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ABSTRACT

This study examined student aptitudes and student behaviors during small group interactions as mediators of the effectiveness of small group learning. The hypotheses to be investigated were that the effects of small group learning on student achievement are produced by students' participation in group interaction, and in the providing and receiving of higher-order explanations. High and low ability students are more often involved in this process than other students. A treatment and control group of fifth grade students completed ability and attitude pretests. The treatment group was trained in small group interaction. All students received regular mathematics classroom instruction. They worked on assignments in mixed ability groups of four students. Achievement, retention and attitude toward mathematics were assessed. A Mann-Whitney comparison showed that trained students participated in more task related interaction than control students. The effects of small group interaction depend on the ability level of the students. Interaction during small group work was most beneficial for low ability students. The study showed they can help themselves by teaching others. A high quality of interaction must prevail if the small group method is to be of maximal effectiveness. (Author/DWH)

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Center for Individualized Schooling

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THE RELATIONSHIP OF STUDENT ABILITY AND SMALL-GROUP INTERACTION TO STUDENT ACHIEVEMENT

by

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Report from the Project on
Studies of Instructional Programming for the Individual Student

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Abstract

This study examined student ability and student behaviors during small-group interaction as hypothesized mediators of the effectiveness of small-group learning. Fifth-grade students ($\underline{n}$ = 43) completed ability and attitude pretests. A treatment group was trained in small-group interaction. Students received regular classroom instruction in mathematics for 4 weeks. Each day students worked on assignments in mixed ability groups of four students. Achievement, retention, and attitude toward mathematics were assessed. A Mann-Whitney comparison showed that trained students participated in more task-related interaction than control students. Results suggested that task-related interaction in the small group enhanced the achievement and retention of high and low ability students but did not facilitate the achievement of medium ability students.

During the past decade, a considerable amount of research has been conducted on cooperative small-group learning. This research has typically investigated the relative effectiveness of small-group, traditional teacher-directed large-group, and individual learning methods (or alternatively cooperative, competitive, and individual goal structures) in producing a variety of educationally desirable outcomes, among them academic achievement and enhancement of self-esteem, attitudes toward school, race relations, and prosocial behaviors. The results of such studies, as presented in a number of recent reviews (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Sharan, 1980; Slavin, 1980), generally point to the greater effectiveness of the cooperative small-group method in promoting gains in both the academic and affective domains. However, some studies suggest that small-group learning is not equally effective for all students. Two studies showed that minority students performed better on an achievement test after small-group learning than after learning in a control group (Lucker, Rosenfield, Sikes, & Aronson, 1976; Slavin, 1977). Other studies have shown that student ability is related to the effectiveness of small-group learning. In a study of secondary school students learning of mathematics, Webb (Note 1) found the following curvilinear aptitude-treatment interaction (ATI) with ability: (a) high ability students learned best either individually or in mixed ability groups; (b) medium ability students performed best after individual learning; and (c) low ability students learned best in mixed ability groups. Peterson, Janicki, and Swing (Note 2) found similar results. Their results suggested that high and low ability students performed best after small-group learning. Medium ability students performed equally well after learning either individually or in a small-group approach. However, in another ATI study similar to the one cited above, Peterson and Janicki (1979) found that high ability students performed best on a retention test after learning individually, but that low ability students obtained higher retention scores after learning individually. Amaria, Biran, and Leith (1969), in an investigation of the learning of secondary school students either individually or in mixed or uniform ability pairs, found that (a) both high and low ability girls obtained higher achievement scores after learning in mixed ability pairs; (b) method of learning made no difference in the performance of low ability boys; and (c) high ability boys performed better after learning in homogeneous ability pairs or individually.

Investigators of small-group learning have sought to identify components of the method which produce positive effects on achievement or, similarly, which facilitate achievement differentially for students with different learner characteristics. Some researchers have proposed that student behavior during small-group work, particularly in the form of peer-tutoring, is importantly related to the effectiveness of small-group learning. Johnson et al. (1981) reported that peer tutoring and peer encouragement were among several variables which contributed to the superiority of cooperative learning methods over methods with individual or competitive goal structures.

Webb (Note 1) observed student interaction during small-group work and related it to the outcomes of the learning process. She concluded that students who actively taught group members or who received explanations from group members performed better on an achievement test after small-group learning than students of comparable ability who did not engage in these behaviors. However, students who received explanations did not retain what they had learned. Students who were denied full participatory rights in group interaction performed worse on the achievement measures than students of the same ability who were included in group interactions. These observations helped to explain Webb's ATI findings because high ability students most often explained in heterogeneous ability groups while low ability students were most often the target of the explanations.

Peterson and Janicki (1979) and Peterson et al. (Note 2) also examined student behavior during small-group work, i.e., the providing and receiving of explanations, as processes that mediated the ATI findings. However, the results produced did not unequivocally explain the findings. While Peterson and Janicki found that explaining was positively related to achievement, when the effects of ability were partialled out, the relationship was no longer significant.

