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ABSTRACT

While programmed instruction has not generally been found to increase mathematics achievement, the problems appear to lie more in managerial and motivational difficulties rather than in the theory of individualizing instruction. This study evaluated programmed instruction in mathematics using a system designed to solve these problems by having students work in heterogeneous teams and do all scoring themselves. This cooperative-individualized program, called Team-Assisted Individualization, or TAI, was assessed in two field experiments in elementary schools. Students in the TAI classes in both experiments scored higher than control students (controlling for pretest and grade) on a standardized mathematics test, but not higher than a group that used the materials and student management but not teams. Attitude and behavioral rating results followed the same general pattern. (Author)

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Combining Cooperative Learning and Individualized

Instruction: Effects on Student Mathematics Achievement,

Attitudes, and Behaviors

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Introductory Statement

The Center for Social Organization of Schools has two primary objectives: to develop a scientific knowledge of how schools affect their students, and to use this knowledge to develop better school practices and organization.

The Center works through five programs to achieve its objectives. The Studies in School Desegregation program applies the basic theories of social organization of schools to study the internal conditions of desegregated schools, the feasibility of alternative desegregation policies, and the interrelations of school desegregation with other equity issues such as housing and job desegregation. The School Organization program is currently concerned with authority-control structures, task structures, reward systems, and peer group processes in schools. It has produced a large-scale study of the effects of open schools, has developed Student Team Learning instructional processes for teaching various subjects in elementary and secondary schools, and has produced a computerized system for school-wide attendance monitoring. The School Process and Career Development program is studying transitions from high school to post-secondary institutions and the role of schooling in the development of career plans and the actualization of labor market outcomes. The Studies in Delinquency and School Environments program is examining the interaction of school environments, school experiences, and individual characteristics in relation to in-school and later-life delinquency.

The Center also supports a Fellowships in Education Research program that provides opportunities for talented young researchers to conduct and publish significant research, and to encourage the participation of women and minorities in research on education.

This report, prepared by the School Organization program, examines the effects on students of using an instructional process in mathematics in which students work together in teams on individualized curricula.

Abstract

While programmed instruction has not generally been found to increase mathematics achievement, the problems appear to lie more in managerial and motivational difficulties rather than in the theory of individualizing instruction. This study evaluated programmed instruction in mathematics using a system designed to solve these problems by having students work in heterogeneous teams and do all scoring themselves. This cooperative-individualized program, called Team-Assisted Individualization, or TAI, was assessed in two field experiments in elementary schools. Students in the TAI classes in both experiments scored higher than control students (controlling for pretest and grade) on a standardized mathematics test, but not higher than a group that used the materials and student management but not teams. Attitude and behavioral rating results followed the same general pattern.

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Individualization of instruction has been one of the most controversial issues in American education for several decades. The compelling argument that students should receive instruction at their own level and progress through it at their own pace has led over the years to development of many programmed instruction models, in which students work individually on their own packets at their own rate through carefully sequenced activities.

The rationale behind individualization of instruction is that students enter class with widely divergent skills and motivations, and that while many students may be ready for what the teacher would present to the entire class, some do not have the prerequisite skills to understand what is being taught, while some have already learned what is being taught or will grasp the idea in a short time. In a highly sequential subject such as mathematics, where learning each skill depends on having mastered a set of prior skills, individualized approaches such as programmed instruction would appear to be especially needed.

As logical as the above argument might appear, the research on programmed instruction does not bear out the effectiveness of programmed methods for mathematics achievement. Reviews and meta-analyses of research on programmed instruction in mathematics (e.g., Ebeling, Note 1, Hartley, Note 2; Miller, 1976; Schoen, 1976) find no trend toward positive effects of these strategies on mathematics achievement.

How can it be that individual programmed instruction does not increase student achievement? There appear to be several problems with programmed approaches. Many students find programmed instruction boring, and individual work isolates students from one another in class, reducing the potential for healthy social interaction and perhaps reducing motivation. Many students become bogged down in individualized programs as the task becomes familiar and monotonous, and there is usually little incentive for students to progress rapidly through their materials or to maintain a high degree of accuracy. Programmed instruction is usually quite difficult to implement. Because students must have their individualized materials checked before they go on to the next unit, they may have to wait for long periods for teaching assistance. This process may reduce the teacher to being a program checker, as the demands of simply checking answers takes the eacher's time away from direct instruction (see Kepler & Randall, 1977 and Schoen, 1976 for discussions of the problems of programmed instruction).

