AN ABSTRACT OF THE THESIS OF

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Title: A Comparison of the Effect of Computer-Assisted-Instruction and Same-Age Peer-Tutoring on Math Achievement of Fourth Grade Students

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Abstract Approved: ______________________________

A pretest-posttest design was used to compare the effectiveness of computer-assisted-instruction (CAI) drill and practice with the effectiveness of same-age peer-tutor drill and practice on promoting mastery of multiplication facts. The subjects were students from three, fourth grade classes in the Reedville School District of Aloha, Oregon. Two fourth grade classes were randomly assigned to two treatment groups: CAI and same-age peer-tutoring. A third class was designated as a control group.

Students in the CAI group drilled on multiplication facts independently at a computer for 10 minutes per day for 25 days. Students in the same-age peer-tutor group tutored classmates using multiplication flashcards for 5 minutes and were tutored for an additional 5 minutes for a total of 10 minutes per day for 25 days. The control group received traditional math instruction consisting of daily, one-minute, mastery tests. Drill and practice was independent and self-

paced.

Treatment consisted of drill and practice on multiplication facts with multipliers 0-9 and multiplicands 6-9. The pretest and posttest were computer-constructed criterion tests consisting of randomly selected multiplication facts from the treatment set. Fifty-two students began the treatment. Forty-five students completed treatment and the posttest.

Analysis of variance and Tukey's multiple comparison test showed a significant difference between the CAI group ($\overline{X}$ = 48.00) and control group ($\overline{X}$ = 67.60) on the pretest. However, on the posttest, analysis of covariance revealed no significant difference among the groups ($p = .05$). Therefore, the null hypotheses for the study were accepted. The hypotheses predicted there would be no significant difference between the groups' mean math scores on the posttest.

Although the study did not identify either CAI or same-age peer-tutoring drill and practice as more effective than the other, it did show both strategies to be equally effective in promoting mastery of basic math facts. The adjusted group means were CAI: 93.97 and same-age peer-tutoring: 93.43. In finding the two strategies to be equally effective, the study identified same-age peer-tutoring as a cost-effective alternative to CAI drill and practice. The findings have implications for staff development, curriculum planning, and for teachers' selection of drill and practice strategies.

A Comparison of the Effect of Computer-Assisted-Instruction and Same-Age Peer-Tutoring on Math Achievement of Fourth Grade Students

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Typed by Elizabeth Pflug

To my supportive and patient
husband, Jerry,
and my wonderful children,
Julianna, Roggy,
and Paul

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A COMPARISON OF THE EFFECT OF COMPUTER-ASSISTED-INSTRUCTION AND SAME-AGE PEER-TUTORING ON MATH ACHIEVEMENT OF FOURTH GRADE STUDENTS

CHAPTER I

INTRODUCTION

Experimental evidence of the effectiveness of drill and practice strategies is needed to aid teachers in selection of the most effective and efficient methods for promoting memorization of basic facts. Basic facts make up a large portion of the elementary school curriculum. For most students, regularly scheduled drill and practice sessions are essential to the development of immediate recall. Deborah Ferrante Alexander (1986) describes the importance of drill and practice.

> When children are unable to master their basic addition, subtraction, multiplication, and division facts, their entire math career is in jeopardy. How often have we heard the lament of fourth and fifth grade teachers who are ready to teach fractions while many of their students still cannot compute 6 times 9 in their head? Middle grade teachers find that simply repeating standard forms of written and oral drill usually does not remediate the problem. (p.209)

Despite its importance, drill and practice is often superseded by more interesting, higher cognitive level instruction. Garson (1983) states that the truly exciting moments in education come when students have taken an active interest in some topic, and have been able to put something together on their own. Whatever is learned this way is learned painlessly, though not effortlessly, and is not soon forgotten. Drill and practice reduces this self-motivated concentration with a seemingly endless stream of petty tasks (p. 123).

Becker (1983), however, points out that without a knowledge of basic language and math facts, the higher-order activities are not possible. Development of mastery of these basic facts requires regularly scheduled drill and practice. Therefore, information regarding the effectiveness of drill and practice strategies is necessary in order to provide efficient skillbuilding programs. Optimum utilization of classroom time demands that these strategies be selected on the basis of proven benefit to the development of mastery of basic facts. This evaluation is best determined when based on thorough experimental research.

The purpose of this study was to determine the comparative effectiveness of computer-assisted-instruction (CAI) drill and practice and same-age peer-tutor drill and practice. In comparing these strategies, the study provides information to aid teachers in their selection of drill and practice methods and in their decisions regarding the use of computers for instruction.

Statement of the Problem

Elementary-school curriculum includes basic facts which require memorization. Success in higher level cognitive learning depends upon mastery of these basic facts. Therefore, it is important that adequate provision be made for regular drill and practice. Research can aid teachers in development of efficient skill building programs by identifying the most effective drill and practice methods.