The present study was designed to further investigate student aptitudes and student behaviors occurring during small-group interaction as mediators of the effectiveness of small-group learning. The hypotheses were as follows: (a) the effects of small-group learning on student achievement are produced by students' participation in small-group interaction, and particularly in the providing and receiving of higher-order explanations; and (b) high and low ability students are more often involved in this process than are medium ability students. A secondary purpose of the study was the evaluation of the effectiveness of a training program employed in the study as an experimental manipulation. The program was designed to increase the quantity and quality of interaction during small-group learning.

Method

Subjects

The participants in the study were 43 fifth-graders from two classes in an elementary school in Madison, Wisconsin. The sample size was deliberately limited so that all students could be extensively observed during small-group work. Students participated as members of their intact classrooms. There were 28 students in one class and 15 in the other. Informed signed parental consent was required as a condition for participation in the study. Each of the teachers had several years of teaching experience and had volunteered to take part in the study.

Instrumentation

Pretests and posttests. Prior to implementation of the experimental procedures the following aptitude tests and questionnaires were administered: Raven's Progressive Matrices (Cronbach's alpha [α] = .86) by Raven (1958); the Mathematical Computations Subtest Form 4B from the Sequential Tests of Educational Progress (α = .86) published by the Educational Testing Service (1970); and an adapted version of the attitude toward mathematics scale (α = .90) developed by Peterson and Janicki (1979) from the Science Attitude Inventory by Klausmeier, DiLuzio, and Brumet (Note 3).

The 15-item attitude toward math scale had a 5-point response format with the following response alternatives: "strongly agree," "agree," "don't care," "disagree," and "strongly disagree." The scale was scored such that a more positive attitude was represented by a higher score. A score of 75 was the maximum score obtainable on this scale.

At the completion of a 10-day unit on long division, student achievement was assessed with a 31-item test (α = .93) constructed by the principal investigator. The test included problems which represented the instructional objectives for the unit, e.g., the dividing of a 2-digit divisor into a 4-digit dividend, estimating quotients, and working story problems requiring division. After an additional 10 days of instruction on a fractions unit, a second achievement test was administered. The fractions test (α = .94) consisted of 34 items and was an adapted version of the unit test supplied by the classes' textbook publisher. It assessed student learning of such concepts as finding a common denominator, adding and subtracting fractions with unlike denominators, and working story problems using fractions. The attitude toward math scale (α = .92) was readministered at the completion of the study.

Two weeks after the end of the study, student retention of division and fractions learning was evaluated. The retention test (α = .94) was composed of 37 items selected from the division and fractions achievement tests. A total of 17 items measured division retention and 20 items assessed fractions achievement.

Observation system. Student behavior was coded during the study using an adapted version of an observation instrument developed by Peterson and Janicki (1979). During the review and development parts of the lesson, students were coded only for off-task behavior. During seatwork, a more detailed coding of student behavior was carried out. On-task behaviors were coded as student (a) listens to teacher; (b) works; (c) explains; (d) asks question of student; (e) receives student explanation; and/or (f) checks answers. Student explanations were differentiated into a number of categories based on the substantively different roles the explanations were thought to play in the learning process. The following categories of "explains" were distinguished in the coding scheme: student provides (a) an answer; (b) conceptual explanation; (c) sequencing explanation; or (d) procedural information. Observers coded (a) off-task, (b) finished, or (c) waiting for help for students who were not engaged in the task.

The generalizability of the observations was assessed using the procedure described by Cronbach, Gleser, Nanda, and Rajaratnam (1972). An estimate of the generalizability of the observations across coders and days was obtained by having one pair of coders code the same two groups of students on 2 days and by having a second pair of coders observe another two groups of students on each of 2 days. Day was considered as a fixed effect. Selected observation categories and their generalizability coefficients (ρ) are as follows: works (ρ = .95; .98); provides answer (ρ = .35; .00); provides conceptual/sequencing explanation (ρ = .95; .98); explains procedures (ρ = .88; .81); receives answer (ρ = .00; .00); receives conceptual/sequencing explanation (ρ = .93; .97); receives procedural explanation (ρ = .28; .88); asks question (ρ = .83; .03); checks answers (ρ = .98; .98); and off-task (ρ = .93; .91). Low frequencies of occcurrence account for the low generalizability coefficients for the explains and receives answer categories, while coder discrepancies produced the low coefficients for the asks question and receives procedural explanation categories.

Training Program

A short program, designed to improve the quality and quantity of task-related small-group interaction, was developed by the principal investigator for use in the study. The major focus of the first part of the two part program was to enhance positive task-related interaction in the group. One main idea, introduced to the students first in a discussion format, emphasized a humanitarian approach to interpersonal relations, i.e., showing consideration and respect for others during interactions. In the context of the discussion "good" teaching behaviors were also briefly described. Another part of the program provided general behavioral guidelines for interacting in the small group.

