*EFFECTS OF PEER TUTORING AND CONSEQUENCES ON THE MATH
PERFORMANCE OF ELEMENTARY CLASSROOM STUDENTS¹*

V. WILLIAM HARRIS AND JAMES A. SHERMAN

SOUTHWEST INDIAN YOUTH CENTER, TUCSON, ARIZONA, AND
UNIVERSITY OF KANSAS

The effects of unstructured peer-tutoring procedures on the math performance of fourth- and fifth-grade students were investigated. Students' performances in two daily math sessions, during which they worked problems of the same type and difficulty, were compared. When students tutored each other over the same math problems as they subsequently worked, higher accuracies and rates of performance were associated with the tutored math sessions. The use of consequences for accurate performance seemed to enhance the effects of tutoring on accuracy. The results from an independent-study control condition, which was the same peer-tutoring except that students did not interact with each other, suggested that interactions between students during the tutoring procedure were, in part, responsible for improved accuracy and rate of performance. When students tutored each other over different but related problems to those that they were subsequently asked to solve, accuracies and rates during tutored math sessions were also higher, suggesting the development of generalized skills in solving particular types of math problems.

In most public school classrooms, one teacher is expected to provide academic instruction to a group ranging in size from 15 to 40 students. Because of the number of students in the class and because the teacher is expected to teach all of the students in the class, the most typical forms of instruction employed are those designed to instruct all of the students at the same time (*e.g.*, lectures). However, if there are significant differences in the skills and academic repertoires of the students in the class, a single common instructional method such as a lecture may not efficiently meet the academic requirements of individual students. For some students, the common instructional method may cover material already known and, thus, may be

highly redundant. For other students, the common instructional method may provide insufficient information to allow them to complete subsequent academic tasks on their own. If the teacher had the opportunity to modify instructional techniques depending upon the particular requirements and deficits of each student, these problems might be eliminated. But the limited class time available and the high ratio of students to teacher in the classroom often make this difficult or impossible. One possible method of allowing for the development of individualized instructional systems for each student without reducing the ratio of students to teachers and without expanding the total amount of time students spend in the classroom, is to use some students as tutors for other students.

Tutoring of some students by other students has been used formally and informally in a variety of ways (see a review of several programs by Thelen, 1969; and the use of a reading tutorial program by Ellson, Barber, Engle, and Kampwerth, 1965), and a number of specific programs have been briefly described and advocated (*e.g.*, Lippitt, 1969; Fleming, 1969;

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Rossi, 1969; Archibeque, 1970). Further, the relatively few studies that have presented numerical data on the effects of student tutoring procedures suggest that tutoring by other students may have positive effects on academic performance. For example, Horst (1931) described a tutoring procedure in Latin in which high school honor students tutored other high school students who had performed poorly in the first grading period of the semester. Of the 160 students who received tutoring, the majority showed improvement in their grades in Latin. Similarly, Caditz (1963) described a program in which high school students who had good grades in algebra tutored others who had poor grades, and found some improvement in the algebra grades of students who were tutored. Reports by Hassinger and Via (1969) and Landrum and Martin (1970) outline a tutoring program in which high school students tutored elementary school children in reading, and show substantial gains on standardized reading achievement tests for both tutors and tutees after a six-week period of tutoring. In fact, the gains were larger for the tutors than for the tutees. In these four studies, however, no data were presented as to the performance of comparable students who were not tutored to provide a basis for evaluating the possible effects of tutoring, although the achievement test gains for tutors and tutees in the reports by Hassinger and Via (1969) and Landrum and Martin (1970) were larger than might be expected simply as a result of the passage of six weeks of time. Cloward (1967) and Taylor (1969) reported two studies of students tutoring others in which an explicit comparison was provided. In the study by Cloward, fourth- and fifth-grade students, who were reading below grade level, were tutored in reading by tenth- and eleventh-grade students for either 2 or 4 hr per week. Over a five-month period, students who were tutored improved more on a standardized reading test than did untutored comparison students, but only the difference for students who were tutored for 4 hr each week was statistically

significant. Further, the tutors used in the study also improved significantly more on standardized reading tests than comparable tenth- and eleventh-grade students who did not serve as tutors. In the study by Taylor, freshman engineering students were tutored by students from an honorary engineering fraternity in physics, math, and English. It was found that the tutored students received better grades at the end of an academic quarter than did students in a matched control group who received no tutoring.