This study compared the effectiveness of computer-assisted-instruction (CAI) drill and practice with the effectiveness of same-age peer-tutor drill and practice in promoting mastery of basic math facts by fourth grade students. Research studies conducted to investigate the effectivenss of CAI and peer-tutoring have typically compared the two strategies with traditional instruction. Rarely have they been compared with one another. Therefore, it is not known which strategy most effectively promotes mastery of basic skills. This study is designed to measure their comparative effectiveness. Such empirical evidence can aid teachers in selection of drill and practice methods and in their decisions regarding use of computers for instruction.

Objectives

Objectives of the study were:

1. Pretest and posttest CAI, same-age peer-tutor, and control group on multiplication facts with multipliers 0-9/multiplicands 6-9 and find the mean score for each group.
2. Find the difference between the pretest and posttest means of each group.
3. Compare the mean differences to determine whether the application of CAI and same-age peer-tutoring caused a significant change in the experimental groups' scores as compared with the control group's scores.

4. Apply analysis of covariance to control for initial differences in pretest scores (covariate).
5. Use the "F" statistic to determine whether the difference in mean scores is significant--large enough to reject the null hypothesis.
6. Apply Tukey's Method to compare individual means.
7. Draw conclusions to aid teachers in making decisions regarding use of computers for drill and practice.

Definition of Terms

The following terms used in the study are defined for the purpose of clarification.

Computer-assisted-instruction (CAI): an instructional situation in which computer technology is used to present material, test for mastery of material, and/or determine sequencing of material (Williams, 1982). CAI includes drill and practice, tutorial, simulation, gaming, and problem-solving programs.

CAI drill and practice programs: a computer software format in which the computer asks a question, gives the student chances to answer, and then displays the correct answer.

Computer literacy: the skills, knowledge, values, and relationships that allow one to function comfortably as a productive citizen in a computer oriented society.

Effectiveness research: educational research in which effectiveness is assessed as a function of empirically demonstratable relationships with academic achievement measures. Studies identifying practices and performances correlated with educationally desirable outcomes constitute effectiveness research.

Learning disabilities: a special education term for children who exhibit a discrepancy between their ability to achieve and their demonstrated achievement. This discrepancy generally refers to the skill areas of reading, mathematics, writing, and the broader areas of perception and language. Learning disabled children are not mentally retarded. Most fall within the normal range of intelligence.

Peer-tutoring: a procedure in which students tutor or teach other students. There are generally two types of peer-tutoring: (1) same-age or class-wide tutoring and (2) cross-age tutoring. In same-age tutoring, tutors and tutees are from the same grade. In cross-age tutoring, older children tutor younger children.

Peer-tutor drill and practice: for this study peer-tutor drill and practice involved fourth grade student partners drilling each other using multiplication flashcards.

Role-playing: a form of simulation used for training purposes. Participants are assigned a role and asked to act out that role as they interact with other role-playing participants. Role-playing may be used to demonstrate desirable or undesirable behavior, to rehearse, to produce attitude change, to act out problems, or for reporting purposes.

Traditional instruction: for this study, traditional instruction consisted of a teacher-designed, self-paced program of multiplication worksheets and tests.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The current limited availability of computers per classroom and the predominance of drill and practice software in most elementary schools have largely restricted classroom use of computers to periodic drill on basic skills. As a result, teachers are asking whether computer drill warrants the scheduling inconveniences caused by having to share a limited number of computers among several classrooms and among students within a classroom. The question arises: Is computer-assisted-instruction (CAI) the most effective means of drill and practice or are other more available methods equally effective?

Research shows peer-tutoring is one provision for drill and practice that increases academic achievement when used as a supplement to traditional instruction. However, studies are rare, which compare CAI and peer-tutoring. Therefore, it is not known which of these strategies most effectively promotes mastery of basic skills.

To date, most CAI and peer-tutoring studies were limited to investicating whether or not these interventions were more effective than traditional instruction. Therefore, research discussed in this review consists primarily of studies using traditional instruction for comparison. Furthermore, since the present study examines only the same-age category of peer-tutoring and the CAI drill and practice category of computer-based-instruction, this review focuses on these specific subcategories. The review includes for both CAI and peer-tutoring: definition, theoretical base, criticism, support, and effectiveness research.

Computer-Assisted-Instruction

Computer-assisted-instruction is defined as the use of the computer for direct instruction of students. This includes drill and practice, problem-solving, simulation, and tutorial (Edwards, Norton, Taylor, Weiss, and Dusseldorp, 1975). The elements common to all CAI are: (1) testing of student understanding and (2) immediate reinforcement of response. Computer use in classrooms has become synonymous with computer-assisted-instruction because most products marketed for education have been CAI programs. One reason this has occurred is ease of design. Also, drill and practice programs are easy for teachers and students to use. Therefore, both supply and demand have made drill and practice the most commonly produced computer-based learning materials (Becker, 1983).