Each of the main topics was first introduced in a discussion. Following each part of the discussion, some of the ideas presented were demonstrated in scripted role-play episodes showing student interaction during small-group work. Student volunteers participated in the role playing while the remainder of the students observed. The behaviors depicted during role playing were then discussed as portraying good or bad examples of the principles presented during the discussion.

The second training session focused on improving the explaining skills of the students, with the primary aim of enhancing their qualifications as "teachers" and secondarily, with the intent of legitimizing the role of explainer for all students with the expected consequence of increasing overall student participation in this role. The second session was essentially a practicum in explaining for the students. However, initially, good explaining behaviors were introduced in a short discussion. The discussion was followed by a demonstration of good and bad explaining. Problems were explained to the entire group of students by the training personnel and student volunteers. Students were requested to indicate the particular incidences of good or bad explaining behaviors and to describe how the unacceptable performances could be improved. Students then practiced explaining using materials prepared by the principal investigator. Subsequently, students commenced work on a problem set in the small group to which they had been assigned. The training personnel monitored individual small groups, listening to each student explain a problem and providing feedback on the individual performances. Two short follow-up sessions were held between the first and second parts of the training program to review the principles taught during the training session and to provide feedback on group performance.

Procedure

Prior to the beginning of the study, the principal investigator met with the teachers in two short sessions. During these meetings the teachers were informed of the general plan and purpose of the study and of their role in the study. Guidelines for the conducting of the review, lecture, and seatwork parts of the class were presented and discussed. The teachers were requested to organize their math lessons as a variation of the direct instructional model developed by Good, Grouws, Beckerman, Ebmeier, Flatt, and Schneeberger (Note 4). Each math lesson consisted of a review, development, and seatwork part with teacher questions and controlled practice constituting integral parts of the instructional approach. Seatwork was worked on by students as members of their small groups instead of individually, as was originally prescribed by Good et al. (Note 4). Teachers were requested to intervene as little as possible in the functioning of the small groups during seatwork, with any intervention conducted in accordance with the guidelines presented in a small-group seatwork manual. During the sessions, it was decided that the curriculum for the study would consist of a 10-day unit on long division from the students' regular textbooks followed by a 10-day unit on fractions. The teachers were asked to closely coordinate their lesson plans so that essentially the same material would be covered at the same pace.

The aptitude tests and questionnaires were administered 2 weeks before the study was scheduled to begin. An "ability" score was computed for each student; the ability score was a sum of the student's z scores on Raven's Progressive Matrices and the Mathematical Computations subtest from the Sequential Tests of Educational Progress. Students with ability scores either in the upper or lower 25% of the distribution for their class were assigned, respectively, to the high and low ability levels, while students in each class in the middle 50% of the distribution composed the medium ability level. One high, one low, and two medium ability students were then randomly assigned to each small group. The small groups were then randomly assigned to either the trained or control condition within each of the two classes.

The day preceding the first day of division instruction, the first part of the training program was conducted in a 50-minute session. While the trained group engaged in training, control students participated in an adult-led discussion on careers in which some knowledge of math is required. Afterwards they completed a math worksheet. Two follow-up sessions were held, respectively, 2 and 5 days after the initial training session. While the trained students were being tested for recall of principles of good small-group interaction during the first short session, control students were quizzed on recall of information from their math career discussion. During the second short session, control students participated in an adult-led discussion on math anxiety.

After 10 days of instruction, the students' learning of division was assessed. The following day the second part of the training program was conducted during a 50-minute session. During this time, control students participated in a game in which two teams of students competed with each other in the speed and accuracy with which group members could work math problems on the board. For the latter part of the session, students were allowed to play other math games with their group members. The teachers were not present in the classroom for any of the training and follow-up sessions or for the control counterpart sessions.

Ten days of fractions instruction followed the second training session. A fractions achievement test was administered at the end of the unit. At this time, the attitude toward math scale was readministered. After a delay of 2 weeks, student retention of division and fractions learning was evaluated.

Student behavior was observed throughout the study using the observation system described. During the lesson, the observers coded two groups of four (or three) students. Each group was coded for approximately 30 intervals of 20 seconds each during review and development. During seatwork each of the groups was coded for an additional 30 intervals. The coding schedule was arranged so that each group was coded an approximately equal number of times during 20 days of the study and an approximately equal number of times as the first and second group to be coded during the lesson. Each of three primary coders coded each group an approximately equal number of times.

