The Effects of Cooperative Learning and Learner Control on High- and Average-Ability Students

☐ Simon Hooper
Chanchai Temiyakarn
Michael D. Williams

The effects of studying alone or in cooperative learning groups on high- and average-ability students were investigated. Also examined were the effects of completing computer-based instruction using either a learner- or program-control version of a lesson. A total of 175 fourth-grade students were classified as being of high or average ability and randomly assigned to paired or individual treatments stratified by ability. Students completed training to enhance small-group interaction before completing a computer-based tutorial and a posttest. Following cooperative learning, students demonstrated increased achievement and efficiency as well as better attitudes toward both the computer lesson and grouping. Students completed more practice items and examples in program-control treatments than in learner-control treatments. However, the form of lesson control did not affect students' achievement or attitudes.

☐ The goal of individualizing instruction to match personal needs has strong intuitive appeal. Individuals differ in aptitude, learning style, and motivation and may therefore require different instructional methods to enhance learning. Not surprisingly, therefore, individualized computer-based instruction (CBI), with its capability to prescribe instructional strategies according to individual needs, permit selection of personally relevant content, and incorporate self-pacing, has received considerable attention (Kinzie, 1990; Ross & Morrison, 1988; Tennyson & Park, 1987).

Despite the goal of matching instruction to individual needs, individualized instruction has obvious logistical and economic limitations. In many schools, students work with computers in small groups because there are fewer computers than students. In fact, students spend almost two-thirds of their computer time working in groups (Becker, 1986). Moreover, creating algorithms to adapt instruction to individual needs and designing and producing multiple versions of lessons are both time consuming and expensive (Carrier & Jonassen, 1988).

Having students work in small groups not only facilitates important administrative and financial issues but appears to have important cognitive and affective benefits. One method of small-group instruction is cooperative learning, wherein small groups of students are united through common incentive and motivation structures and work together to achieve a common goal (Slavin, 1983). Substantial evidence exists to suggest that interacting in cooperative learning groups improves students' achievement compared to studying alone (Johnson & Johnson, 1989). Cooperative learning also improves students' attitudes both toward work and other students (Hansell & Slavin, 1981; Johnson & Johnson, 1981; Sharan, 1980; Slavin & Madden, 1979).

Although most cooperative learning research has been conducted in non-computer settings, while CBI is usually designed for individual use, the benefits of cooperative learning appear to transfer to students working at the computer. Students completing CBI in cooperative groups generally perform as well as, and often better than, students working alone (Carrier & Sales, 1987; Dalton, Hannafin, & Hooper, 1989; Hooper, 1992b; Johnson, Johnson, & Stanne, 1985, 1986; Mevarech, Silber, & Fine, 1991; Shlechter, 1990). Also, cooperative learning may reduce hardware and software problems that hinder the achievement of less able students working alone (Hativa, 1988).

Cooperative learning appears to foster two important cognitive activities: active processing of information and cross-modeling (Bandura, 1977; Singer, 1978). Explaining to a partner appears to help students generate elaborations between new and existing information, resulting in deep processing of lesson content (Webb, 1982c). Modeling has both cognitive and metacognitive effects on learning. Listening to a summary may provide an alternative representation of lesson content. Similarly, constructive criticism from a partner may enhance students' understanding. From a metacognitive perspective, modeling helps students develop skills that enhance learning. According to Bandura (1977), observation helps students form rules that govern behavior. Students can observe potent interaction techniques and learning strategies being used by partners, as well as the results of investing mental effort in an activity (Spurlin, Dansereau, Larson, & Brooks, 1984).

Despite the apparent benefits associated with cooperative learning, several questions remain about how groups should be formed. One issue concerns ability composition. Most cooperative learning methods recommend heterogeneous grouping by ability (Aronson, 1978; Johnson & Johnson, 1986; Sharan, 1980; Slavin, 1980). Heterogeneous ability grouping has important potential affective consequences. Students are more likely to experience diverse cultures, attitudes, and value systems when working in heterogeneous groups than in homogeneous groups or when studying alone (Sharan, 1980). Advocates also claim that heterogeneous ability grouping has important cognitive consequences (Slavin, 1990), especially when tutor/tutee relationships exist among group members (Webb, 1982a, 1982b). Less able students are presumed to benefit from the extra attention, alternative knowledge representations, and modeling that more able students provide; more able students benefit from the cognitive restructuring that occurs when providing in-depth explanations to peers (Webb, 1989). However, skeptics suggest that heterogeneous grouping fails to challenge high-ability students (Willis, 1990) and that less able students benefit at the expense of their more able partners (Mills & Durden, 1992; Robinson, 1990).

The perception that more able students are constrained by their less able partners causes many teachers and parents to resist heterogeneous ability grouping for cooperative learning groups. For example, Slavin (1990) reported that parents and teachers are often concerned high-achievers will coach less able partners instead of learning new content, and that group progress will be reduced to that of the least able group member. Research evidence for this effect is inconclusive. Some studies do suggest that heterogeneous grouping benefits one ability group at the expense of another. For example, Hill (1982) claimed that, with complex tasks, heterogeneous grouping hinders the performance of high-ability students. Slavin (1983) suggested heterogeneous grouping offers few benefits to low-ability students if they are simply given correct answers. Webb (1982a) and Swing and Peterson (1982) reported that heterogeneous grouping hinders the performance of average-ability students when groups include a wide range of student abilities. However, other studies reported that students of all abilities benefitted from heterogeneous grouping compared to students of similar ability working alone (Hooper, 1992b; Mevarech et al., 1991; Yager, Johnson, Johnson, & Snider, 1986). Further research is needed to clarify the effects of heterogeneous ability grouping.

In addition to establishing the effects of heterogeneous ability grouping, it is important to investigate design issues for cooperative CBI (Cohen, 1991). Designers should not assume that instructional strategies that are appropriate for individualized instruction are also suitable for cooperative CBI.