Thus the experience of implementation and evaluation of programmed instructional materials in mathematics would certainly justify abandoning this approach; it is difficult, expensive, and no more effective than traditional methods. However, the problems programmed instruction was designed to solve still remain, and are becoming more serious. American classrooms are becoming increasingly heterogeneous. One reason for this is the increased mainstreaming of low achieving students, under PL94-142. Another reason is desegregation, which often combines students who are different in social class backgrounds and therefore tend to be different in skills. Tracking is being abandoned in many schools, often because it can lead to resegregation of students. The problem of heterogeneity of students in the same class cannot be ignored.

Can the problems of programmed instruction be solved in a way that would make this strategy effective? This paper reports the results of two studies designed to evaluate a new individualized instructional approach in mathematics that uses cooperative learning teams to attempt to solve the motivational and implementation problems of programmed instruction. Cooperative learning methods, in which students work in small, heterogeneous learning groups and are rewarded based on the learning performance of the group members, have been found in several dozen field experiments to increase student achievement. They have also been found to increase student self-esteem, liking of students of different races or ethnic groups, acceptance of mainstreamed, low achieving students, and many other variables (see Slavin, 1980 for a review of cooperative learning). However, cooperative learning methods are group-paced; the entire class studies the same material at the same rate. Cooperative learning confronts the problem of the heterogeneous classroom to some degree because the heterogeneous nature of the learning group makes it possible for low-performing students to learn from their higher-performing groupmates, but in a very heterogeneous mathematics class it is simply inappropriate for some students to be studying the same material that the class is studying; for some it is too easy, and for others it is too difficult.

The combination of cooperative learning and individually programmed instruction evaluated in the studies reported in this paper was designed to address the problems of programmed instruction in two ways. First, the students themselves manage the individualized program. Second, students are motivated to complete their units rapidly and accurately because team recognition is provided based on the number of programmed units completed by team members each week and the accuracy of these units. This program was also expected to address the problems of group-paced cooperative learning by providing materials appropriate to each student's level of mathematics performance and allowing students to proceed at their own rate through the materials. It was designed for use by a regular teacher without an aide.

The two studies reported here investigated the effects of the combined cooperative-individualized program on student achievement, attitudes, and behaviors. The methods and results of the two studies are described below.

Study 1: Methods

Subjects

The subjects in Study 1 were 504 students in grades 3, 4, and 5 in a middle-class suburban Maryland school district. Eighty percent of the students were white, 15% were black, and 5% were Asian (primarily Korean). Six percent of the students were receiving special education services for a serious learning problem at least one hour per day, and an additional 17% of the students were receiving other educational services, such as special reading or speech instruction. The students were in eighteen classes in six schools. The schools were randomly assigned to one of three conditions: Cooperative-Individualized (using Team-Assisted Individualization, or TAI), Materials Only (MO), or Control. These treatments are described below. One third, fourth, and fifth grade class was then selected to participate in the study in each school. The three experimental treatments were implemented for eight weeks in Spring, 1981.

Treatments

Team-Assisted Individualization (TAI). The principal components of the TAI program were:

1. Teams. Students were assigned to four- to five-member teams by the project staff. Each team consisted of a mix of high, average, and low achievers as determined by a diagnostic test, boys and girls, and students of any ethnic groups in the class represented in the proportion they made up of the entire class. Students identified as receiving resource help for a learning problem were evenly distributed among the

teams. Four weeks into the project, students were reassigned to new teams by their teachers according to the same procedures.

2. Diagnostic test. The students were pretested at the beginning of the project on mathematics operations. Students were placed at the appropriate point in the individualized program based on their performance on the diagnostic test.

3. Curriculum materials. For all their mathematics instruction, students worked on individualized curriculum materials covering addition, subtraction, multiplication, division, numeration, decimals, fractions, and word problems. These materials had the following subparts:

--An Instruction Sheet explaining the skill to be mastered and giving a step-by-step method of solving problems.

--Several Skillsheets, each consisting of twenty problems. Each skillsheet introduced a subskill that led to final mastery of the entire skill.

--A Checkout, which consisted of two parallel sets of ten items.

--A Final Test.

--Answer Sheets for Skillsheets, Checkouts, and Final Tests.