Results

Effects of Training on the Amount and Kind of Task-Related Interaction

Median and mean proportions of intervals coded for selected categories of behaviors observed were calculated for the total instructional period. Intervals coded for each category were weighted by total intervals. Codes for conceptual and sequencing explanations were combined into a single category. "Task-related interaction," construed as interaction hypothetically facilitative of learning, was formed by combining the conceptual/sequencing (higher-order) explaining, procedural (directions) explaining, receiving a conceptual/sequencing explanation, receiving procedural explanations, asking questions, and answer checking categories. Median and mean proportions for the total instructional period are reported in Table 1. In the table each percentage point represents approximately 22 seconds of interaction for each 20-25 minute seatwork period.

To determine the effects of the training program on the amount of task-related interaction and the amount and kind of explanations produced in the small group, category proportions for (a) the trained and control groups and (b) the trained and control groups within each ability level, were compared using a one-tailed Mann-Whitney U test. A Mann-Whitney test

Table 1

Medians, Means, and Standard Deviations of Proportions of Intervals Coded for Small-Group Behaviors for the Total Instructional Period

		Control				Trained			
		Total (n = 20)	High (n = 5)	Medium (n = 10)	Low (n = 5)	Total (n = 23)	High (n = 6)	Medium (n = 11)	Low (n = 6)
Works	Mdn:	.81[a]	.81	.80	.86	.76	.76	.79	.73
	M:	.77	.76	.78	.76	.76	.75	.76	.76
	SD:	.15	.17	.15	.16	.09	.08	.11	.07
Provides answer	Mdn:	.01	.01	.01	.00	.00	.00	.00	.00
	M:	.02	.02	.02	.02	00	.00	.00	.00
	SD:	.03	.02	.04	.03	.00	.01	.01	.00
Explains: conceptual/ sequencing	Mdn:	.01	.01	.01	.01	.02	.05	.02	.03
	M:	.02	.04	.02	.01	.05	.05	.05	.04
	SD:	.03	.06	.02	.01	.05	.04	.06	.04
Explains: directions	Mdn:	.01	.02	.01	.01	.02	.02	.02	.00
	M:	.02	.02	.02	.01	.02	.03	.02	.02
	SD:	.02	.02	.02	.01	.02	.02	.02	.02
Receives: answer	Mdn:	.01	.01	.00	.01	.00	.00	.00	.00
	M:	.04	.04	.03	.05	.00	.00	.00	.01
	SD:	.07	.07	.06	.09	.00	.00	.00	.01
Receives: conceptual/ sequencing	Mdn:	.01	.01	.02	.04	.04	.00	.04	.07
	M:	.02	.01	.03	.03	.05	.01	.06	.07
	SD:	.03	.01	.04	.03	.05	.01	.05	.05

Table 1 (continued)

		Control				Trained			
		Total (n = 20)	High (n = 5)	Medium (n = 10)	Low (n = 5)	Total (n = 23)	High (n = 6)	Medium (n = 11)	Low (n = 6)
Receives: directions	Mdn:	.02	.02	.02	.02	.03	.01	.03	.03
	M:	.02	.02	.02	.02	.03	.02	.03	.04
	SD:	.02	.01	.02	.02	.02	.01	.02	.02
Asks question	Mdn:	.01	.01	.01	.01	.03	.01	.03	.03
	M:	.02	.02	.02	.02	.03	.02	.03	.04
	SD:	.02	.01	.03	.01	.02	.01	.02	.02
Answer checking	Mdn:	.04	.04	.04	.05	.06	.04	.07	.06
	M:	.05	.05	.04	.05	.08	.05	.09	.08
	SD:	.03	.03	.02	.05	.06	.04	.06	.05
Off-task	Mdn:	.08	.09	.08	.06	.06	.18	.06	.05
	M:	.13	.13	.13	.14	.10	.14	.09	.08
	SD:	.13	.13	.14	.16	.09	.09	.09	.09
Task-related interaction	Mdn:	.14	.14	.14	.14	.22	.16	.23	.28
	M:	.16	.17	.16	.15	.26	.18	.28	.29
	SD:	.07	.08	.08	.06	.13	.07	.14	.16

[a]An approximation of actual time spent (in minutes) in each of the behaviors during each 20-25 minute seatwork period can be calculated by using the following formula: P x 22, where P equals the tabled proportion.

was used instead of a parametric procedure because the observation data were not normally distributed. An overall Type I error of .12 (or α = .03 per comparison) was used in testing the difference between the comparison groups on each of the behavioral categories of interest. This unconventional alpha level was used because of the low power of the analysis.