Thus, not only is student tutoring a widely advocated procedure, but the data available suggest that it may be academically beneficial to the students involved. Nevertheless, the possible academic benefits need to be experimentally evaluated more carefully in a variety of settings. The purpose of this investigation was to evaluate experimentally the effects of peer tutoring, and peer tutoring in combination with consequences for academic performance, on the academic performance of elementary school children in mathematics.

METHOD

Subjects

For the majority of experimental conditions, 24 students in a fourth-grade classroom located in a poor economic area served. At the outset of the fourth-grade academic year, the students had scored a mean of 3.2 yr on the two math components of the Iowa Test of Basic Skills. The teacher, a third-year intermediate instructor, reported that the overall classroom performance in mathematics was the lowest of any academic area. During the last set of experimental conditions, 25 students in a fifth-grade classroom in the same school also participated in the study. These students scored a mean of 4.4 yr on the two math components of the Iowa Test of Basic Skills given at the outset of the academic year.

Prodecure

Daily math assignments, consisting of one to two pages of arithmetic problems in the

fourth-grade Addison-Wesley textbook were selected by the teacher in advance of the study. Because of the arrangement of the textbook, the problems in an assignment varied considerably in number, type, and difficulty over the different days. However, each assignment required, in the teacher's judgement, an appropriate daily amount of work from students.

Each daily assignment was divided into two separate assignments of equal length. The first assignment included all even-numbered problems, and the second included all odd-numbered problems. These assignments were then given to the students to be completed in two separate 20-min math periods. The first period for one-half of a daily assignment (math₁) occurred in the afternoon, and the second math period for the other half of the daily assignment (math₂) occurred during the morning of the next day. Both math periods preceded a 20-min recess period. The purpose of dividing each daily assignment into two separate assignments in this way was to try to arrange assignments of equal difficulty. Thus, the effects of various experimental procedures could be evaluated by comparing student performances in math₁ and math₂ without the possibly confounding variables of problem difficulty that might have been present had performances been compared over different types of math problems.

Before math₁, the teacher instructed the students regarding that day's assignment by providing a brief lecture, including the completion of sample problems similar to problems the students were required to complete during both math periods. After discussion of the assignment, the teacher passed out answer sheets, numbered to indicate which problems the students were to work during that math period. To counter-balance the problems assigned in math₁ and math₂, and to reduce the probability of cheating during math sessions, the teacher handed out the answer sheets in checkerboard fashion, alternating the first and second assignments for students in each row. In this way, a student would have a different assignment than

the students sitting directly in front, behind, or to the right or left of him. When each student had received an answer sheet, the teacher announced that the students could begin working on their assignments. After completing an assignment, the student handed his paper to a grader located at a table adjacent to the teacher's desk at the head of the classroom. The grader recorded the time taken for the student to complete his assignment, graded and recorded the correct and total number of problems worked, and handed the paper back to the student. The student, if he chose, could work again problems that he missed on the first check, and hand his paper to the grader for a second check. The grader then followed the same procedure outlined for the first check, and returned the graded paper to the student. During each math session, a student was allowed three checks by the grader. At the end of the math session, all papers that had not been scored by the grader were collected and graded for the first time.

Throughout the study, at any time during a math period, a student could ask questions about the problems by raising his hand, being acknowledged by the teacher, and advancing to her desk. At no time did the teacher give the answer to a student having difficulty with a problem.

Peer Tutoring With Same Problems

Fifteen minutes before the first math period, each student was given a copy of the math problems that he was to be assigned in the upcoming math session. The teacher then asked the students to arrange themselves in groups of two or three, and to help each other solve the problems. Any single tutorial group was generally composed of only those students working on the same assignment in the next math session. During the 15-min tutorial period, the teacher praised students who helped each other work the problems, and was available to answer questions concerning the assignment. At the end of the tutorial period, the tutoring assignment sheets and any work sheets used by the students

were collected, and answer sheets for the assignment in the math session were given out.

The tutoring procedure was first used before the math₁ period for 10 days, and then was used before the math₂ period for 10 days. With the exception of the prior tutoring period, all conditions during math₁ and math₂ were the same.