4. Team Study Method. Following the diagnostic test, students were given a starting place in the individualized mathematics units. They worked on their units in their teams, following these steps:

--Students formed into pairs or triads within their teams. Students located the unit they were working on and brought it to the team area. Each unit consisted of the Instruction Sheet, Skillsheets, and Checkouts stapled together, and the Skillsheet Answer Sheets and Checkout Answer Sheets stapled together.

--In pairs, students exchanged Answer Sheets with their partners. In triads, they gave their Answer Sheets to the student on their left.

--Each student read his or her I. truction Sheet, asking teammates or the teacher for help if necessary.

--After reading the Instruction Sheet, each student began with the first Skillsheet in his or her unit.

--Each student worked the first four problems on his or her own Skillsheet and then had his or her partner check the answers against the Answer Sheet. If all four were correct, the student could go on to the next Skillsheet. If any were wrong, the student had to try the next four problems, and so on until he or she got one block of four problems correct.

--When a student got four in a row on the last Skillsheet, he or she could take Checkout A, a ten-item quiz that resembled the last Skillsheet. On the Checkout, students worked alone until they were finished. When they were finished, a teammate scored the Checkout. If the student got eight or more correct, the teammate signed the Checkout to indicate that the student was certified by the team to take the Final Test. If the student did not get eight correct, the teacher was called in to explain any problems the student was having. The teacher would then ask the student to work again on certain Skillsheet items. The student then took Checkout B, a second ten-item test comparable in content and difficulty to Checkout A. Otherwise, students skipped Checkout B and went straight to the Final Test. No student could take the Final Test until he or she had been passed by a teammate on a Checkout.

--When a student "checked out," he or she took the Checkout to a student monitor from a different team to get the appropriate Final Test. The student then completed the Final Test, and the monitor scored it. Three different students served as monitors each day.

5. Team Scores and Team Recognition. At the end of each week, the teacher computed a team score. This score was the sum of the average number correct of all Final Tests taken by all team members (the Accuracy Score) and the average number of units covered by each team member times ten (the Progress Score). Criteria were established for team performance. A high criterion was set for a team to be a "SUPERTEAM," a moderate criterion was established for a team to be a "GREATTEAM," and a minimum criterion was set for a team to be a "GOODTEAM." The teams meeting the "SUPERTEAM" and "GREATTEAM" criteria received certificates.

6. Teacher Review Sessions. Every day, the teacher worked with single students or groups of two to ten students who were at about the same point in the curriculum for 5-15 minute sessions. The purpose of these sessions was to go over any points with which students were having trouble and to prepare students for upcoming units.

Materials-Only Program (MO). The MO group used the same curriculum materials and procedures as the TAI group with the following exceptions.

1. Students worked individually, not in teams. They checked their own answer sheets for all Skillsheets and Checkouts. Criteria for going on (i.e., four correct for Skillsheets and eight out of ten for Checkouts) were the same as for TAI.

2. Students did not receive team scores or certificates.

In all other respects, including curriculum organization, student monitors, teacher review sessions, and recordkeeping, the MO treatment was identical to TAI.

Control. The control group used traditional methods for teaching mathematics, which consisted in every case of small homogeneous teacher-directed math groups and traditional texts.

Measures

Mathematics Achievement. The Mathematics Con-.tations subscale of the Comprehensive Test of Basic Skills, Level 2, Form S., was administered as a pre- and posttest of student mathematics achievement. The CTBS (rather than a curriculum-specific test) was used to be sure experimental and control classes would have equal opportunities to have their learning be registered on the test.

Attitudes. Two eight-item attitude scales were given as pre- and posttests. The scales were Liking of Math Class (e.g., "This math class is the best part of my school day"), and Self-Concept in Math (e.g., "I'm proud of my math work in this class;" "I worry a lot when I have to take a math test"). For each item, students marked either YES!, yes, no, or NO!. Scores of negatively scored items were reversed, so that high scale scores indicated more positive attitudes. Coefficient alpha reliabilities computed on the pretests were:

	Alpha
Liking of Math Class	.861
Self-Concept in Math	.770

Behavior Ratings. Teachers rated a sample of their students at pre- and posttesting on the School Social Behavior Rating Scale, or SSBRS (Slavin, Note 3). The subsamples consisted of all students receiving some form of special service for a learning problem (e.g., reading or math resource, speech, or special education), plus a random selection of six other students. The SSBRS consists of four scales designed to elicit teacher ratings of student behavioral and interpersonal problems; students receiving special services were oversampled because they were seen as most likely to have behavioral and interpersonal problems that might be remedied by a cooperative-individualized treatment (see Slavin, Leavey, & Madden, Note 4). The four scales were Classroom Behavior (e.g., "Does not attend to work"), Self-Confidence (e.g., "Becomes easily upset by failures"), Friendships (e.g., "Has few or no friends"), and Negative Peer Behavior (e.g., "Fights with other students"). There were six items in the Negative Peer Behavior Scale, and eight in the other three scales. A factor analysis using varimax rotation produced factor loadings consistent with the *a priori* scales. Coefficient alpha reliabilities computed on the pretests were:

	Alpha
Classroom Behavior	.888
Self-Confidence	.882
Friendships	.938
Negative Peer Behavior	.914

Experiment 1: Results

The data were analyzed by means of multiple regressions, where for each dependent variable (posttest), the R^2 for a full model including pretest, grade, and treatment was tested against the R^2 for pretest and grade (see Kerlinger & Pedhazur, 1973). Initial tests for potential pretest differences using one-way analysis of variance indicated no pretest differences at or beyond the $p < .10$ level for CTBS pretests. There were also no differences on self-concept in math, but there were significant differences on liking of math class ($F(2,448) = 4.14$, $p < .02$), due to high pretest scores in the MO class. On the behavioral rating data, no pretest differences were found on Classroom Behavior or Negative Peer Behavior, but significant differences were found on Friendships ($F(2,205) =$

5.82, $p < .01$) and marginally significant pretest differences were found on Self-Confidence ($F(2,205) = 2.76$, $p < .07$). In both cases, the largest number of problems were reported on the pretests in the MO classes.

Insert Tables 1 & 2 Here

The pre- and posttest means on all dependent variables by treatment are shown in Table 1. Table 2 presents the results of the multiple regressions, including both the overall (3 x 1) results and each of the pairwise comparisons.

The results for the Comprehensive Test of Basic Skills (CTBS) indicated a marginally significant overall treatment effect, controlling for pretest and grade ($F(2,431) = 2.76$, $p < .07$). The Team-Assisted Individualization group gained significantly more in achievement than the Control group ($F(1,284) = 5.39$, $p < .03$), while the Materials Only group gained marginally more than the Control group ($F(1,294) = 2.90$, $p < .09$). However, there were no significant differences between the TAI and MO groups.

Results for the Liking of Math scale indicated a significant overall treatment effect ($F(2,448) = 11.66$, $p < .001$), as well as significant differences between TAI and Control ($F(1,299) = 16.37$, $p < .001$) and between MO and Control ($F(1,302) = 19.50$, $p < .001$), with both experimental groups scoring higher than the control group, controlling for pretest and grade. There were no differences between TAI and MO. Overall treatment effects were also found for Self-Concept in Math ($F(2,445) = 4.13$, $p < .01$). TAI significantly exceeded Control on this variable ($F(1,295) = 7.28$, $p < .01$), while MO marginally exceeded the Control group ($F(1,301) = 3.21$, $p < .08$).

Statistically significant overall treatment effects beyond the .001 level were found for all four bheavioral rating scales (see Tables 1 and 2). For Class Behavior, TAI students were rated as having significantly fewer problems, controlling for pretest and grade, than either Control students ($F(1,137) = 27.55$, $p < .001$) or MO students ($F(1,122) = 11.24$, $p < .001$), but there were no differences between MO and Control. On Self-Confidence, the Control group was rated as having more problems than either TAI students ($F(1,137) = 38.25$, $p < .001$) or MO students ($F(1,146) = 10.88$, $p < .001$). The TAI group had fewer problems reported than the MO group ($F(1,121) = 5.51$, $p < .03$). The Control classes were also scored as having more friendship problems than either TAI classes $(1,137) = 12.15$, $p < .001$) or MO classes ($F(1,146) = 14.24$, $p < .001$), but there were no differences between TAI and MO. The same pattern of effects was seen for ratings of Negative Peer Behavior--more problems were reported in the Control group than in TAI classes ($F(1,128) = 28.30$, $p < .001$), or MO classes ($F(1,112) = 29.24$, $p < .001$), but no differences between TAI and MO were found.