One such relevant set of strategies relates to lesson control. In general, three forms of lesson control are used in CBI design: learner, program, and adaptive control. Learner control involves delegating instructional decision making to learners. When given instructional control, students may, for example, seek additional help, modify the difficulty level or content density, and manipulate the course sequence and instructional strategies to match their individual needs (Laurillard, 1987). Program (or linear) control prescribes an identical instructional sequence for all students, regardless of interest or need. Adaptive control modifies lesson features according to student aptitude (e.g., Snow, 1980), prior performance (e.g., Tobias, 1987), or ongoing lesson needs (e.g., Tennyson, Christensen, & Park, 1984).

Reigeluth and Stein (1983) suggested that instructional effectiveness and efficiency improve as learner control increases. Learner control nurtures system independence by encouraging students to select and manipulate instruction according to their needs and stimulating them to invest greater mental effort in a task (Federico, 1980; Salomon, 1983, 1985). If learning is found to be equivalent in both learner- and computer-controlled settings, learner control should stimulate productive design and development, increase learning efficiency, and enhance student motivation (Steinberg, 1984). Finally, linear control may lower student motivation by imposing an inappropriate lesson sequence on learners, and adaptive instruction may foster system dependence (Hannafin & Rieber, 1989).

Unfortunately, reviews of the literature do not generally support the use of learning control when students work alone (Carrier, 1984; Hannafin, 1984; Milheim & Martin, 1991; Steinberg, 1977, 1989). Learner control seems to be most effective when prior knowledge is high or when students possess well-developed metacognitive abilities. Students who possess low prior knowledge or poorly developed metacognitive strategies often make ineffective instructional decisions and leave instruction prematurely (Garhart & Hannafin, 1986).

The effects of learner control in cooperative-learning groups are as yet unknown. Less able students may function effectively in learner-controlled environments under the guidance of more able peers. Under this hypothesis, more able partners provide a model of effective learning that less able peers can emulate. Alternatively, dominant partners may impose their intentions on the group, which could decrease the learning potential for other members. In the latter case, some students may benefit more from working alone than from working in a group.

The purpose of this study was to extend previous research comparing the effects of completing CBI in groups and alone. The study examined the effects of cooperative versus individual CBI on the performance of high- and average-ability students. The study also examined the effects of learner and program control in individual and cooperative treatments. Finally, the study investigated these treatment effects on students' attitudes toward the instructional content, learning in groups, and partners.

METHOD

Subjects

A sample of 175 fourth-grade students from a predominantly white, upper-middle-class, suburban elementary school participated in the study. All students from the six fourth-grade classes in the school participated. Students were classified as being of high or average ability according to their performance on the mathematics subscale of the California Achievement Test (CAT). High-ability students scored at or above the median score and average-ability students scored below the median score of all fourth-grade students in the school. The median score fell at the 83rd percentile. The mean CAT score for the high-ability students was at the 92nd percentile and the range was from the 83rd to the 99th percentile. The mean for the average students was at the 61st percentile and the range was from the 12th to the 82nd percentile. Six students who were classified as being of average ability scored below the 30th percentile on the CAT.

Within each class, students were assigned to paired or individual treatment groups. Paired treatments included one high-ability student and one average-ability student. Initially, the study included four analysis groups: high-ability individual ($n = 41$); average-ability individual ($n = 47$); high-ability pair ($n = 42$); and average-ability pair ($n = 42$). Three students whose CAT scores were unobtainable completed the study alone, but their scores were not analyzed. Also excluded were scores of students who did not complete the posttest. A total of 162 subjects completed the study.

Materials

Cooperation Training

Training was designed to enhance intra-group interaction and cooperation. Training involved three phases: generation, practice, and reflection. Initially, students were asked to generate examples of activities that benefit or limit group effectiveness. The purpose of this exercise was to focus students' attention and to engage students in group processing (Johnson & Johnson, 1989). Next, students completed several cooperative activities. After each activity, students discussed ways to improve the effectiveness of group interaction. The purpose of the activities was to practice using cooperative learning strategies. The practice exercises were similar to those used prior to other cooperative learning studies (Hooper & Hannafin, 1991; Hooper, 1992b).

CBI Lesson Content

A CBI lesson used in several previous studies (Hooper, 1992b; Hooper & Hannafin, 1991; Hooper, Ward, Hannafin, & Clark, 1989) was modified for this study. The lesson included two exercises. The first was an activity designed to teach students how to use a computer mouse to navigate through the lesson. The second was a tutorial covering the information to be learned during the lesson. To reduce the effects of prior knowledge, the lesson content was based upon a symbol system. The only essential prerequisites involved calculations using the four basic arithmetic operations.

The tutorial included three phases: learning the symbol system, applying rules to the symbols, and using a special modifier. During each phase, students completed instruction, answered related questions and received immediate feedback, and attempted a mastery quiz of the lesson content. The first phase involved learning eight symbols. Each symbol represented a constant or an operation. The value of a constant was determined by the number of lines comprising the symbol. For example, a triangle represented the numeral 3. Parabolas represented operations. For example, the operations "add" and "subtract" were represented by parabolas similar to greater-than and less-than symbols. One information screen was presented for each of the eight symbols. However, instruction on the rules governing the symbols was not provided. Students completed up to eight practice questions that tested retention of the symbol meanings. The second phase involved combining the symbols. Instruction was provided on how to evaluate combinations of symbols, after which students completed a maximum of seven examples illustrating the evaluation process and eight practice questions concerning application of symbol combinations. The final phase required students to learn the role of a special modifier. The modifier caused symbols contained within a box to be evaluated before other symbols and then doubled. Instruction was followed by a maximum of six examples and four related practice questions.