As predicted, averaging over ability levels, the trained group engaged in more task-related interaction than did the control group, z = -2.61, $p < .03$. The mean ranks of the trained high, medium, and low ability students exceeded that of their respective same ability counterparts in the control group. However, only the difference between the trained and control medium ability students was statistically significant, z = -2.11, $p < .03$. A breakdown of the task-related interaction category into its constituent behaviors showed that trained students provided and received more higher-order explanations than did control students, respectively, z = -1.88, $p < .03$, and z = -1.94, $p < .03$. With the exception of receipt of explanations by high ability students, more intervals were coded for high, medium, and low ability students in the trained group than in the control group for each of these two behaviors. However, only the difference between receipt of higher-order explanations by trained and control medium ability students was statistically significant, z = -2.15, $p < .03$. Trained students checked answers more often than control students, z = -1.94, $p < .03$. Again, there was the tendency for trained students at each ability level to engage in the behavior more often than same ability control students. Control students provided more answers to group members and received more answers from group members than did trained students, respectively, $z = -2.02$, $p < .03$ and $z = -2.21$, $p < .03$. These differences occurred consistently at each ability level. A comparable number of intervals were coded for trained and control students for the works, explains and receives directions, and off-task categories.

Achievement, Retention, and Attitude Differences

To determine if initial differences in ability existed between the trained and control groups, the ability scores of the two groups were compared with a Mann-Whitney U test. The test results showed that the two groups were comparable in ability. Mann-Whitney comparisons of the ability scores of the trained and control students within the high, medium, and low ability levels were also made. The results indicated that students of the trained and control groups at each ability level were of comparable entering ability. Ability scores are presented in Table 2.

The median and mean scores for the trained and control groups on the division, fractions, and retention tests are reported in Table 2. Differences in performance on the achievement and retention measures for the trained and control group and for trained and control students within each ability level were examined by a one-tailed Mann-Whitney U test. An overall Type I error of .12 was assigned to each set of four comparisons investigating differences, respectively, in division, fractions, and retention.

Mann-Whitney comparisons for division achievement indicated that there were no statistically significant differences between the trained and control groups, either overall or within ability level. With the exception of medium ability students, mean rank differences in division

Table 2

Medians, Means, and Standard Deviations of the Trained and Control Groups

for Ability and Achievement and Retention Scores

		Control				Trained			
		Total (n = 20)	High (n = 5)	Medium (n = 10)	Low (n = 5)	Total (n = 20)	High (n = 5)	Medium (n = 10)	Low (n = 5)
	Mdn:	.28	1.90	.28	-1.38	.15	1.86	.15	-1.43
Ability	M:	-.16	1.84	-.16	-2.14	.08	1.85	.25	-2.05
	SD:	1.90	.39	1.52	1.43	1.66	.98	.58	1.28
	Mdn:	26.5	30.0	30.5	15.0	29.5	35.0	27.0	28.0
Division	M:	24.9	29.2	28.6	13.2	26.7	32.4	25.9	22.4
	SD:	11.05	8.53	7.07	12.91	8.55	6.73	7.00	11.24
	Mdn:	28.0	30.2	28.2	20.0	29.0	33.0	30.0	24.0
Fractions	M:	25.7	29.8	27.9	17.2	28.5	31.4	29.1	22.6
	SD:	8.7	3.63	9.87	11.12	6.10	2.70	3.84	9.07
	Mdn:	29.5	38.0	29.5	24.0	33.5	37.0	30.0	28.0
Retention	M:	27.9	36.8	28.7	17.2	28.0	36.0	29.9	22.8
	SD:	11.51	6.34	8.34	13.77	11.79	4.47	9.05	14.04

performance were in favor of the trained students. The results of the Mann-Whitney comparisons for fractions achievement duplicated the findings from the division analysis. Although in each of the four comparisons the mean rank of the trained students exceeded to some extent that of the control students to which they were being compared, the mean rank differences were not statistically significant. Results of the retention test analysis indicated that the trained and control groups performed comparably on this measure. This finding extends to within ability level comparisons of the two groups. However, as indicated by mean ranks, only the high ability control students outperformed their trained counterparts.

Relationship of Small-Group Interaction to Achievement and Retention

A correlational analysis was performed to determine if selected behaviors occurring in the small-group setting were importantly related to performance on the achievement and retention tests. Spearman correlations, relating division achievement, fractions achievement, and retention scores, respectively, to the explaining, receiving, answer checking, total task-related interaction, working, and off-task behavioral categories were computed within each ability level for the trained and control groups combined. Partial correlation coefficients, in which the effects of ability and off-task behavior were removed, were computed from the zero-order Spearman correlations between interaction behaviors and achievement and retention. The correlations were tested for significance with a one-tailed test. The partial correlation coefficients for the division, fractions, and total instructional periods are reported in Table 3.