Study 2: Methods

Subjects

The subjects in Study 2 were 375 students in grades 4, 5, and 6 in another suburban Maryland school district. Fifty-five percent of the students were white, 43% were black, and 2% were Asian. Four percent of the students were receiving special education services for a serious learning problem at least one hour per day, and an additional 23% of the students were receiving other special educational services, such as special reading or speech instruction. Four schools were involved in the study: two TAI schools were matched with two Control schools. One TAI and one Control school were primarily middle- to lower-middle class in student population; one TAI and one Control school were primarily lower class. A total of ten TAI and six Control classes participated in the study.

Treatments

Study 2 compared TAI to Control methods (as described for Study 1) for ten weeks in spring, 1981.

Measures

The achievement, attitude, and behavioral rating measures were the same as in Study 1. Coefficient alpha reliabilities based on the pretests in Study 2 were as follows:

	Alpha
Liking of Math Class	.843
Self-Concept in Math	.768
Classroom Behavior	.933
Self-Confidence	.835
Friendships	.906
Negative Peer Behavior	.926

Study 2: Results

The data were analyzed exactly as in Study 1, using multiple regressions testing the R^2 for a full model including treatment to that for a restricted model including only pretest and grade. No individual comparisons were computed because there were only two treatments. Initial tests for potential pretest differences indicated no significant treatment differences for the CTBS scores or for Self-Concept in Math, but the Control group had significantly higher Liking of Math pretests than the TAI group ($F(1,303) = 5.24$, $p < .03$). For the behavioral rating scales, teachers reported marginally fewer problems on the Friendship scale in the TAI groups than in the Control groups ($F(1,177) = 3.23$, $p < .08$), but there were no other significant pretest differences.

Insert Tables 3 & 4 Here

The pre- and posttest means by treatment are shown in Table 3, and the results of the multiple regressions are summarized in Table 4.

The results for the CTBS closely mirror the TAI vs. Control comparison in Study 1. The TAI students scored significantly higher than control students, controlling for pretest and grade ($F(1,299) = 4.70$, $p < .03$). However, there were no significant differences on the Liking of Math Class or Self-Concept in Math scales. Controlling for pretests and grade, the TAI teachers reported significantly fewer problems than the Control teachers with regard to Self-Confidence ($F(1,151) = 6.27$, $p < .02$) and Friendships ($F(1,141) = 7.07$, $p < .01$), but there were no differences seen on Classroom Behavior or Negative Peer Behavior.

Thus, while the achievement results of Study 2 confirm the TAI vs. Control comparison in Study 1, the strong attitude effects were not replicated, and the behavioral rating results of Study 1 were replicated only for Self-Confidence and Friendship Behaviors.

Discussion

The results of the two studies evaluating the Team-Assisted Individualization (TAI) program clearly support the conclusion that this method increases student achievement (as measured by the Comprehensive Test of Basic Skills) more than traditional instruction using homogeneous math groups. Significant differences in achievement favoring the TAI condition were found in both studies. Translating the CTBS scores into grade equivalents, it can be seen that in both studies, the TAI group gained twice as many grade equivalents as the Control groups. In Study 1, the TAI group gained 0.44 grade equivalents while the Control group gained only 0.22 units. In Study 2, the TAI group gained 0.28 grade equivalents, while the Control group gained 0.13 units. These figures should not be seen as definitive, as grade equivalents computed on relatively short periods (eight and ten weeks, respectively) are unstable, but they do provide some indication that the TAI-Control differences are not trivial, and if they held up over a longer period, might be quite substantial.

Although the evidence supporting the positive effects of the Team-Assisted Individualization program on mathematics achievement is relatively unambiguous, the critical elements of the TAI program for student achievement are not so clear. The evidence of Study 1 comparing TAI and Control conditions to a program that did not use cooperative teams generally suggests that the teams do not add to the achievement effects of the TAI program, as there were no significant achievement differences between TAI and the Materials-Only treatment. However, the differences between TAI and Control are larger than those between MO and Control; the latter do not attain conventional levels of statistical significance ($p < .05$).

On the two attitude scales, the results of the two studies differ. In Study 1, the TAI and MO groups increased over time in Liking of Math Class and Self-Concept in Math while the Control group decreased; this was reflected by statistically significant differences between each of the experimental groups and the Control group, but there were no differences between the TAI and MO conditions. Attitudes also improved in the TAI condition in Study 2, but the control groups stayed about even over the course of the study, and the TAI-Control differences did not approach statistical significance.