Following each phase, students completed mastery quizzes. Students working in pairs collaborated while attempting the quizzes; thus, performance on the quizzes was an indication of group, not individual, mastery. Those who mastered the quiz began the next phase of instruction. Alternatively, students were told to review their errors and to attempt a parallel version of the quiz when ready. This procedure continued until either mastery was demonstrated or the quiz had been repeated twice. After two repetitions, the next segment was presented automatically. The quiz following the first phase included eight multiple-choice items on symbol meanings. The quiz following the second phase included six application questions on symbol use. The final quiz included five application questions on use of the special modifier. Mastery was set at 100% for all quizzes.

Students were permitted access to a help screen throughout the lesson, except while completing the mastery quizzes. The help screen summarized the eight symbol meanings. The average completion time for the tutorial was 36 minutes.

Two versions of the lesson were developed: learner control and program control. The versions differed in the students' control over the number of examples and practice items and whether to receive explanatory feedback. In the program-control version, subjects attempted all 21 examples and 20 practice items and automatically received explanatory feedback following incorrect responses. In the learner-control versions, students were asked after each example, practice item, or incorrect response whether they wanted to attempt another item or receive the solution to the question. Students completed all eight examples during the first phase, but in the second and third phases students decided after each item whether to complete additional examples and embedded questions and whether to receive explanatory feedback following an incorrect response. However, both lesson-control versions permitted unrestricted access to the help screen. Also, completion of the mastery quizzes was mandatory and not subject to student control.

Posttest

The posttest contained 7 fact, 13 application, 10 generalization, and 10 problem-solving questions. Fact and application questions tested the lesson content. Fact questions measured recall of the symbol meanings. Application questions measured the ability to evaluate combinations of symbols, including the special modifier. Generalization questions required students to use previously unseen symbols, based on the same rules as the symbol system learned, to evaluate symbol combinations. For example, a pentagon was introduced as a new symbol representing the numeral 5. Problem-solving questions generated combinations of symbols and required students to apply rules governing the symbols to solve unfamiliar problems. (Examples of the posttest questions can be found in Hooper & Hannafin, 1991.)

The questions were presented in a ten-page booklet containing four questions on each page. To avoid providing unnecessary cues, students were not permitted to review previous pages or to advance to subsequent pages until the allotted time had elapsed. Consequently, students were limited in the time available to answer the questions, thus ensuring experimental control of the testing environment. Two minutes were allocated to completing the answers on each of the first five pages, and one and one-half minutes to completing the answers on each of the remaining pages. These times were determined to be adequate based on pilot test results. Data from the study indicated a KR-20 reliability of .92 for the overall posttest.

Attitude Survey

An attitude survey containing 14 Likert-type items was designed to assess attitudes toward the computer lesson (six items) and attitudes toward grouping (eight items). Subjects responded to both positively and negatively worded statements by marking their opinions on a scale from 1 (strongly agree) to 5 (strongly disagree). The purpose of the items assessing attitudes toward the computer lesson was to determine students' liking for, and perceived difficulty of, the instruction. An example item is, "I didn't understand the computer lesson." The purpose of the items assessing attitudes toward grouping was to determine students' liking for, and perceived efficacy of, working with a partner. An example item is, "Partners help each other to learn." Data from the study indicated KR-20 reliabilities of .76 for attitudes to the computer lesson and .79 for attitudes to grouping. Within each subscale, scores were averaged to produce subscale means. To facilitate interpretation, scales were reversed so a high score indicates a positive attitude.

Dependent Measures

Three dependent measures were obtained for each student: achievement, attitude, and efficiency. Achievement was assessed through the posttest subscales and was an indication of lesson-based learning by individual students. Ratings for each item on the attitude survey were summed to yield subscale scores. Efficiency was calculated by dividing individual posttest total scores by lesson completion time for each student.

During the lesson, the computer recorded lesson completion time and four performance indicators: access to help, total practice items completed, total examples received, and embedded quizzes completed. Students working in pairs produced one data set and thus were treated as one case in analysis of group-based measures. Lesson completion time was the time to complete the tutorial. The "access to help" measure indicated frequency of access to the help screen. The "total practice items completed" measure indicated the number of practice questions completed during the tutorial. The "total examples received" measure indicated the number of examples received during phases two and three of the tutorial. The "embedded quizzes completed" measure indicated the total number of quizzes completed before mastering the lesson content.

Design

The study employed two designs. For individual measures, a randomized block design was employed with two crossed experimental factors, Grouping and Source of Control, and one blocking factor, Ability. For group-based measures, a completely randomized design was employed with two crossed experimental factors: Grouping and Source of Control. Group-based measures reflect data recorded at each computer.

Individual Measures

Achievement across the groups was compared using a 2 × 2 × 2 factorial design. Between-subjects factors were Ability (High or Average), Grouping (Individual or Cooperative), and Source of Control (Learner or Program). The resulting experimental treatments—individuals with learner control, individuals with program control, partners with learner control, and partners with program control—were each divided into high- and average-ability groups. Four levels of posttest questions—factual, application, generalization, and problem solving—served as the dependent measures.

Means for the two subscales on the attitude survey, and efficiency were analyzed using separate 2 × 2 × 2 factorial designs, again with Ability, Grouping, and Source of Control as between-subjects factors. The attitude scores included two measures: attitudes toward the computer lesson and attitudes toward grouping. Efficiency was determined by dividing individual scores by lesson completion time.

Group-based Measures

For analysis purposes, a combined score was obtained for students in pairs for each of the lesson performance indicators and time on task; that is, students working in pairs were treated as a single observation. Performance was compared using a 2 × 2 factorial design. Between-subjects factors were Grouping (Individual or Cooperative) and Source of Control (Learner or Program). These groups were compared on four performance indicators: access to help, total practice items completed, total examples received, and embedded quizzes completed. Time on task was analyzed with a separate 2 × 2 ANOVA with Grouping and Source of Control as between-subjects factors.