The theoretical underpinnings of CAI is behaviorism, the doctrine that the objective acts of persons and animals are the chief or only subjective matter of scientific psychology. CAI has its foundation in Thorndike's law of effect: behavior followed by pleasure is more likely to be repeated than behavior not followed by pleasure. This law of cause and effect has been used most widely in animal training. Animals are given a stimulus or cue. When the desired response occurs, they are given reinforcememt. Thereby, the animal is conditioned to a prescribed response. Reinforcement increases the probability of a given response being repeated in reaction to a particular stimulus (Burke, 1983, p.22).

This process is known as S-R Theory. B.F. Skinner applied S-R Theory or the law of effect to humans in his Programmed Instruction (PI). In PI, a question constitutes the stimuli, the answer is the response, and the reinforcement is the positive feedback of a correct answer. To insure effectiveness of the reinforcement, PI attempts to assure that students' answers are correct (Burke, 1982, p. 23).

Most CAI-authoring systems are based on the S-R model. The three elements of Programmed Instruction are the basis of most CAI programs. These include: (1) single or narrowed objectives, (2) active responses, and (3) immediate feedback.

Much criticism of computer-assisted-instruction is aimed at its theoretical base of S-R Theory. The critics point to a lack of evidence that the law of effect applies to higher-order cognitive human learning. The major objection is to the use of conditioning: the lowest form of learning. Critics believe educators should expand students' intellects and higher order thinking skills such as creativity and intuition rather than condition them to someone else's correct answers. The critics argue that students should be taught to use their own higher level thought processes rather than simply repeat given responses (Garson, 1980).

A closely related criticism focuses on the computer's exaggerated emphasis on the learning of facts. Repetitive drill on facts is useful only when students already understand the relevant principles and procedures. Therefore, computers serve as testing instruments rather than as teaching aids. Becker (1983) counters this argument by stating that higher-order activities depend upon knowing basic language and math skills (p. 24).

Another type of criticism is made by proponents of holistic education. The holistic view of education stresses the importance of a broad constellation of competencies, the components of which may be developing at different rates for different students (Jackson, in Cuban, 1986). This view emphasizes the importance of personal relations to student learning. It claims technologies will displace, interrupt, and minimize the relationship between teacher and child. Students working with computers lose time with teachers and bonds develop between students and machines. Weizenbaum (1976) states that computerized reasoning is essentially technical and unemotional, divorced from the richness of human experience. The brain's cortex is not a whole human being. Computerized reasoning represents a very small part of the human thought process. When students view what they get from machines as equivalent to human thought, they may exaggerate the importance of technical reasoning and minimize the value of emotion and personal relations (Cuban, 1986, p. 17).

Cuban summarizes Weizenbaum's criticism of the instrumental rationalism underlying technology. Weizenbaum describes the programmer's thinking as linear, logical, and rule governed. Thus, technical and analytic thought (instrumental reasoning) is magnified for students through their programs. Instrumental reasoning amplifies calculation, values numbers, and elevates scientific experts to social engineers. When instrumental reasoning is amplified, higher level thought is reduced or deemphasized. Weizenbaum says this instrumental reasoning has little to do with creativity, intuition, and feeling (Weizenbaum, in Cuban, 1986, p. 17).

Further criticism comes from those who believe computers in education are an extension of the scientific management movement initiated in the early 1900's. Proponents of the scientific management philosophy believe schools should be managed like business corporations. Teachers are viewed as technicians. Accountability, learning objectives, teacher unions, collective bargaining, and the effective school reform movement are extensions of this mindset. According to this perspective, schooling is improved by planned, systematic and engineered teaching. The major assumption is anyone can teach who possesses the appropriate technical skills. Critics of computer instruction consider it part of this larger effort to bureaucratize schooling and rationalize teaching through increased emphasis on bureaucratic definitions of productivity. This approach assumes instruction is a technical, mechanical process and its outcomes are predictable when teachers do it skillfully (Cuban, 1986, p. 88).

Other critics are concerned about possible negative effects upon children from collateral learning which may accompany computer instruction. Cuffaro (1984) points out that computers teach many significant, misleading, and unintentional lessons to children beyond the programmed ones. The effect on children of sustained exposure to the two-dimensional world view of the computer screen is not known.

Despite these criticisms, support for computer education is prevalent among teachers. For example, in 1983, The National Education Association (NEA) found strong support for computers among teachers. Contrary to the belief that teachers fear being replaced by computers, teachers expressed a desire to use computers and viewed them as a positive influence on instructional effectiveness, job satisfaction, and professional challenge.

A major source of support for computer education comes from individuals who view computers as a way to free teachers to carry out the more worthwhile aspects of teaching. The most limited resource in the classroom is the teacher's attention and response to individual needs. Basic skills require repetition and memorization. The teacher's attention is taken up with this practice activity when it could be better spent on higher level learning and relating to students. Using computers to drill students frees the teacher for more uniquely human functions of instruction (Becker, 1983, p. 17).