The effects of the tutoring procedure on arithmetic behavior were then investigated when there were consequences for accurate math performance during both math periods. This was done as follows: the teacher announced to the students that anyone receiving a 90% correct or better score on his math assignment in any math session (three grading checks allowed) could immediately leave the class for recess. The teacher also told the students that if a student did not obtain a 90% or better score on his math assignment within the 20-min math session, he would be allowed to go to recess at the regularly scheduled time. Given the "early to recess" consequence in both math₁ and math₂, the effects of the peer tutoring procedure described above were evaluated. Initially, tutoring was done before math₁ for seven days. Next, tutoring was done before math₂ for eight days. Then, these two conditions were repeated, with seven days of each.

Independent Study With Same Problems

To determine whether or not the improved math performance observed following the tutorial procedure was a function of the interaction between students during the tutorial period or simply a result of presenting the material to be assigned in the upcoming math session 15 min early, an independent study procedure was arranged. The independent study procedure was identical to the tutorial procedure in every way, except that students were not allowed to interact with each other. Instead, the students were given the math assignment that they would work on during math₁ or math₂ 15 min before that math period, and were told to study them individually.

At first, the independent study period was

arranged to occur prior to math₂. After six days, the 15-min independent study period was replaced by the 15-min tutorial period, which was left in effect for six days. This sequence of conditions was then repeated with six days in each condition. During this sequence of manipulations, the consequence procedure for 90% correct or better math performance was in effect during both math₁ and math₂.

Peer Tutoring With Related Problems

After the above conditions were employed, a tutoring procedure was used in which students tutored each other before either math₁ or math₂ on non-identical but closely related problems to those they were asked to work during a particular math assignment. The related problems were the same as those to be worked on that day's math assignment, except that the specific numbers used in each problem were different. Otherwise, the tutoring procedures were identical to that used initially in the study, with no consequences in effect for correct performance. At first, tutoring with related problems was arranged before math₁ for five days, then before math₂ for five days. This sequence was repeated, with five days in each condition. To determine the possible effects of using tutoring with students who had not previously been exposed to any of the procedures, peer-tutoring with related problems was used in a fifth-grade classroom. In this classroom, as in the fourth-grade classroom, math was divided up into two periods, one in the morning (math₁) and one in the afternoon (math₂). The tutoring procedure was first used before math₁ for nine days, and then was used before math₂ for seven days.

Behavioral Measures and Reliability of Recording

Throughout the study, the accuracy with which students completed problems and the rate of problem completion (problems completed per minute) were compared between math₁ and math₂. To evaluate grading reliability, answer sheets initially graded by the classroom grader

were periodically graded by a second observer. To eliminate the cues of the marks placed on the papers by the classroom grader, a cardboard sheet, patterned to match the answer sheets, covered the marks made by the classroom grader when the second observer graded answer sheets. These reliability measures on grading were taken at least once for both math₁ and math₂ during each experimental condition. Over this period, the classroom grader and the other grader agreed as to the correctness of an answer on 100% of the occasions. Periodically during the initial stages of the study, a second observer also recorded the time taken by students to complete an assignment to be graded the first time. Later in the study, these reliability measures were taken only for a sample of the students, but were always done at least once for math₁ and math₂ during each experimental condition. The times recorded for students to complete an assignment the first time by the classroom grader and the second observer never differed by more than 30 sec.

RESULTS

Figure 1 shows the mean per cent correct and the mean number of problems worked per minute on the first grading check in math₁ and math₂ when tutoring over the same problems was evaluated. The first set of bars shows the measures obtained when the tutorial period preceded only the math₁ sessions. The mean per cent correct in math₁ sessions was 8% higher than the mean per cent correct in math₂ sessions. The mean rate of problems worked in math₁ sessions was twice that of math₂ sessions. The second set of bars shows the measures obtained when the tutorial procedure preceded only math₂ sessions. The mean per cent correct in the math₂ sessions was 10% higher than that in the math₁ sessions. The mean rate of problems worked per minute in the math₂ sessions was twice that in the math₁ sessions. Thus, the tutoring procedure appeared to enhance both the

accuracy and rate of performance in the math session which it preceded.

Figure 2 shows the mean per cent correct and the mean number of problems worked per minute on the first grading check when tutoring over the same problems was evaluated in the presence of a consequence procedure for 90% correct or better math performance. In these

Fig. 1. Mean per cent correct and mean number of problems worked per minute on the first grading check in math₁ and math₂ within each of the experimental conditions in which the tutoring procedure was evaluated. The first bar in each pair represents math₁; the second bar represents math₂.