Data Analysis

Bray and Maxwell (1985) recommended combining conceptually related dependent variables in a single MANOVA. Consequently, for individual analyses, dependent measures were divided into three sets of variables: posttests, attitudes, and efficiency. For group-based analyses, dependent measures were divided into two sets of variables: the lesson performance indicators and time on task. Separate MANOVA's were conducted on each set of variables. Significant overall effects were followed up with univariate ANOVA's. For significant terms, the effects' sizes are reported (η) and are given in standard deviation units. Calculations were made using the Statistical Package for the Social Sciences (SPSS) 4.0 for the Macintosh, Systat, and Testat.* All tests of significance adopted an alpha level of .05.

Experimental Procedures

To resolve logistical constraints, the study was conducted during a five-week period. Six classes participated for three consecutive weeks: two classes during the first, second, and third weeks, two during the second, third, and fourth weeks, and two during the third, fourth, and fifth weeks. Six training sessions, one for each class, were conducted during the first week. Training lasted for aproximately 50 minutes and was completed by all students in intact classes.

Subjects were assigned to treatments using stratified random sampling. Initially, high- and average-ability students were randomly assigned to paired and individual treatment groups. Next, within each class, subjects in the paired treatment were ranked within each ability group. Partners were assigned by combining students with identical ranks: The most able high-ability student was paired with the most able average-ability student, then the second most able high- and average-ability students were paired, and so on. Thus, heterogeneity among group members was established.

The study was conducted in the school's computer laboratory. Students were assigned to a computer and completed either the learner- or program-control version of the CBI lesson. Students in paired and individual treatments were kept physically separate to reduce the opportunity for interaction with other students. Furthermore, at least two observers were present in the lab at all times to prevent individuals from receiving help from other students, as well as to offer procedural help. Students were told to complete the lesson on the computer, that they would be tested individually on the lesson content, and that individual grades for group members would be determined by averaging group members' scores. All students completed the lesson.

Approximately one week following the experiment, students completed the posttest and attitude survey individually. The posttest was administered immediately following the attitude survey. Eight absentees completed the posttest one week later.

RESULTS

Individual Measures

Scale Reliabilities and Intercorrelations

Table 1 presents intercorrelations among all the posttests, attitudes, efficiency, and completion time measures. Three posttest measures—fact, application, and generalization—are relatively homogeneous, but the fourth measure, problem solving, is less related to the others, perhaps due to floor effects operating in the scale. The two attitude measures are not related to each other, although attitudes toward lesson content are highly related to three of the posttests (a positive correlation in this case indicates that favorable attitudes are related to high posttest scores). Efficiency is highly related to all the posttest scales and

*SPSS © 1990, SPSS, Inc.; Systat © 1990, Sysat, Inc.; Testat © 1986, Systat, Inc.

TABLE 1 ☐ Scale Reliabilities and Intercorrelations. Values on the diagonal are coefficient alpha reliabilities. Pairwise *n*'s are in parentheses.

	Fact	*Application*	*Generalization*	*Problem Solving*	*Attitude: Lesson*	*Attitude: Grouping*	*Efficiency*
Fact	0.83						
	(162)						
Application	.71**	0.87					
	(162)	(162)					
Generalization	.50**	.61**	0.83				
	(162)	(162)	(162)				
Problem Solving	.22*	.19*	.28**	0.79			
	(162)	(162)	(162)	(162)			
Attitude: Lesson[a]	.37**	.36**	.30**	.09	0.76		
	(160)	(160)	(160)	(160)	(162)		
Attitude: Grouping[a]	.06	−.01	.12	.10	.05	0.79	
	(160)	(160)	(160)	(160)	(162)	(162)	
Efficiency[b]	.58**	.72**	.64**	.41**	.38**	.08	
	(160)	(160)	(160)	(160)	(158)	(158)	
Completion Time[b]	−.13	−.17*	−.18*	−.07	−.25**	−.03	−.61**
	(160)	(160)	(160)	(160)	(160)	(160)	(160)

*$p < .05$
**$p < .005$
[a]Correlation signs are reversed to facilitate data interpretation.
[b]Reliabilities were not calculated for Completion Time or Efficiency.

the lesson-content attitude measure. (Efficiency, being a function of time and overall achievement, is naturally positively correlated with time and each of the posttest measures.)

Additionally, Table 1 reports (values on the diagonal) coefficient alpha reliabilities (an index of scale homogeneity; see Lord & Novick, 1968) for each scale. Scale reliabilities ranged from .76 (attitude toward computers) to .87 (application posttest).

Posttests

Table 2 reports the means and standard deviations on the four posttests. A MANOVA on these posttests indicated significant effects for Ability (Wilks' $\lambda = .847$, $F(4, 151) = 6.84$, $p < .001$) and for Grouping (Wilks' $\lambda = .915$, $F(4, 151) = 3.52$, $p = .009$). However, the Ability-by-Grouping interaction was not statistically significant.

Univariate follow-up tests indicated that Ability was significantly related to all the posttests except fact: application ($MS_{Error} = 14.15$, $F(1, 154) = 6.17$, $p = 0.14$, $\eta = .198$); generalization ($MS_{Error} = 7.67$, $F(1,154) = 13.88$, $p < .001$, $\eta = .209$); problem solving ($MS_{Error} = 5.05$, $F(1, 154) = 16.06$, $p < .001$, $\eta = .310$). In each case, high-ability students outscored average-ability students (see means in bottom section of Table 2).

Follow-up examination of the Grouping effect indicated that Grouping was significantly related to generalization ($MS_{Error} = 7.67$, $F(1, 154) = 8.00$, $p = .005$, $\eta = .224$). In addition, the effect on problem solving approached significance ($MS_{Error} = 5.05$, $F(1, 154) = 3.60$, $p = .06$, $\eta = .153$). In each case, students in cooperative groups outperformed students working individually (see Table 2 for means). However, the effects on fact and application scales were not significant.