Proponents of CAI claim that the interactive nature and visual appeal of computers make CAI a more enjoyable learning experience than most traditional methods. Furthermore, student feedback is direct and immediate, an impossible condition, with one teacher per classroom (Becker, 1983, p. 18).

Positive research results on CAI drill and practice occur more often in mathematics instruction than in language instruction. In the majority of 30 experimental comparisons, Vinsonhaler and Bass (1972) found CAI math drill and practice at the elementary level was more effective than traditional instruction in raising standardized test scores. The research of Jamison, Suppes, and Wells (1974) showed CAI drill programs particularly effective for students who started below grade level. They concluded CAI is an effective supplement to regular instruction at the elementary level, although it may not be as cost-effective. Ragosta, Holland, and Jamison (1981) found CAI drill and practice with computational mathematics had a positive impact. However, on mastery of mathematics concepts, gains sometimes favored the control group.

Although these positive effects of CAI were reported, the most common theme of the CAI literature is the elusiveness of definitive data related to computer-based instruction effectiveness (Jamison et al., 1974; Avner, Moore, and Smith, 1980). Avner, Moore, and Smith point out that justifying the selection of computer-based instruction over other methods is problematic due to the almost total lack of unambiguous evidence about its instructional effectiveness. In 1974, Jamison, Suppes, and Wells concluded no uniform conclusions could be drawn about the effectiveness studies. The abundance of effectiveness studies since 1974 has not changed the validity of this observation (Avner, Moore, and Smith, 1980).

As a result of the uncertainty surrounding computer instructional effectiveness, several scholars compiled the results of the research literature and derived narrative conclusions (Grayson, 1970; Jamison, Suppes, and Wells, 1974; Thomas, 1979; and Edwards, Norton, Taylor, Weiss, and VanDusseldorp, 1975). Edwards et al. (pp. 141-151, 1975) concluded:

1. All studies reviewed showed normal instruction supplemented

by CAI to be more effective than traditional instruction.

2. When CAI was substituted for traditional instruction--totally or partially--45 percent of the studies showed greater achievement gains were made by CAI students, 40 percent found little or no difference; and 15 percent showed mixed results.
3. It cannot be concluded that any CAI mode is more effective than other modes of instruction.
4. CAI is equally effective when compared with other nontraditional methods.
5. It takes less time for students to learn with CAI than with other instructional strategies.
6. The learning retention levels of CAI students may not be as high as those of traditionally taught students.

Thomas' (1979) conclusions were contradictory to those of Edwards et al. In his narrative analysis of computer effectiveness research, he states, "Achievement gains over other more traditional methods are the norm...CAI students gain mastery status in a shortened period of time" (p. 111).

The failure of narrative summaries to provide consistent information led researchers to seek quantitative analysis of the individual CAI effectiveness research studies through meta-analysis. Meta-analysis is a research technique developed by Glass (1976) to integrate findings of experimental studies. Burns and Bozeman (1981) used meta-analysis to analyze and integrate research findings relative to CAI effectiveness in math instruction in elementary schools.

They concluded math achievement is enhanced when regular classroom instruction is supplemented by CAI.

Kulik and Kulik (1985) conducted a meta-analysis of more than two decades of research totaling 51 studies on CAI students in secondary schools. Students in the studies were in sixth grade or above. Kulik and Kulik concluded from their analysis that students who received CAI scored higher on objective math tests than students who received traditional instruction (Bracey, 1982, p. 52).

In general, research studies have been limited to determining whether or not CAI is more effective than traditional instruction (Bracey, 1982, p. 54). Recently, however, Henry Levin, Gene Glass, and Gail Meister (1984) compared the cost effectiveness of four common methods used by policy makers to improve math and reading skills: (1) peer-tutoring, (2) computer-assisted-instruction, (3) reducing class size and (4) increasing the amount of time devoted to skill instruction. Levin et al. collected studies of these four methods and analyzed their findings about the effect of each strategy on student test scores. According to the cost-effectiveness ratio produced by the researchers, peer-tutoring was far more cost-effective than computer-assisted-instruction (Cuban, 1986).

Another recent study of computer-instruction and peer-tutoring was conducted by Icabone and Hannaford (1986). These researchers compared: (1) students' performance using the microcomputer voice synthesizer and the human tutor on the number of words correctly and incorrectly recognized and (2) students' performance using the microcomputer voice synthesizer and the human tutor on the number of words correctly and incorrectly recalled. They concluded that the microcomputer with voice synthesizer appeared to be equally effective as a human tutor in facilitating both recognition and recall of previously unknown words (p. 38).