The results of the behavioral ratings should be interpreted with some caution, as they rely on teacher judgments, not independent behavioral observation. As the experimental teachers were aware that they were in an experimental condition, they may have had difficulty maintaining objectivity (although there was no direct evidence of bias, and teachers were instructed to be objective and not try to make their program look good or bad). In both experiments, TAI teachers reported fewer problems relating to student Self-Confidence and Friendship Behaviors than did Control teachers. TAI teachers in Study 1 also reported fewer problems relating to Classroom Behavior and Negative Peer Behavior, but these effects were not replicated in Study 2. The Materials-Only groups in Study 1 also had fewer problems reported than did the Control groups on all of the rating scales except Classroom Behavior, but there were significant differences between the TAI and MO groups on Classroom Behavior and Self-Confidence, in both cases favoring the TAI groups. These TAI-MO differences are not so likely to have been influenced by teacher bias favoring the experimental conditions, as both the TAI and MO teachers were using experimental procedures and were largely unaware of one another.

Thus, looking at the overall results, it is apparent that the Team-Assisted Individualization (TAI) approach has positive effects on student mathematics achievement, behavior ratings, and (at least in one study) student attitudes. The effects appear to be due primarily to features that the Team-Assisted Individualization and Materials-Only conditions have in common. Because the literature on programmed instruction does not generally support the effectiveness of this strategy in mathematics (Ebeling, Note 1; Hartley, Note 2; Miller, 1976; Schoen, 1976), we must consider why this particular form of programmed instruction was apparently effective. There are three primary features common to the TAI and MO treatments that are different from previous programmed mathematics methods: self or partner checking, frequent mastery checks allowing students to skip material they already understand, and the curriculum materials themselves.

The particular way that concepts are introduced in the curriculum materials is unlikely to explain the achievement effects seen in Studies 1 and 2; the sequence of units and development of concepts were largely modeled on existing texts and are not particularly unusual. However, the format of the curriculum materials and the self-checking (MO) or partner-checking (TAI) procedures are more unique to these methods. The initial research plan called for use of existing programmed mathematics materials. However, inspection of available materials indicated that they were inappropriate for the TAI and MO procedures because they did not provide enough items for each step in the development of an operation. This meant that if students missed a few items, they could be stuck until the teacher could explain the operation to them, as there were no more items to try. Again, a major assumption in the development of the MO and TAI programs was that an aide would not be available, so too many requirements for the teacher's limited time could lead to the failure of the program. For this reason, the curriculum that was developed provided twenty items for each step; students worked the items in blocks of four and proceeded to the next step only if they got the four items in a block correct. This allowed students to see and correct their own errors in most cases and made it impossible for students to go to the next step without having mastered the previous one. Similarly, provision of two parallel checkouts at the end of each unit required the students to show mastery before taking the final test, but provided a backup if students failed to show mastery the first time.

In one sense, the features common to the TAI and MO programs may more closely approximate an ideal model of individualized instruction than have previous programmed methods. A basic principle of individualization is that students should spend neither more nor less time than they need to learn a particular skill or concept (see Carroll, 1963). Because students have different skills and learning rates, much time is wasted in group-paced instruction, as some students have already mastered what is being taught while others may be hopelessly behind (see Karweit, Note 5). Subgrouping, such as that used in the control groups in this study, increases the efficiency of instruction for the homogeneous groups because the teacher can take the students' learning rates into account, but it also requires that the students not working with the teacher at any given time spend large amounts of time on unsupervised seat work, which has been found to be of minimal instructional value (Anderson, Note 6; Brophy, 1979). Programmed instruction addresses the problem of different learning rates by allowing students to work at thier own level and rate, but traditional programmed instruction models still waste many students' time by requiring them either to work on problems they already know or to continue to work problems even if they do not understand them (in addition to time wasted for managerial reasons, such as waiting for problems to be checked). In TAI and MO, students spend little time on skills they have mastered, but they have the time (and practice items) to resolve any problems that they do have. The large number of items and immediate feedback necessary to make this system work could not be used without the self- or partner-checking procedures, as the checking load would be unmanageable even with an aide. It is an empirical question whether the model common to TAI and MO is in fact more efficient than that used in traditional programmed methods, but at present the use of the frequent mastery checks with many backups and the self- or partner-checking are the features most likely to explain the achievement effects found in the present studies.