Attitudes

A MANOVA indicated a main effect for Grouping (Wilks' $\lambda = .718$, $F(2, 151) = 29.66$, $p < .001$). Univariate follow-up tests indicated that students in cooperative groups had significantly more positive scores than students working individually on both attitudes toward the computer lesson ($MS_{Error} = 25.51$, $F(1, 152) = 6.02$, $p = .015$, $\eta = .196$; M's =

TABLE 2 □ Achievement Means and Standard Deviations on the Four Posttest Subscales

ABILITY GROUPING		LEVEL OF QUESTIONING: *Fact* *(max. = 7)*	*Application* *(max. = 13)*	*Generalization* *(max. = 10)*	*Problem Solving* *(max. = 10)*	*Total*
HIGH						
Individual						
LC (n = 16)	M	6.31	8.50	3.19	1.94	19.94
	SD	1.66	3.78	2.79	2.54	8.28
PC (n = 19)	M	6.16	7.58	4.00	1.26	19.00
	SD	1.54	4.44	3.32	2.38	8.82
Total	M	6.23	8.00	3.63	1.57	19.43
	SD	1.57	4.12	3.07	2.44	8.47
Cooperative						
LC (n = 22)	M	6.55	8.73	5.46	2.32	23.05
	SD	1.01	3.09	3.22	2.93	7.66
PC (n = 19)	M	6.37	8.37	5.53	3.05	23.32
	SD	1.34	4.22	3.20	3.55	10.10
Total	M	6.46	8.56	5.49	2.66	23.17
	SD	1.16	3.61	3.17	3.21	8.76
AVERAGE						
Individual						
LC (n = 21)	M	5.76	6.81	2.48	0.81	15.80
	SD	2.07	3.82	2.09	1.81	7.26
PC (n = 25)	M	6.12	7.20	2.76	0.36	16.44
	SD	1.48	3.75	2.52	0.76	6.55
Total	M	5.96	7.02	2.63	0.57	16.17
	SD	1.76	3.75	2.31	1.34	6.81
Cooperative						
LC (n = 20)	M	6.00	6.80	3.65	0.75	17.20
	SD	1.41	3.37	2.74	1.29	6.59
PC (n = 20)	M	6.30	6.45	2.75	0.95	16.45
	SD	1.63	3.59	2.07	1.79	6.78
Total	M	6.15	6.63	3.20	0.85	16.83
	SD	1.51	3.44	2.44	1.55	6.61
MAIN EFFECTS SUMMARY						
Ability						
High (n = 76)	M	6.30	8.30	4.63	2.16	21.45
	SD	1.36	3.84	3.24	2.92	8.77
Average (n = 86)	M	6.05	6.84	2.90	0.70	16.48
	SD	1.64	3.59	2.38	1.44	6.69
Grouping						
Individual (n = 81)	M	6.07	7.44	3.06	1.00	17.58
	SD	1.68	3.92	2.69	1.95	7.69
Cooperative (n = 81)	M	6.31	7.61	4.36	1.77	20.04
	SD	1.35	3.64	3.04	2.68	8.36
Source of control						
LC (n = 79)	M	6.15	7.68	3.75	1.44	19.03
	SD	1.58	3.56	2.92	2.30	7.84
PC (n = 83)	M	6.23	7.38	3.68	1.33	18.60
	SD	1.48	3.98	2.97	2.44	8.39

Note: LC = Learner Control; PC = Program Control

1.83 and 2.16, respectively), and attitudes toward grouping (MS_{Error} = 39.94, F(1, 152) = 47.47, $p < .001$, η = .489; *M*'s 2.09 and 2.95, respectively). No other statistically significant differences were found on attitudes.

Efficiency

The ANOVA indicated a significant effect for Ability (MS_{Error} = .11, $F(1, 152) = 9.16$, p = .003, η = .238). High-ability students (M = 0.68) were more efficient than average-ability students (M = 0.51). Additionally, a significant effect was found for Grouping (MS_{Error} = .11, $F(1, 152) = 7.26$, $p = .008$, η = .213). Students who worked in groups (M = 0.67) were more efficient than students who studied alone (M = 0.51). No other statistically significant differences were found.

Group Measures

A MANOVA on the four on-line performance indicators (access to help, total practice items completed, total examples received, and embedded quizzes completed) indicated main effects for Grouping (Wilks' λ = 0.893, $F(4, 121) = 3.64$, $p = .008$) and Source of Control (Wilks' λ = 0.045, $F(4, 121)$ = 636.32, $p < .001$).

Univariate follow-up tests indicated that Grouping was significantly related to access to help (MS_{Error} = 17.31, $F(1, 124) = 11.43$, $p < .001$, η = .294), and to embedded quizzes (MS_{Error} = 7.23, $F(1, 124) = 4.44$, $p < .04$, *eta* = .188). Students working alone accessed the help screen more frequently than students working in groups (*M*'s = 4.73 and 2.00, respectively) and required more attempts to master the embedded quizzes (*M*'s = 6.80 and 5.80) than students in groups. Means for total examples (8.40 and 7.84) and total practice (15.49 and 14.67), although not statistically different, were also greater for individuals than for paired students.

Results also indicated that Source of Control was significantly related to total practice (MS_{Error} = 14.07, $F(1, 124) = 197.35$, $p < .001$, η = .787) and examples (MS_{Error} = 1.08, $F(1, 124) = 2517.63$, $p < .001$, η = .977). Not surprisingly, Program-Control groups completed more questions than did Learner-Control groups (*M*'s = 20.00 and 10.13, respectively) and received more examples in the second and third phases of the lesson (*M*'s = 13.00 and 3.19).