In summary, research on computer-based instruction is contradictory and inconclusive. In order to clarify the numerous and diverse conclusions, researchers have evaluated the research findings in two ways: narratively and with meta-analysis. Their most conclusive finding was: CAI is more effective than traditional instruction only when it is used in conjunction with traditional teaching. Until recently, most researchers limited their investigations to comparisons of CAI to traditional teaching. However, in 1984, Levin et al. compared CAI and peer-tutoring (cross-age) in a cost-effectiveness study. In 1986, Icabone and Hannaford compared the microcomputer voice synthesizer to peer-tutoring. These studies differ from the present investigation in that Levin et al. used results of previous studies to determine cost effectiveness while Icabone and Hannaford were interested primarily in the voice synthesizing aspect of the computer.

Peer-Tutoring

Peer-tutoring is defined as a one-to-one teaching process in which the tutor has the same general academic status as the tutee. Terms sometimes used interchangeably with peer-tutoring are: "proctoring," "peer teaching," "cooperation," "unstructured tutoring," and "group reinforcement" (Cohen, 1986, p. 175). Within the broad category of peer-tutoring are: cross-age peer-tutoring and same-age peer-tutoring. Cross-age tutoring involves older children, with more advanced skills, tutoring younger students. Same-age peer-tutoring is sometimes referred to as classwide and/or intra-class peer-tutoring. It may involve either same-age students of equal skill in a tutor/tutee relationship or same-age students of equal skill working together. Studies show peer-tutoring to be beneficial to both tutor and tutee not only in situations where the tutor is more skilled than the tutee but in situations where the lower skilled serves as the tutor (Dineen, Clark, and Risley, 1977, p. 231).

The theoretical underpinnings of the academic aspect of peer-tutoring are based in the research on effective instruction. Cohen (1986) identifies individualization, modeling, motivation, and similarity as the four elements of effective instruction most responsible for the success of peer-tutoring. Individualization maximizes active participation which, according to Piaget (1936), develops comprehension and cognitive-organization skills. Peer-tutoring promotes active participation through personal attention, explanation, demonstration, immediate feedback, and reinforcement. Furthermore, learning can be adjusted to the specific level and pace of the learner through individualization (Cohen, 1986, p. 176).

The modeling benefits attributed to peer-tutoring are derived from the tutee's perceived similarity to the tutor and/or the tutee's perception of the tutor as having high status. Bronfenbrenner (1970) found that American children are more inclined to look to their peers (similarity) rather than to adults for models.

Motivational benefits provided by peer-tutoring include tangible, social, academic and/or moral reinforcement. Tangible or material rewards may be given for correct work. Social motivation may result from verbal reinforcement and association with someone of perceived higher status. Academic motivation results from mastering subject matter, improved grades, and academic gain (Cohen, 1986, p. 178).

The element of "similarity" in the peer-tutor/tutee relationship has several advantages. A peer may be better able to explain subject matter than an adult because of similarity of cognitive frameworks and language/gesture repertoire. Also, peers may not have formed the prejudices against slower learners which some adults may have developed (Cohen, 1986, p. 178).

Despite the professed benefits of peer-tutoring described in the effectiveness literature, peer-tutoring has been criticized by teachers for several reasons. Harris and Aldridge (1983) surveyed regular and special education teachers enrolled in a course entitled, "Teaching the Handicapped Child in the Regular Classroom," to find out why they did not use peer-tutoring. They gave the following reasons:

1. It is threatening to let children teach. Teaching is the teacher's responsibility.
2. Peer-tutors might teach incorrect information.
3. Brighter students will be held back while they teach the

slower students.

4. Less skilled students working with less skilled students is ineffective.
5. Peer-tutoring causes behavioral problems and excessive noise.
6. If teachers have to supervise, they might as well teach.
7. Tutors could become haughty while tutee's self-concepts could be lowered.
8. Parents might object (p. 43-46).

Cohen (1986) describes a similar criticism of peer-tutoring. "Sometimes the child's social skills of communication, attention, empathy, understanding, etc., may be insufficiently developed for him/her to effectively fulfill the role of teacher" (p. 179). Since the tutor still has less developed cognitive structures, she/he may not have fully mastered the material and may teach an incorrect version. Cohen states this may have been the reason for insignificant gains of tutees in the studies of Allen and Feldman, 1973; Erickson and Cromack, 1972; and Kelley, 1972.

Much support for peer-tutoring is found among the proponents of cooperative learning structures. Johnson and Johnson (1975) have compiled research findings and written extensively on cooperative versus competitive learning structures. They conclude that a cooperative structure is the most effective goal structure for promoting achievement in problem solving tasks. Schmuck (1977) also describes the advantages of cooperation over competition. He states research has shown classrooms with supportive friendship patterns enhance academic learning while tense interpersonal environments get in the way of learning (p. 273). The potential of peer-tutoring to provide cooperative learning environments is a major reason peer-tutoring has found support among educators.