Table 3

Partial Correlations of Selected Small-Group Behaviors with the Division, Fractions, and Retention Test Performance of High, Medium, and Low Ability Students

	Division				Fractions				Retention			
	Total (n = 43)	High (n = 11)	Medium (n = 21)	Low (n = 11)	Total (n = 43)	High (n = 11)	Medium (n = 21)	Low (n = 11)	Total (n = 43)	High (n = 11)	Medium (n = 21)	Low (n = 11)
Works	-.09	-.10	-.21	.58**	.03	.11	.09	-.66**	.02	-.29	-.17	.42
Provides answer	.05	.28	.22	.15	-.05	-.06	-.23	-.10	-.06	.65**	-.44**	-.08
Explains: conceptual/ sequencing	.11	.51*	-.21	.14	.17	-.03	-.04	.72***	.34***	.89***	-.15	.50*
Explains: directions	-.19	.02	-.05	-.06	-.01	-.07	-.25	.07	-.08	.27	-.29	-.11
Receives: answer	-.51***	-.76***	-.56***	-.49*	.00	-.20	-.02	.18	-.09	-.23	-.32*	-.30
Receives: conceptual sequencing	.05	.07	-.18	.30	.14	-.29	.07	.57**	.11	.36	.20	.44
Receives: directions	.13	-.30	.21	.58**	.09	.30	-.27	.33	.13	-.10	.19	.34
Answer checking	.18	.44	-.29	.63**	.24*	-.66**	.28	.59**	.32**	-.38	.20	.77***
Off-task	-.13	-.10	-.15	.06	-.32**	-.51*	.08	-.70***	-.49***	-.70***	-.43**	-.44*
Task-related interaction	.04	.18	-.27	.48*	.15	.00	-.10	.60**	.23*	.42	-.07	.53*

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

The results indicated that a number of the small-group behaviors were related to division achievement. Providing conceptual/sequencing explanations was positively related to the achievement scores of high ability students, $r_s = .51$, $p < .10$. High, medium, and low ability students receiving a higher proportion of answers during seatwork performed poorer on the division test than did students receiving fewer answers during small-group interaction, respectively, $r_s = -.76$, $p < .01$, $r_s = -.56$, $p < .01$, and $r_s = -.49$, $p < .10$. Low ability students who received more procedural explanations, checked answers more often, and engaged in more task-related interaction tended to obtain higher achievement scores, in order, $r_s = .58$, $p < .05$, $r_s = .63$, $p < .05$, and $r_s = .48$, $p < .10$. Working was also related to higher division achievement for low ability students, $r_s = .58$, $p < .05$.

A few categories of small-group behavior were related to fractions achievement. Low ability students who more often provided and/or received conceptual/sequencing explanations during seatwork obtained higher achievement scores, $r_s = .72$, $p < .01$ and $r_s = .57$, $p < .05$, respectively, for explaining and receiving. Answer checking and achievement were also positively related for low ability students, $r_s = .59$, $p < .05$. High ability students who more often engaged in off-task behavior or in answer checking tended to perform poorer on the fractions achievement test than those students who spent less time engaged in these behaviors, respectively, $r_s = -.51$, $p < .10$ and $r_s = -.66$, $p < .05$. Off-task was similarly related to fractions achievement for low ability students, $r_s = -.70$, $p < .01$. Low ability students who more often participated in task-related interaction obtained higher scores on the achievement test, $r_s = .60$, $p < .05$, while those who spent more time working on their own tended to obtain lower scores on the fractions test, $r_s = -.66$, $p < .05$.

Student interaction during division and fractions instruction was in a few cases related to performance on the retention test. Providing conceptual/sequencing explanations was strongly and positively correlated with retention test performance for high ability students, $r_s = .89$, $p < .01$ and was moderately and positively related to the retention scores of low ability students, $r_s = .50$, $p < .10$. Low ability students who participated more often in answer checking retained more on the delayed test, $r_s = .77$, $p < .01$. Off-task behavior was negatively related to retention of division and fractions learning for high ability students, $r_s = -.70$, $p < .01$, for medium ability students, $r_s = -.43$, $p < .05$, and for low ability students, $r_s = -.44$, $p < .10$. Low ability students who more often participated in task-related interaction during division and fractions seatwork acquired higher retention test scores than did low ability students who engaged less frequently in interaction, $r_s = .53$, $p < .10$.

<u>Relationship of Student Aptitudes to Participation in Small-Group Interaction</u>

<u>Student ability</u>. One-tailed Mann-Whitney <u>U</u> comparisons were performed to determine if the students' ability level was related to the role the student assumed during small-group interaction. An overall Type I error of .12 was divided equally among the three comparisons conducted for each category of explaining or receiving behavior.

Generally, the results showed a trend in the expected direction. Higher ability students tended to more often engage in explaining behaviors than did lower ability students and lower ability students were more often the target of the explanations than were higher ability students. However, for explaining behaviors, the only statistically significant differences showed that medium ability students provided significantly more answers to their peers than did low ability students, $z = -1.72$, $p < .03$, and high ability students provided more procedural explanations than low ability students, $z = -1.87$, $p < .03$. For the receiving explanations behaviors, both medium and low ability students were more often the targets of higher-order explanations than were high ability students, respectively, $z = -2.84$, $p < .03$, and $z = -2.73$, $p < .03$.