A final ANOVA was conducted on the total time to complete the lesson at each computer. A significant effect was found for Grouping (MS_{Error} = 1084.51, $F(1, 125) = 13.10$, $p < .001$, η = .308), indicating that students working alone required more time to complete the lesson than did students working in cooperative groups (*M*'s = 38.57 and 32.21 minutes, respectively). No other statistically significant differences were found on group-based measures.

DISCUSSION

The purposes of this study were to examine the effects of completing CBI alone and in cooperative learning groups on high- and average-ability students and the effects of studying in learner- and program-controlled treatments. Results indicate that cooperative learning improved the achievement of high- and average-ability students on tests of higher-level learning. Achievement on generalization questions was significantly higher following group work than when students studied alone, and differences in achievement on problem-solving questions approached significance. On measures of lesson-based learning (fact and application), no differences in achievement were found; furthermore, question complexity may have influenced results. Problem-solving questions were extremely difficult for fourth-grade students, and a floor effect appears to have artificially compressed the score distribution.

Results seem to indicate differential effects for grouping on the type of learning measured by each of the four achievement scales. Findings were only significant for questions that presumably required deeper cognitive processing. However, direct comparisons between the dependent variables should be made with caution. Each dependent variable was examined independently in data analyses. Even so, trends were similar for all measures.

Students worked more efficiently in groups than alone. Furthermore, on measures of group-based (rather than individual) on-line performance, students completed the instruction faster in cooperative learning groups than alone. These results differ from those of many other cooperative learning studies, which found that group learning often takes longer to complete than individual learning. The finding of the current study may reflect the lesson design. During instruction, progress was restricted by quizzes embedded in the lesson, and students who did not demonstrate mastery repeated portions of the instruction. Students in groups who experienced difficulties could receive help from a partner, while students working alone could not. Such help probably promoted understanding, thereby facilitating quiz mastery and reducing lesson completion time. In a related study in which students in cooperative learning groups completed mastery quizzes alone or with a partner, collaborators demonstrated higher achievement than students who completed the quizzes alone (Hooper & Hannafin, 1991). This result suggests that students benefitted from the opportunity to interact during the quizzes. Grouping may have helped students to make fewer errors on the quizzes and promoted diagnosis and remediation of learning difficulties.

Cooperative grouping appears to have established a mutually supportive learning environment in which both cognitive difficulties and navigational disorientation were overcome. In contrast, students studying alone had to rely on the features of the design. This hypothesis is supported by performance measures recorded during instruction and by informal observations during the experiment. Students studying alone accessed the help screen more often and required more attempts to master embedded quizzes than did students in groups. Also, observers noted that students working alone encountered greater difficulty reading and understanding lesson directions than did students working in pairs.

In addition to improving performance, grouping improved students' attitudes. Students working in groups demonstrated more positive attitudes toward cooperative learning and toward the computer lesson than did students working alone. Although only modest differences were found in attitudes toward the lesson, differences in attitudes toward cooperative learning were impressive. Students who worked in groups rated cooperative learning almost a point higher on a 5-point scale than did students who worked alone. Apparently, students were more positive about the learning experience following group work than were students who worked alone. Attitudes toward one's learning experience are important. Students are more likely to learn from and use CBI in the future when their feelings of self-efficacy toward computers and their attitudes about CBI are high (Sutton, 1991). Conversely, students with negative attitudes about cooperative learning are less likely to invest effort in the group process or to engage in activities that mediate achievement.

As expected, high-ability students outperformed average-ability students on application, generalization, and problem-solving questions. Similarly, high-ability students outscored average-ability students on lesson efficiency. However, no differences between the two groups were found on tests of factual learning. Furthermore, no differences were found between the groups in attitudes toward the lesson or toward grouping.

Although the interaction between Grouping and Ability was not statistically significant, the most able students appear to have benefitted the most from the group learning experience. Overall achievement increased by almost 20% for high-ability students, but only by 4% for average-ability students. High-ability students may have benefitted from generating explanations for their less able partners, while less able partners may have adopted more passive roles. A recent study (Mulryan, 1992) investigating behavior during cooperative learning using children of similar age, ability, and socioeconomic status found that the most able students adopted the most active roles and that the least able students demonstrated high levels of passive behavior—a role not generally associated with higher achievement (Webb, 1989). However, student interaction was not recorded in the present study. Insight into group functioning might have been facilitated by relating individual performance to intra-group interaction.

In summary, students learned more productively and developed better attitudes when studying with partners in cooperative learning groups than when working alone. Students were more efficient, demonstrated greater achievement on measures of higher-level learning, and reported more positive attitudes toward the computer lesson and toward cooperative learning.

Apparently, the issue of students' selecting only limited instructional support when provided learner control applies to group as well as individual CBI. Students in the program-control treatment attempted more than four times as many examples and nearly twice as many practice questions. However, no differences were found between learner- and program-control treatments for achievement, attitudes, efficiency, or time on task. The absence of significant differences between lesson-control treatments indicates that some students may have processed lesson content superficially. Presumably, students in the program-control treatment did not attend very well to the additional examples or questions. Although learner control was not detrimental in the lesson employed in this study, in other lessons limited support might reduce achievement.

This research and several other related studies (Dalton et al., 1989; Hooper, 1992b; Johnson et al., 1985, 1986; Mevarech et al., 1991) suggest that students often complete CBI more effectively in cooperative learning groups than alone. To date, however, researchers and designers have focused little attention on designing CBI for groups. For example, although a substantial research body exists on feedback for individualized instruction, whether feedback is effective for cooperative learning groups remains unexplored. Attention should be focused on the factors that influence the effectiveness of group learning environments: individual accountability, positive interdependence, promotive interaction, collaborative skills, and group processing. (See Hooper, 1992a, for an outline of issues affecting cooperative CBI design.)

Two limitations of the present study should be noted. First, the participants in this study demonstrated unusually high achievement on standardized tests. Consequently, the results may not generalize to differently defined groups of high- and average-ability students. Second, all students completed the cooperation training and were informed that they would work alone or with a partner during the experiment. Consequently, some students who worked alone may have preferred to work with a partner. These students may have experienced greater motivation and achievement had they worked with a partner.