Another reason peer-tutoring has gained support from educators is its potential to provide students with "academic engaged time." Data gathered from elementary classrooms have identified "academic engaged time" as a highly significant correlate of achievement. Engaged time distinguishes classrooms that produce above and below average achievement levels (Jenkins and Jenkins, 1985). Berliner, Fisher, Filby, and Marlieve (1976) describe academic engaged time as the time a student spends in academically relevant tasks that are moderately difficult. Academic engaged time is not the same as allotted instructional time. It is the time students are actively engaged in learning tasks. Rosenshine and Berliner (1978) summarized research on effective classrooms. They found time spent engaged in relevant content appears to be a requisite to learning. Essentially, teachers who make a difference in students' achievement are those who put students into contact with curriculum materials and find ways to keep them in contact (p. 12). The major skill needed by a teacher is the ability to arrange sufficient content coverage and academic engaged minutes per day (Rosenshine and Berliner, 1978, p. 13).

Engaged time could be maximized for each student only through one-to-one instruction. Since this is impossible for one teacher to accomplish, it is common practice in elementary schools to use small group instruction. Small groups provide more opportunities for engaged time than large group instruction. However, small groups cannot accommodate the differences of all students. Some students are forced to proceed with new objectives before they master the current objective. Others may have to wait for slower students (Jenkins and Jenkins, 1985, p. 2). Jenkins and Jenkins propose engaged time can be increased through the use of peer-tutors. "Some of the best helpers are other students who can be recruited from inside their own school" (p. 2).

Research supports Jenkins and Jenkins' conclusions about the benefits of peer-tutoring. The majority of studies show students' academic achievement is increased when traditional instruction is supplemented by peer-tutoring.

Most tutoring research has investigated cross-age tutoring. Relatively few studies have investigated same-age or intra-class peer-tutoring. These few have been conducted primarily with inner-city Chapter I students and special education students: learning disabled, behaviorally disabled, autistic, educable mentally retarded, and hearing impaired students (Delquadri, Greenwood, Whorton, Carta, and Hall, 1986, p. 539). Since the present research investigates same-age peer-tutoring, the review is confined to discussion of those studies which include intra-class peer-tutoring.

Scruggs and Osguthorpe (1986) evaluated the effects of same-age intra-class peer-tutoring and cross-age tutoring on reading skill achievement. Their subjects were 47 elementary age learning and/or behaviorally disordered students from five elementary schools. Two experiments were conducted. In experiment I, behaviorally disordered students tutored younger learning and behaviorally disabled students.

The tutees' gains were twice those of the control students on a reading criterion test. The gain score of the tutors, however, was only eight percent greater than the control students. Pre-post differences among tutees, tutors and control students were not significant for word reading, reading comprehension, or total reading subscores on the Woodcock-Johnson reading test (p. 189).

In experiment II, the 31 subjects were eleven second-grade students, eight third-grade students, five fourth-grade students, and seven fifth-grade students. All of them were learning and/or behaviorally disordered students attending five elementary schools. Sixteen students acted as tutor-tutees in the experimental group. The remaining fifteen students were the control group. Students in the experimental group gained an average of ten percent on the diagnostic measure compared to the control student who made no gain. These differences were significant, $p < .003$. Pre-post gain scores on the Woodcock-Johnson reading subtests were not significant. However, on the Woodcock-Johnson word-attack subtest, the experimental group gained 2.1 words while the control group gained a mean of 1.2 words. Neither groups gained significantly on letter identification or passage comprehension (Scruggs and Osguthorpe, 1986, p. 191).

Oakland and Williams (1975) examined the effectiveness of same-age peer-tutoring on reading achievement of third and fourth graders who were reading below grade level. The researchers compared three groups: (1) a total tutorial program, (2) a supplementary tutorial program, and (3) a non-tutorial program (control group). Differences among the three treatment groups on the Metropolitan Achievement

Test subtests of word knowledge and comprehension were not statistically significant for third graders, fourth graders, or for third and fourth graders combined. The supplementary tutorial group gained approximately one year's growth in word knowledge and approximately six months growth in comprehension during the nine month treatment period. The progress of the other two groups was below this level. Students who received traditional instruction averaged eight months growth in word knowledge and approximately six months growth in comprehension during the nine month treatment period. The progress of the other two groups was below this level. Students who received traditional instruction averaged eight months growth in word knowledge and four months growth in comprehension. Although between-group differences were not statistically significant for the three groups, the results tended to favor use of the supplementary tutorial program (Oakland and Williams, 1975, p. 168).

Greenwood, Dinwiddie, Terry, Wade, Stanley, Thibadeau, and Delquadri (1984) compared classwide peer-tutoring in spelling, vocabulary and mathematics to teacher-developed instruction. They focused upon the order in which the two methods were presented. Students, including the lowest performing in the class, mastered the content best during tutoring regardless of whether tutoring instruction was presented before or after the teacher-developed instruction. In a second and third part of the study, Greenwood et al. (1984) demonstrated that classwide peer-tutoring was causally related to increased student achievement on Friday tests (Delquadri, Greenwood, Whorton, Carta, and Hall, 1986, p. 539).