Attitude toward math. Attitude toward math exhibited consistent patterns of relationships to small-group interaction within each of the ability levels. High ability students with higher posttest attitudes toward math tended to provide more higher-order explanations than did students with less positive attitudes, $r_s = .72$, $p < .01$, and to engage in more task-related interaction, $r_s = .47$, $p < .10$ and $r_s = .60$, $p < .05$, in order, for the pre- and posttests. For high ability students off-task was negatively related to pre- and posttest attitude scores, respectively, $r_s = -.42$, $p < .10$ and $r_s = -.49$, $p < .10$.

Medium ability students with more positive attitudes also tended to interact more in the small group than medium ability students with less positive attitudes. Pretest attitude scores were positively related to the providing and receiving of higher-order explanations, respectively, $r_s = .30$, $p < .10$ and $r_s = .32$, $p < .10$, and to total task-related interaction, $r_s = .52$, $p < .01$. Posttest attitude scores were positively related to total task-related interaction, $r_s = .35$, $p < .10$. Congruently, medium ability students with more positive attitudes tended to spend less time off-task than students with less positive attitudes, $r_s = -.35$, $p < .10$.

Attitude toward math was highly related to the small-group interaction of low ability students. However, the direction of the relationship was opposite that found for high and medium ability students. Scores on the pre- and postattitude measures were negatively related to the providing of higher-order explanations, $r_s = -.88$, $p < .01$ and $r_s = -.85$, $p < .01$; to the receiving of higher-order explanations, $r_s = -.87$, $p < .01$ and $r_s = -.75$, $p < .01$; and to total task-related interaction, $r_s = -.60$, $p < .05$ and $r_s = -.50$, $p < .10$. Low ability students with higher posttest attitude scores tended to spend more time engaged in individual work than did low ability students with lower posttest attitude scores, $r_s = .58$, $p < .05$.

Discussion

The main purpose of this study was to investigate the relationship of (a) student interaction during small-group learning to academic achievement and (b) student ability to small-group interaction in an effort to substantiate and explain previous ability x treatment interaction findings when small-group and individual learning approaches were compared. Results from the present study support previous ATI findings indicating that low ability students benefit from a small-group approach (Amaria et al., 1969; Webb, Note 1; Peterson et al., Note 2). The present findings also support prior studies which showed that the achievement of high ability students was facilitated by learning in a small heterogeneous ability group (Amaria et al., 1969; Peterson & Janicki, 1979; Peterson et al., Note 2; and Webb, Note 1), but that medium ability students did not benefit from learning in a small mixed ability group (Peterson & J. ..ki, 1979; Webb, Note 1; Peterson et al., Note 2).

Student interaction and student ability were examined as variables which were hypothesized to operate interdependently to produce the ATI findings. Results from this study indicated that task-related small-group interaction was highly related to the academic achievement of low ability students. Task-related interaction was also positively related to the achievement of high ability students, but to a lesser extent than for low ability students. Task-related small-group interaction was unrelated to the achievement of medium ability students.

Evidence pointing to these relationships was acquired through three analyses: (a) within ability level comparisons of the achievement and retention scores of trained and control students; (b) within ability level comparisons of task-related interaction engaged in by trained and control students; and (c) within ability level correlations of small-group behaviors with division, fractions, and retention test scores. Results from these three sources were integrated and a determination of the strength of the relationship between interaction and test performance was then made based on the logical consistency of the findings in conjunction with the strength of the results produced by the individual analyses. This approach is used in the following discussion to substantiate the findings presented above.

Results from the three analyses for trained and control low ability students converged to form a consistent pattern which suggested that the higher test scores of trained low ability students were produced by greater involvement in types of small-group interaction which were related to better test performance. Descriptive statistics showed that trained low ability students outperformed control low ability students by median differences of 13, 4, and 4 points, respectively, on the division, fractions, and retention tests (or by .8, .5, and .4 standard deviation units based on mean differences). In addition, trained students in comparison to control students tended to work less individually and to participate in more task-related interaction. Finally, correlational data, by showing that specific small-group behaviors and overall interaction were positively and moderately related to test performance, suggested that the higher test scores of trained students were a product of their participating in more task-related interaction.

For high ability students, inconsistencies in the three data sources examined precluded the making of a strong statement concerning the role of small-group work in these students' learning of mathematics. Participation in a greater amount of higher-order explaining was not necessarily accompanied by higher achievement nor was higher achievement necessarily preceded by more explaining. Thus, only correlational evidence remained as the data source for determining the relatedness of small-group interaction to performance. Correlations showed that for high ability students higher-order explaining was positively related to division and retention scores.