The failure to find significant differences between the TAI and MO conditions was not anticipated, as a long series of studies of cooperative learning methods has indicated that students in cooperative groups working toward a goal based on group members' achievement learn more than students who work toward individual goals only (see Slavin, 1980; Slavin, in press). However, as a practical matter, there is no particular reason not to use teams. Teachers who have used both MO and TAI have reported that the teammates reduce the teacher's load by answering their teammates' questions and by keeping their teammates honest in terms of checking answers, thus reducing the number of times that students fail tests and need remedial instruction because they did not proceed properly through their Skillsheets and Checkouts. Team scoring is easy to do, and the team certificates create a great deal of excitement and motivation. In the course of a longer intervention, the benefits of the team component might become more apparent, if the initial thrill many students experience at being able to work at their own level and rate wear off over time or if students gradually become less conscientious about checking themselves. Even if there were no measurable achievement differences between the Team-Assisted Individualization treatment and the Materials-Only treatment, the effects of the teams on social and self-concept outcomes might argue for their use. In this study, the TAI groups were reported to have fewer problems relating to Self-Confidence and Friendships than the Materials-Only groups, and a separate analysis (Slavin, Leavey, & Madden, Note 4) found that the TAI program had positive effects on friendships between mainstreamed and normal-progress students. Research on cooperative learning methods that do not use individualized materials has shown consistent benefits of these methods on such outcomes as race relations and self-esteem (see Slavin, 1980; Slavin, in press).

Perhaps the most important finding of this study was that an individualized mathematics program was developed that could be managed by a single teacher without an aide, relying on the students themselves to manage the routine checking and procedures of the program. Quite positive teacher attitudes toward the program were important indicators of the feasibility of implementing the program without additional assistance or heroic efforts. In a post-experimental questionnaire, all but two teachers in Study 1 (one TAI and one MO) and all but two in Study 2 indicated that they planned to use their program in the next school year; in fact, all but one of the twelve teachers who participated in Study 1 did continue to use their program (or switched from MO to TAI) in the next school year, and the school district encouraged an additional twenty-four teachers (mostly in the same schools) to participate. Of the ten experimental teachers in Study 2, six continued to use the TAI program, and one left teaching; his replacement also learned and used the program.

As indicated in the Introduction, the theory that students should receive instruction at their own level is virtually unassailable, especially in a subject as sequentially ordered as mathematics. The difficulties have come in applying this theory in the classroom, where the managerial and motivational problems of individualization have led to equivocal findings and declining use of true individualization methods, such as programmed instruction. The present study suggests that if these problems can be overcome, learning and other important outcomes can be enhanced. The methods described in this paper must still be evaluated over a longer time period to be sure that the results maintain, but the evidence presented here is enough to at least reopen the issue of individualization and programmed instruction and to justify further explorations of methods that apply the principle of providing students instruction at their own level while using students themselves to solve the managerial and motivational problems inherent in individualization.

Table 1

Means and Standard Deviations of Achievement, Attitude, and Behavioral Rating Variables by Treatment, Experiment 1

		TAI		MO		Control	
		X	(S.D.)	X	(S.D.)	X	(S.D.)
CTBS Achievement	Pre	30.18	(10.08)	28.51	(11.59)	29.25	(11.27)
	Post	33.12	(9.43)	31.45	(11.31)	31.02	(11.86)
	N	138		148		148	
Liking of Math Class	Pre	24.37	(6.23)	25.02	(5.09)	23.23	(5.07)
	Post	25.09	(6.19)	25.51	(4.35)	21.93	(5.75)
	N	147		150		154	
Self-Concept in Math	Pre	24.87	(4.13)	24.23	(4.89)	24.56	(4.16)
	Post	25.80	(4.23)	24.97	(4.42)	24.40	(4.72)
	N	145		150		153	
Behavior Rating* Classroom Behavior	Pre	5.07	(4.85)	4.35	(5.37)	4.81	(5.88)
	Post	2.93	(3.43)	5.26	(7.85)	5.41	(5.85)
	N	58		68		83	
Behavior Rating* Self-Confidence	Pre	3.97	(3.76)	4.12	(5.32)	2.64	(3.55)
	Post	1.90	(2.80)	3.31	(5.05)	3.78	(4.57)
	N	58		67		83	
Behavior Rating* Friendships	Pre	1.95	(3.29)	4.46	(7.19)	2.00	(3.32)
	Post	1.57	(3.89)	2.79	(5.48)	3.17	(4.08)
	N	58		67		83	
Behavior Rating* Negative Peer Behavior	Pre	2.00	(3.13)	2.13	(4.08)	1.82	(3.00)
	Post	0.94	(1.94)	1.16	(2.58)	2.87	(3.76)
	N	49		67		83	

*For the behavioral ratings, high scores indicate more problems reported.