In summary, potential benefits of peer-tutoring are grounded upon instructional effectiveness theory. The four elements of effective instruction attributed to peer-tutoring are individualization, modeling, motivation, and similarity. Despite some criticisms by teachers that peer-tutors may not be cognitively or affectively qualified to teach others, peer-tutoring receives much support from those who view "cooperative learning structures" and "academic engaged time" as important to instruction.

The majority of peer-tutoring studies utilized cross-age peer-tutoring and compared it with traditional instruction. The relatively few studies utilizing same-age peer-tutoring typically included Chapter I learning disabled (LD) students. Scruggs and Osguthorpe (1986), Oakland and Williams (1975) and Greenwood et al. (1984) found increases in academic achievement associated with peer-tutoring in LD settings. The present research differs from these studies in three ways: (1) regular classrooms were used, (2) peer-tutoring was compared to computer-assisted-instruction rather than to traditional instruction, and (3) with the exception of three students, subjects were not learning or behaviorally disabled.

CHAPTER III

METHODOLOGY

Introduction

The purpose of the study was to compare the effect of computer-assisted-instruction (CAI) drill and practice and same-age peer-tutoring drill and practice on math achievement of fourth grade students. The research literature describes both CAI and peer-tutoring as effective strategies for promoting achievement of basic skills when used as supplements to traditional instruction. To determine their comparative effectiveness, two fourth grade classes were randomly assigned to two treatment groups: CAI and same-age peer-tutoring. A third class was designated as the control group. The dependent variable criteria was analyzed using analysis of covariance. This chapter includes a description of the subjects, research design, validity, treatment, hypotheses, and method of analysis.

Subjects

The subjects used in the study were fourth grade students from Reedville School District in Aloha, Oregon. Reedville is an elementary school district with five schools and approximately 1900 students. It is located in a small suburban area of average to below average economic level. Determination of this status is based upon number of students qualifying for free lunches and number of homes within the district which are valued between $50,000 and $70,000.

Students who participated in the study were from three fourth grade classes in a school of 450 students. One class of 15 students made up the CAI treatment group. A second class of 18 students was the peer-tutor treatment group and a third class of 19 students participated as a control group. The total number of subjects was 52.

Research Design

A Pretest-Posttest Design was used to investigate the effects of CAI drill and practice and same-age peer-tutor drill and practice upon math achievement of fourth grade students. The design included two treatment groups or variations of the independent variable: methods of instruction. These were CAI drill and practice and same-age peer-tutor drill and practice. The experimental groups were formed by randomly assigning one of three fourth grade classes to a CAI treatment group (15) and a second fourth grade class to a same-age peer-tutor treatment group (18). Due to scheduling constraints, the third fourth grade class (19) was unable to participate in the experiment as a treatment group. As a result, this class was arbitrarily designated as the control group. It was not included in the random assignment of treatment conditions.

Since all three fourth grade classes were formed initially by a random procedure, it was assumed the classes were equally matched on academic ability. In June of the previous school year, third grade teachers ranked their students as high, medium, or low achievers. Student names were randomly drawn from each rank to form three groups consisting of equal numbers of high, medium, and low achievers. These groups comprised the fourth grade classes used in the experiment. Ranking was based upon professional judgment of the teachers.

Design Matrix

The design matrix was as follows:

Randomly Assigned	Pretest	Treatment	Posttest
Experimental Group A (15)	T_1	X_a (CAI)	T_2
Experimental Group B (18)	T_1	X_b (PT)	T_2
Control Group (19)	T_1		T_2

The dependent variable was the student's adjusted math test scores on the computer constructed criterion test. Steve Gardner's (1982) computer program, Speed Drill Maker, was used to create the pretest (Test 1) and the posttest (Test 2). Each of these tests included 100 randomly ordered multiplication facts with multipliers 0-9 and multiplicands 6-9. The adjustment of the posttest score was made through the application of analysis of covariance.

Internal Validity

The Pretest-Posttest Design was chosen for its potential to control various sources of internal invalidity. These include: (1) the effects of intersession, (2) the effects of intrasession, (3) differential selection effects, and (4) statistical regression. The effect of intersession (extraneous variables that arise between pretest and posttest) were balanced by the use of a control group. The effects of intrasession conditions (variation which the groups may experience when they are tested and treated separately) were controlled by: (1) testing the subjects at the same time as a group, and (2) by randomly assigning the two classes to the experimental conditions. Differential selection was controlled through use of random assignment in the initial formation of the three classes. Third grade teachers ranked their students as high, medium, or low achievers. Student names were randomly drawn from each rank to form three groups consisting of equal numbers of high, medium, and low achievers. The groups were the fourth grade classes used in the experiment. Analysis of covariance was also employed to aid in removing the effects of initial group differences in math scores.

Statistical regression was controlled by use of a control group and random assignment. Therefore, high scorers were randomly dispersed among the groups and the regression effect equalized.