The pattern of findings produced by the three data sources was consistent for medium ability students. Correlations of small-group behaviors with division, fractions, and retention scores showed the absence of positive relationships. Therefore, more participation in behaviors hypothetically related to subject matter acquisition was not expected to be accompanied by higher achievement. The findings agreed with this proposition. Although trained medium ability students engaged in more interaction than control medium ability students, the two groups performed comparably on the fractions and retention test, while trained students scored lower (but not significantly lower) than the controls on the division test. This latter finding is consistent with the correlational data for division which showed that more participation in task-related interaction tended to be negatively (although not significantly) associated with division achievement.

The data provided additional insights about the relationship of task-related small-group interaction to achievement. First, the correlational data showed that a larger variety of small-group behaviors was positively related to the test performance of low ability students than to the achievement and retention scores of high and medium ability students. Although the relationships were not statistically significant in all cases, the providing and receiving of higher-order explanations, the receiving of directions, and answer checking were consistently and positively related to better task performance by low ability students. In comparison, only the providing of higher-order explanations showed a similar relationship to the achievement and retention of high ability students. These findings concur with expectation, for by definition low ability students are expected to manifest fewer of the competencies required for effective academic performance. Results from this study suggest that working with peers may partially compensate for the learning deficiencies of low ability students.

The data also suggest that material difficulty may affect the facilitatory potential of task-related interaction. For instance, in this study, the fractions material was less difficult than the long division material as indicated by the higher percentage correct scores acquired by the students on the fractions achievement test. For high ability students, higher-order explaining was related to better division test performance but not to higher fractions achievement. It is conceivable that fractions achievement and higher-order explaining were uncorrelated because explaining as a supplementary learning aid was simply not needed. However, because there was a slight ceiling effect for high ability students on the fractions test, a relationship between the two variables may not have occurred because of statistical reasons. Unfortunately, it is not possible to determine which of the above explanations is most appropriate, for the conditions suggesting the explanations are confounded. To the contrary, for low ability students, the providing and receiving of higher-order explanations during division instruction were not strongly related to higher achievement, but participation in these behaviors was significantly related to better performance on the fractions test. Possibly, the division material was too difficult for low ability students to generate, as explanations, clear formulations of the problems and to thereby benefit from the explaining process. Similarly, the material may have been too difficult for these students to comprehend or apply information offered to them through student explanations.

Finally, the results from this study do not support one hypothesis offered in explanation of the failure of small-group learning to facilitate the achievement of medium ability students. Webb (Note 1) hypothesized that medium ability students are denied full participatory rights in a small heterogeneous ability group and that their academic performance is negatively affected as a result. Present findings failed to substantiate this hypothesis by showing that medium ability students engaged in an amount of interaction intermediate to that of high and low ability students. However, this study provided no information about an alternate construal of the above hypothesis--that the performance of medium ability students may suffer in mixed ability groups because of the affective consequences of the rebuffs they experience.

Conclusions and Implications

The most important finding of the study was that the effects of small-group interaction depend on the ability level of the students. Interaction during small-group work was most beneficial for low ability students. High ability students also appeared to benefit from small-group interaction, although to a lesser extent than low ability students. For medium ability students, small-group interaction was unrelated to achievement and retention.

These results suggest hypotheses about the nature of the learner needs of low ability students while simultaneously proposing a learning method which addresses these needs. Generally, low ability students appear to need and to benefit from a more active involvement with the task which includes the opportunity to receive repeated explanations of the material, to formulate and convey their ideas, and to receive immediate feedback.

However, the importance of these findings is somewhat qualified by the size of the sample studied in this investigation. Generally, results produced from a sample of the size employed in this study may not be stable. That is, it may be difficult to replicate the results.

Nonetheless, if the small-group method is to be of maximal effectiveness in promoting learning, obviously a high quality of interaction must prevail. Results from the study suggest that minimal training in group interaction can improve the quantity and quality of small-group interaction. The implementation of a training program accompanied by ongoing teacher supervision aimed at keeping students on-task and at reinforcing principles and practices of "good" small-group interaction would conceivably contribute substantially to the achievement of quality interaction.

Careful attention to group composition could also play an important role in maximizing group effectiveness. The results suggest that high ability students who after some experience with small-group learning have more positive attitudes toward math, are the best candidates to combine with low ability students in a small group, for they are more inclined to engage in task-related interaction than high ability students with less positive attitudes. However, it may be even more important for the learning of low ability students to establish a mode of small-group interaction whereby low ability students are required to explain the material to other students who already understand it. The intent and objective of the activity would be to require the low ability student to formulate an organized and coherent conceptualization of the subject matter being taught. The activity would also provide the opportunity for feedback and for the clarification and correction of misunderstandings. The effectiveness of such a procedure is suggested by the finding that explaining in the small group is related to achievement and is consistent with reports by Gartner, Kohler, and Riesman (1971) that students who most need academic assistance can help themselves by teaching others.

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