Fig. 2. Mean per cent correct and mean number of problems worked per minute on the first grading check in math₁ and math₂ during the experimental conditions in which the tutoring procedure was evaluated in the presence of the consequence procedure for 90% correct or better math performance. The first bar in each pair represents math₁; the second bar represents math₂.

manipulations, the students' accuracy and rate of performance were always higher in the math session preceded by the tutorial period than the

comparison math session. The mean per cent correct varied from 11 to 16% greater in the tutored math sessions than the comparison

math sessions. The mean number of problems worked was always nearly twice as high in the tutored math sessions as in the comparison math sessions. It should be noted that the accuracy differences between tutored and comparison math sessions were slightly larger, and the rate differences slightly smaller, when there were consequences for accurate math performance than when there were no consequences (see Figure 1).

Figure 3 shows the mean per cent correct and the mean number of problems worked per minute on the first grading check when tutoring with the same problems and independent study procedures were compared. The independent study or tutoring period always preceded the second math session. Both tutoring and independent study procedures produced larger rates and accuracies in the math session they preceded than in the comparison math sessions. However, the tutoring period was correlated with larger increments in accuracy and rate than the independent study period. The mean per cent correct for the independent study math sessions was 6% and 9% greater than the respective comparison math session. The mean per cent correct for the tutored math sessions was 15 and 16% greater than the respective comparison math sessions. The mean number of problems worked per minute for the independent study math sessions was 0.37 and 0.54 greater than the respective comparison math session. The mean number of problems worked per minute for the tutored math sessions was 0.98 and 1.17 greater than the respective comparison math sessions.

Figure 4 shows the effects of tutoring with related problems on the subsequent math performance of the fourth- and fifth-grade students. In the fourth grade, when tutoring over related problems preceded math₂ sessions, both mean accuracy and rate were higher than those obtained during the math₁ comparison sessions. The mean per cent correct for tutored math₂ sessions was 14 and 16% higher, and the number of problems worked per minute was 0.79 and 0.73 higher. When tutoring with related problems preceded math₁, there was only a slightly higher mean accuracy and rate of performance in math₁ as compared to math₂. Similar results were obtained in the fifth-grade classroom.

Mean|per-cent-correct and mean-number|of problems-worked-per-minute data for all three grading checks were similar to the data obtained from the first grading check in each of the conditions represented by Figures 1, 2, 3, and 4.

To indicate the effects of experimental conditions on the performance of individual students, the performance of each student following a tutoring period or an individual study period was compared to his or her performance during the comparison math session for that day. Table 1 shows the percentage of student days in which both accuracy and rate were higher in the math session preceded by tutoring or individual study. These data are consistent with the averages presented in Figures 1, 2, 3, and 4, and indicate that, most of the time, tutoring produced both increased rate and accuracy.

Table 1

Percentage of student days in which students achieved *both* higher accuracy and rate during the math session preceded by tutoring or independent study *versus* that day's comparison math session.

<i>Tutoring with the Same Problems</i>	<i>Tutoring with the Same Problems and Consequences for 90% Accuracy</i>	<i>Individual Study with the Same Problems and Consequences for 90% Accuracy</i>	<i>Tutoring with Related Problems Preceding Math₂</i>	<i>Tutoring and Related Problems Preceding Math₁</i>
74%	83%	66%	79%	59%

Fig. 3. Mean per cent correct and mean number of problems worked per minute on the first grading check in math₁ and math₂ during the experimental conditions in which the effects of the tutoring and independent study procedures were compared. The first bar in each pair represents math₁; the second bar represents math₂.

Fig. 4. Mean per cent correct and mean number of problems worked per minute on the first grading check in math₁ and math₂ for the fourth- and fifth-grade students when tutoring with related problems was used. The first bar in each pair represents math₁; the second bar represents math₂.

DISCUSSION

The present investigation evaluated the effects of unstructured peer-tutoring on the math behavior of fourth- and fifth-grade students. Improved math performance (*i.e.*, higher accuracy and rate) was observed in the math

sessions preceded by a 15-min tutoring period, whether the tutorial period involved the same problems as those solved in the subsequent math period or involved different-but-related problems. Further, the effects of tutoring did not seem to be transitory, as tutoring produced increased accuracy and rate of performance over

a number of replications of tutoring in the fourth-grade classroom. Tutoring with the same problems in combination with consequences for academic performance produced larger accuracy differences and smaller rate differences between tutored and comparison math sessions than did tutoring with the same problems alone. Independent study control conditions indicated that the effect of the tutoring procedure with the same problems could not be attributed solely to the opportunity that students had to study the math problems for 15 min before a math session.