Directions for further research are recommended. As previously mentioned, the nature of intra-group interaction was not examined in the present study. The outcomes of cooperative learning are generally attributed to intra-group interaction. Consequently, researchers should analyze student interaction to help explain the factors that influence group functioning. Such research may be conducted using experimental methods, but naturalistic methods may generate deeper insight into how learners interact.

Researchers should examine other factors that influence cooperative learning. One such factor is group composition. Several recent studies have examined the effects of varying group composition according to gender, ability, or personality characteristics. One personality characteristic that may affect group composition is task persistence. Carrier and Williams (1988) identified a curvilinear relationship between task persistence and achievement while students study alone: Medium task persisters outperformed high and low task persisters. However, the effects of combining students with varying degrees of task persistence in cooperative learning groups have not been investigated.

Finally, researchers should examine learner control in varied computer learning environments. Environments that offer significant user control, such as simulations, hypermedia, and electronic encyclopedias, may soon be more common to most learners' experiences with computers than will be standard computer-based tutorials. Moreover, the concern of designers of CBI may not be whether to employ learner control or other forms of control, but how to improve the effectiveness of learner-controlled environments.

CBI and the interpersonal interaction promoted by cooperative learning provide complementary strengths. Computers can transform information, thereby helping students to build connections between abstract and physical events, establish mental models, and avoid developing misconceptions. Through collaboration, students can experience the cognitive benefits of teaching, observe and imitate cognitive strategies, provide encouragement to stay on task and exert mental effort, and explore diverse ideas and procedures. By combining computer-assisted instruction and cooperative learning, the benefits of each can be enhanced. □

Simon Hooper, Chanchai Temiyakarn, and Michael D. Williams are with the College of Education at the University of Minnesota.

REFERENCES

Aronson, E. (1978). *The jigsaw classroom.* Beverly Hills, CA: Sage Publications.

Bandura, A. (1977). *Social learning theory.* Englewood Cliffs, NJ: Prentice Hall.

Becker, H. J. (1986). Our national report card: Preliminary results from the new John Hopkins' study. *Classroom Computer Learning, 6*(4), 30–33.

Bray, J. H., & Maxwell, S. E. (1985). *Multivariate analysis of variance.* Beverly Hills, CA: Sage.

Carrier, C. A. (1984). Do learners make good choices? A review of research on learner control in instruction. *Instructional Innovator, 29*(2), 15–17.

Carrier, C. A., & Jonassen, D. H. (1988). Adapting courseware to accommodate individual differences. In D. H. Jonassen (Ed.), *Instructional designs for instructional courseware* (pp. 203–226). Hillsdale, NJ: Lawrence Erlbaum.

Carrier, C. A., & Sales, G. (1987). Pair versus individual work on the acquisition of concepts in a computer-based instructional lesson. *Journal of Computer-Based Instruction, 14,* 11–17.

Carrier, C. A., & Williams, M. D. (1988). A test of one learner-control strategy with students of differing levels of task persistence. *American Educational Research Journal, 25,* 285–306.

Cohen, E. G. (1991, April). *Classroom management and complex instruction.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Dalton, D. W., Hannafin, M. J., & Hooper, S. (1989). The effects of individual versus cooperative computer-assisted instruction on student performance and attitudes. *Educational Technology Research and Development, 37*(2), 15–24.

Federico, P.-A. (1980). Adaptive instruction: Trends and issues. In R. E. Snow, P.-A. Federico, & W. E. Montague (Eds.), *Aptitude, learning, and instruction: Vol. 1, Cognitive process analysis of aptitude* (pp. 1–26). Hillsdale, NJ: Lawrence Erlbaum.

Garhart, C., & Hannafin, M. J. (1986). The accuracy of cognitive monitoring during computer-based instruction. *Journal of Computer-Based Instruction, 13,* 88–93.

Hannafin, M. J. (1984). Guidelines for using locus of instructional control in the design of computer-assisted instruction. *Journal of Instructional Development, 7*(3), 6–10.

Hannafin, M. J., & Rieber, L. P. (1989). Psychological foundations of instructional design for emerging computer-based interactive technologies: Part II. *Educational Technology Research and Development, 37*(2), 102–114.

Hansell, S., & Slavin, R. E. (1981). Cooperative learning and the structure of interracial friendships. *Sociology of Education, 54,* 98–106.

Hativa, N. (1988). Computer-based drill and practice in arithmetic: Widening the gap between high- and low-achieving students. *American Educational Research Journal, 25,* 366–397.

Hill, G. (1982). Group versus individual performance: Are N + 1 heads better than one? *Psychological Bulletin, 91,* 517–539.

Hooper, S. (1992a). Cooperative learning and computer-based instruction. *Educational Technology Research and Development, 40*(3), 21–38.

Hooper, S. (1992b). The effects of peer instruction on learning during computer-based mathematics instruction. *Journal of Educational Research, 85,* 180–189.

Hooper, S., & Hannafin, M. J. (1991). The effects of group composition on achievement, interaction, and learning efficiency during computer-based cooperative instruction. *Educational Technology Research and Development, 39*(3), 27–40.

Hooper, S., Ward, T. W., Hannafin, M. J., & Clark, H. T. (1989). Factors influencing small group learning in a college age population. *Journal of Computer-Based Instruction, 16,* 102–109.

Johnson, D. W., & Johnson, R. T. (1981). Effects of cooperative and individualistic learning experiences on interethnic interaction. *Journal of Educational Psychology, 73,* 444–449.

Johnson, D. W., & Johnson, R. T. (1986). *Circles of learning: Cooperation in the classroom.* Edina, MN: Interaction Book Co.

Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research.* Minneapolis: Interaction Book Co.