Table 2

Results of Multiple Regressions, Experiment 1

	R^2 Total	R^2 Inc	F	d.f.	p <
CTBS					
Overall	.752	.003	2.76	2,431	.07
TAI vs Control	.769	.004	5.39	1,284	.03
TAI vs MO	.721	.000	1	1,284	n.s.
MO vs Control	.766	.002	2.90	1,294	.09
Liking of Math Class					
Overall	.327	.035	11.66	2,448	.001
TAI vs Control	.360	.035	16.37	1,299	.001
TAI vs MO	.275	.000	1	1,295	n.s.
MO vs Control	.312	.004	19.50	1,302	.001
Self-Concept in Math					
Overall	.410	.011	4.13	2,445	.01
TAI vs Control	.442	.014	7.28	1,296	.01
TAI vs MO	.382	.003	1.28	1,293	n.s.
MO vs Control	.406	.006	3.21	1,301	.08
Behavior Rating: Classroom Behavior					
Overall	.600	.041	10.43	2,204	.001
TAI vs Control	.672	.066	27.55	1,137	.001
TAI vs MO	.471	.049	11.25	1,122	.001
MO vs Control	.609	.000	1	1,147	n.s.
Behavior Rating: Self-Confidence					
Overall	.536	.071	15.52	2,203	.001
TAI vs Control	.577	.118	38.25	1,137	.001
TAI vs MO	.478	.024	5.51	1,121	.03
MO vs Control	.571	.032	10.88	1,146	.001
Behavior Rating: Friendships					
Overall	.549	.040	9.10	2,203	.001
TAI vs Control	.595	.036	12.15	1,137	.001
TAI vs Mo	.541	.001	1	1,121	n.s.
MO vs Control	.549	.044	14.24	1,146	.001
Behavior Rating: Negative Peer Behavior					
Overall	.507	.075	20.80	2,194	.001
TAI vs Control	.526	.105	28.30	1,128	.001
TAI vs MO	.405	.002	1	1,112	n.s.
MO vs Control	.561	.088	29.24	1,146	.001

Table 3

Means and Standard Deviations of Achievement, Attitude, and Behavioral Rating Variables by Treatment, Experiment 2

		TAI		Control	
		X	(S.D.)	X	(S.D.)
CTBS Achievement	Pre	28.50	(9.39)	27.12	(9.87)
	Post	30.84	(9.16)	28.40	(9.36)
	N	189		114	
Liking of Math Class	Pre	22.34	(5.98)	23.97	(5.97)
	Post	23.07	(6.28)	23.96	(6.03)
	N	192		113	
Self-Concept in Math	Pre	22.35	(4.61)	23.61	(4.75)
	Post	24.36	(4.82)	23.95	(4.69)
	N	192		113	
Behavior Rating*: Classroom Behavior	Pre	8.62	(9.09)	8.64	(6.03)
	Post	8.97	(9.55)	8.00	(7.52)
	N	107		74	
Behavior Rating*: Self-Confidence	Pre	3.88	(4.22)	4.67	(4.63)
	Post	3.66	(3.70)	5.25	(5.22)
	N	82		73	
Behavior Rating*: Friendships	Pre	2.32	(3.96)	3.23	(4.56)
	Post	1.81	(3.44)	3.92	(5.47)
	N	81		64	
Behavior Rating*: Negative Peer	Pre	3.83	(5.71)	3.92	(4.43)
	Post	3.64	(5.87)	4.60	(5.35)
	N	107		73	

*For the behavioral ratings, high scores indicate more problems reported.

Table 4

Results of Multiple Regressions, Experiment 2

	R^2_{Total}	R^2_{Inc}	F	d.f.	p <
CTBS	.602	.006	4.70	1,299	.03
Liking of Math Class	.307	.000	<1	1,301	n.s.
Self-Concept in Math	.376	.004	1.86	1,301	n.s.
Behavioral Rating: Classroom Behavior	.633	.004	1.72	1,177	n.s.
Behavioral Rating: Self-Confidence	.567	.018	6.27	1,151	.02
Behavioral Rating: Friendships	.545	.023	7.07	1,141	.01
Behavioral Rating: Negative Peer Behavior	.608	.006	2.67	1,176	n.s.

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