects on various types of students; such information can suggest possible guidelines to decision makers for assignment of students to treatments and thus for adapting instructional methods to meet the individual needs of students in order to optimize learning. Results of a study such as this can also generate hypotheses for further research into relationships among student characteristics, instructional treatments, and achievement outcomes. For example, use of this model to evaluate the relationships between learner characteristics and treatments examined in this study might be extended to other similar samples and similar instructional methods to determine whether the results found here can be replicated or refined.

References

Astin, A. A. and Panos, R. J. The evaluation of educational programs. In R. L. Thorndike (ed.), Educational Measurement, Second Edition Washington, D.C.: American Council on Education, 1971.

Berliner, D. C. and Cahen, L. S. Trait-treatment interaction and learning. In F. N. Kerlinger (ed.), Review of Research in Education. Itasca, Illinois: F. E. Peacock Publishers, 1973.

Bledsoe, J. Self concept of Children and their intelligence, achievement, interests, and anxiety. Childhood Education, 1967, 43, 436-438.

California Test Bureau, Comprehensive Test of Basic Skills: Technical Report. Monterey, California: CTB/McGraw-Hill, 1970.

Campbell, P. B. School and self-concept. Educational Leadership, 1967, 24 (6), 510-515.

Cattell, R. B. and Butcher, H. J. The prediction of achievement and creativity. Indianapolis: Bobbs-Merrill, 1968.

Cohen, J. Multiple regression analysis as a general data-analytic system. Psychological Bulletin, 1968, 70 (6), 426-443.

Cohen, R. Conceptual styles, culture conflict, and nonverbal tests of intelligence. American Anthropologist, 1969, 71 (5), 828-856.

Cooley, W. W. Techniques for considering multiple measurements. In R. L. Thorndike (ed.), Educational Measurement, Second Edition. Washington, D. C.: American Council on Education, 1971.

Crandall, V. C., Katkovsky, W., and Crandall, V. J. Children's beliefs in their own control of reinforcements in intellectual-academic achievement situations. Child Development, 1965, 36 (1), 91-109.

Cronbach, L. J. Beyond the two disciplines of scientific psychology. American Psychologist, 1975, 30 (2), 116-127.

Cronbach, L. J. and Snow, R. E. Aptitudes and instructional methods: A handbook of research on interactions. New York: Irvington Publishers, in press.

District Evaluator. Conclusions regarding the comparability of the 1974 CTBS data (Form R) with that obtained in previous years (Form Q). District memorandum (Jefferson)* School District, January 3, 1975.

District Evaluator. "Revision of November 29, 1971 Paper: IPI MATH: ILLUSIONS AND REALITIES." District memorandum, (Jefferson)* School District, January 19, 1972.

District Superintendent, Project Director, and Evaluator. Title III Project Skill: Skill Development Through Individual Learning Levels, Final Report. (Jefferson)* School District, June 1972.

Kerlinger, F. N. and Pedhazur, E. J. Multiple regression in behavioral research. New York: Holt, Rinehart and Winston, 1973.

Lefcourt, H. M. Recent developments in the study of locus of control. In B. H. Maher (ed.), Progress in Experimental Personality Research. Vol. 6 New York: Academic Press, 1972.

Lindvall, C. M. and Cox, R. C. Evaluation as a Tool in Curriculum Development: The IPI Evaluation Program, AERA monograph series on Curriculum Evaluation. Chicago: Rand McNally, 1970.

Maguire, T. O. Evaluation of the IPI project. The Alberta Journal of Educational Research, 1971, 17 (4), 255-273.

Marx, R. W. Test manual: The Sears Self-Concept Inventory. Stanford Center for Research and Development in Teaching, Stanford Univerity, forthcoming.

Marx, R. W. and Winne, P. H. A validation study of self-concept in low SES black children with implications for educational programs. Paper presented at the annual meeting of the American Educational Research Association, Chicago, 1974.

Messick, S. The criterion problem in the evaluation of instruction: Assessing possible, not intended outcomes. In M. C. Wittrock and D. E. Wiley, The Evaluation of Instruction: Issues and Problems. New York: Holt Rinehart and Winston, 1970.

Purkey, W. W. Self-Concept and school achievement. Englewood Cliffs, New Jersey: Prentice-Hall, 1970.

*Jefferson is a pseudonym used for the district in this study.

Randhawa, B. S. and Fu, L. L. W. Assessment and effect of some classroom environment variables. Review of Educational Research, 1973, 43 (3), 303-321.

Research for Better Schools. Progress report II: Individually Prescribed Instruction. Philadelphia: Research fo Better Schools, Inc., 1971.

Sears, P. S. Memorandum with respect to use of the Sears Self-Concept Inventory. Mimeographed, Stanford University, 1966.

Sears, P. S. The effect of classroom conditions on the strengths of achievement motive and work output on elementary school children. Cooperative Research Project No. OE 873, Stanford University, 1963.

Sears, P. S., Bloch, M., Hubner, J., Gamble, J., Adenubi, M., and Crist, J. Effective reinforcement for achievement behaviors in disadvantaged children: The first year. Stanford University, Stanford Center for Research and Development in Teaching (Technical Report No. 30), 1972.

Snow, R. E. Representative and quasi-representative designs for research on teaching. Review of Educational Research, 1974, 44 (3), 265-291.

Webster, W. J. and Mendro, R. L. The investigation of aptitude-treatment interactions as an integral part of program evaluation. The Journal of Experimental Education, 1974, 43 (1), 86-91.

Williams, R. L. and Cole, S. Self-concept and school adjustment. Personnel and Guidance Journal, 1968, 46 (5), 478-481.

Winer, B. J. Statistical Principles in Experimental Design, New York: McGraw-Hill, Second Edition, 1971.

Witkin, H. A. and Moore, C. A. Cognitive style and the teaching-learning process. Paper presented at the annual meeting of the American Educational Research Association, Chicago, 1974.

Witkin, H. A., Oltman, P. K., Raskin, E., and Karp, S. A. A manual for the Embedded Figures Tests. Palo Alto: Consulting Psychologists Press, 1971.