Johnson, R. T., Johnson, D. W., & Stanne, M. B. (1985). Effects of cooperative, competitive, and individualistic goal structures on computer-assisted instruction. *Journal of Educational Psychology, 77,* 668–677.

Johnson, R. T., Johnson, D. W., & Stanne, M. B. (1986). Comparison of computer-assisted cooperative, competitive, and individualistic learning. *American Educational Research Journal, 23,* 382–392.

Kinzie, M. B. (1990). Requirements and benefits of effective interactive instruction: Learner control, self-regulation, and continuing motivation. *Educational Technology Research and Development, 38*(1), 1–21.

Laurillard, D. M. (1987). Computers and the emancipation of students: Giving control to the learner. *Instructional Science, 16*(1), 3–18.

Lord, F. M., & Novick, M. R. (1968). *Statistical theories of mental test scores.* Reading, MA: Addison-Wesley.

Mevarech, Z. R., Silber, O., & Fine, D. (1991). Learning with computers in small groups: Cognitive and affective outcomes. *Journal of Educational Computing Research, 7,* 233–243.

Milheim, W. D., & Martin, B. L. (1991). Theoretical bases for the use of learner control: Three different perspectives. *Journal of Computer-Based Instruction, 18*(3), 99–105.

Mills, C. J., & Durden, W. G. (1992). Cooperative learning and ability grouping: An issue of choice. *Gifted Child Quarterly, 36*(1), 11–16.

Mulryan, C. M. (1992). Student passivity during cooperative small groups in mathematics. *Journal of Educational Research, 85,* 261–273.

Reigeluth, C. M., & Stein, F. S. (1983). The elaboration theory of instruction. In C. M. Reigeluth (Ed.), *Instructional-design theories anad models* (pp. 335–382). Hillsdale, NJ: Lawrence Erlbaum.

Robinson, A. (1990). Cooperation or exploitation? The argument against cooperative learning for talented students. *Journal of Education of the Gifted, 14*(3), 9–27.

Ross, S. M., & Morrison, G. R. (1988). Adapting instruction to learner performance and background variables. In D. H. Jonassen (Ed.), *Instructional designs for instructional courseware* (pp. 227–245). Hillsdale, NJ: Lawrence Erlbaum.

Salomon, G. (1983). The differential investment of mental effort in learning from different sources. *Educational Psychologist, 18*(1), 42–50.

Salomon, G. (1985). Information technologies: What you see is not (always) what you get. *Educational Psychologist, 20*(4), 207–216.

Sharan, S. (1980). Cooperative learning in small groups: Recent methods and effects on achievement, attitudes, and ethnic relations. *Review of Educational Research, 50,* 241–271.

Shlechter, T. M. (1990). The relative instructional efficiency of small group computer-based training. *Journal of Educational Computing Research, 6,* 329–341.

Singer, R. N. (1978). Motor skills and learner strategies. In H. F. O'Neil, Jr. (Ed.), *Learning strategies.* New York: Academic Press.

Slavin, R. E. (1980). Cooperative learning. *Review of Educational Research, 50,* 315–342.

Slavin, R. E. (1983). *Cooperative learning.* New York: Longman.

Slavin, R. E. (1990). Point-counterpoint: Ability grouping, cooperative learning and the gifted. *Journal for the Educational of the Gifted, 14*(3), 3–8.

Slavin, R. E., & Madden, N. A. (1979). School practices that improve race relations. *American Educational Research Journal, 16,* 169–180.

Snow, R. E. (1980). Aptitude, learner control, and adaptive instruction. *Educational Psychologist, 15,* 151–158.

Spurlin, J. E., Dansereau, D. F., Larson, C. O., & Brooks, L. W. (1984). Cooperative learning strategies in processing descriptive text: Effects of role and activity level of the learner. *Cognition and Instruction, 1,* 451–463.

Steinberg, E. R. (1977). Review of student control in computer-assisted instruction. *Journal of Computer-Based Instruction, 3*(3), 84–90.

Steinberg, E. R. (1984). *Teaching computers to teach.* Hillsdale, NJ: Lawrence Erlbaum.

Steinberg, E. R. (1989). Cognition and learner control: A literature review, 1977–1988. *Journal of Computer-Based Instruction, 16*(4), 117–124.

Sutton, R. E. (1991). Equity and computers in the schools: A decade of research. *Review of Educational Research, 61,* 475–503.

Swing, S. R., & Peterson, P. L. (1982). The relationship of student ability and small group interaction to student achievement. *American Educational Research Journal, 19,* 259–274.

Tennyson, R. D., Christensen, D. L., & Park, O.-C. (1984). The Minnesota Adaptive Instructional System: A review of its theory and research. *Journal of Computer-Based Instruction, 11*(1), 2–13.

Tennyson, R. D., & Park, O. C. (1987). Artificial intelligence and computer-based learning. In R. M. Gagné (Ed.), *Instructional technology: Foundations* (pp. 319–342). Hillsdale, NJ: Lawrence Erlbaum.

Tobias, S. (1987). Mandatory text review and interaction with student characteristics. *Journal of Educational Psychology, 79,* 154–161.

Webb, N. M. (1982a). Group composition, group interaction, and achievement in cooperative small groups. *Journal of Educational Psychology, 74,* 475–484.

Webb, N. M. (1982b). Peer interaction and learning in small cooperative groups. *Journal of Educational Psychology, 74,* 642–655.

Webb, N. M. (1982c). Student interaction and learning in small groups. *Review of Educational Research, 52,* 421–445.

Webb, N. M. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research, 13,* 21–39.

Willis, S. (1990). Cooperative learning fallout. *ASCD Update, 32*(8), 6, 8.

Yager, S., Johnson, D. W., Johnson, R. T., & Snider, B. (1986). The impact of group processing on achievement in cooperative learning groups. *Journal of Social Psychology, 126,* 389–397.