During the conditions in which students tutored each other over problems different than but related to the problems they were to work on that particular day's math assignment, the effects on accuracy and rate were consistently greater when the tutoring period preceded math₂ than when it preceded math₁ (see Figure 4 and Table 1). If tutoring over related problems produced general skills in solving a particular type of math problem, this might be expected because tutoring preceding math₁ would be related to subsequent performance in both math₁ and math₂ for that assignment (since math₁ and math₂ of a particular assignment were composed of the same type of problems). Tutoring preceding math₂ presumably would have a direct effect only on performance during math₂ for a particular assignment. However, it should be noted that during tutoring with the same problems, accuracy and rate were similarly affected whether the tutoring preceded math₁ or math₂. This may reflect, in part, the direct carry-over of working the same problems or receiving answers from other members of the group as well as the tutoring immediately preceding a particular math session.

The rates of responses of subjects over the various experimental conditions varied considerably. In particular, when tutoring alone over the same problems was employed, rates were much higher (see Figure 1) than when this type of tutoring was used in combination with the recess contingency for students completing

the assignment with 90% accuracy (see Figures 2 and 3). These differences may have been a result of the recess contingency, but, because the type, difficulty, and number of problems varied from day to day, it is impossible to determine this. Further, when tutoring over related problems was employed without the recess contingency (see Figure 4), rates were also relatively low, suggesting that the recess contingency may not have been responsible for producing lowered rates of response. Nevertheless, the possible interactive effects on rate of response between tutoring and contingencies with both completion and accuracy requirements remains to be experimentally evaluated.

Because the tutoring procedure did not specify which students were to be tutors or tutees during a tutorial period, it was not possible to ascertain the differential effects the tutoring procedure may have had on the tutor or tutee *per se*. However, other investigators have reported that a tutorial procedure may be effective in improving academic performance for both the tutor and the tutee (Cloward, 1967; Landrum and Martin, 1970; Hassinger and Via, 1969).

During the tutorial period, two or three students helped each other solve problems identical to or similar to those problems assigned in the following math session. Feedback given by students to other students as to the correct procedure for working a problem was a characteristic of tutoring potentially responsible for the observed effect on math performance. Students modelling the procedure for correctly solving a math problem to other students during the tutorial period may have also been partially responsible for the improved math performance. In those cases where tutoring involved problems identical to those worked in the subsequent math period, it is possible that students simply learned the answers to particular problems by doing it themselves or by getting the answers from another member of the group (although all materials were removed from the students after tutoring sessions to prevent direct copying

of answers). However, the improvement in performance resulting from tutoring over different-but-related problems indicates an improvement in skills in solving particular types of arithmetic problems, rather than learning specific answers to problems.

A particular advantage of the present tutoring procedure was its ease of implementation. The tutoring seemed to work in the absence of specific training procedures for tutors and required little time and only a few additional materials to implement. The teacher advocated continued use of the tutoring in math, and expressed an interest in using similar tutoring procedures in other academic areas.

The fact that tutoring was effective in the absence of specified training procedures for tutors suggests that some elementary school students may already possess some skills effective for enhancing the academic performance of other students. Similar unstructured tutoring programs have been reported to be effective in other subject areas (e.g., Horst, 1931; Caditz, 1963; Hassinger and Via, 1969; Landrum and Martin, 1970; Taylor, 1969).

That tutoring in combination with consequences for academic performance produced somewhat larger accuracy differences between tutored and comparison math sessions than did tutoring alone suggests that further research carefully examine the contingencies related to the tutorial procedure under investigation. The effectiveness of tutoring may be, in part, a function of the consequences for engaging in such a procedure.

The potential advantages of employing students as tutors in the classroom for education are numerous. Probably most important is that the addition of persons in the classroom who can answer questions, give instructions, and provide feedback regarding academic performance may enhance the academic performance of students

in the classroom. Further, the use of students as tutors for other students allows the teacher more time to spend instructing students with more severe academic deficits. The student tutor also may acquire teaching skills and improve his own academic performance as a result of the tutorial experience. Further research is necessary to determine the conditions under which tutorial procedures may realize these and other potential advantages for education.

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