External Validity

External validity, the generalizability of the finding to other students and situations, is compromised in several ways by the selected design. Several extraneous variables interact with the experimental treatment and make the sample unrepresentative of the population from which it is selected. These extraneous variables include: interaction of pretesting and treatment, interaction of selection, interaction of treatment with history, and reactive effects of experimental procedures (Van Dalen, 1966, p. 264).

Interaction of pretesting and treatment may occur as the result of pretesting. Pretesting may sensitize the subjects to the treatment so they respond differently than if no pretesting had taken place. Interaction of selection and treatment occurs if subjects in the experiment are different in any particular way from persons to whom the results are generalized. Interaction of selection and treatment can be reduced by increasing the number and types of schools participating in the experiment. In this experiment, limited availability of computers and software prohibited extending the research to include other school settings, therefore, selection and treatment interaction may have been operating. Interaction of treatment with history or a contemporaneous event compromises external validity if the experiment coincides with a dramatic event or an atypical condition (Van Dalen, 1966, p. 265). No such event or condition was evident during this experiment.

Reactive effects of experimental procedures may also prevent generalization of findings to other populations. If subjects know they are participating in an experiment, they may perform better because they have been singled out for special treatment (Van Dalen, 1966, p. 266). The Hawthorne Effect is one example of reactive effects of experimental procedures. The researcher recognized the potential threat to external validity from the Hawthore Effect and established certain constraints. These constraints involved limiting random assignment to total classes. Random selection and assignment of students would have required a mixing of the two treatment classes. Mixing students may have alerted students they were involved in an experiment. By maintaining intact classes, it was possible to keep students unaware of the experiment.

The Novelty or Disruption Effect was also controlled by maintaining intact classes. The Novelty Effect results when treatment is different from instruction that is normally received (Borg, 1979, p. 529). Combining students in the treatment classes would have constituted a novel and disrupting situation. Students had previous experience with both CAI and flashcard drill with peers. Therefore, these treatments did not constitute a novel situation.

Treatment

Treatment consisted of math drill and practice on multiplication facts with multipliers 0-9 and multiplicands 6-9. The computer group received treatment via the computer program, Math Sequences, by Milliken (1980). Students in the CAI group worked on this program independently at computers for 10 minutes per day for six weeks during October and November of 1986. Students were given prior instruction on program format but not on the multiplication facts included in the treatment.

Treatment for the same-age peer-tutor group also included multiplication facts with multipliers 0-9 and multiplicands 6-9. However, students in this group received instruction through peer-tutoring. These students participated in peer instruction for 10 minutes per day for six weeks during October and November of 1986. Each student in the peer-tutor group received peer-tutoring for five minutes and administered peer-tutoring for five minutes.

Peer-tutors were trained accoring to guidelines developed by Deborah Alexander (1986). (See Appendix B.) Gray (1978) says tutor training is essential. Without it, tutors might unconsciously or consciously damage tutees' egos. Areas in which tutors were trained included: giving directions, confirming correct responses, applying nonpunitive corrections, and praising tutees for appropriate behavior. They were also trained in gathering and replacing instructional materials, recording student performance, and allocating time. A role playing activity was used in which tutors learned appropriate verbal and nonverbal corrective techniques. (See Appendix C.)

Students in the control group received traditional instruction consisting of daily, one-minute, mastery tests on addition, subtraction, and multiplication facts. Students memorized math facts on their own time and at their own pace. At the time of the experiment, five students in the control group had achieved a mastery level which included multiplication facts within the treatment set (multipliers 0-9 and multiplicands 6-9). None of the students in the CAI or same-age peer-tutor group received instruction on multiplication facts before the experiment. The control group was included in pretesting and posttesting.

Hypotheses

The research compared computer-assisted-instruction drill and practice with same-age peer-tutor drill and practice on effectiveness in promoting mastery of multiplication facts. The null hypotheses tested were:

1. There is no significant difference between the math posttest mean scores of students receiving drill and practice from computer-assisted-instruction and the math posttest mean scores of students receiving drill and practice from same-age peer-tutoring ($H_0 \mu 1 = \mu 2$).
2. There is no significant difference between the math posttest mean scores of students receiving drill and practice from computer-assisted-instruction and the math posttest mean scores of students in the control group ($H_0 \mu 1 = \mu 3$).
3. There is no significant difference between the math posttest mean scores of students receiving drill and practice from same-age peer-tutoring and the math posttest mean scores of students in the control group ($H_0 \mu 2 = \mu 3$).

A two-tailed test was used to test the statistical hypotheses. The alpha level was set at .05. The measurement unit for analysis was the class mean used as an individual score. Analysis of covariance was used to determine the difference in group means.

Method of Analysis

One-way analysis of covariance (ANCOV), analysis of variance (ANOVA), the "F" statistic, and Tukey's Method were the statistical tools used in the study. Courtney (1983) defines analysis of covariance as a statistical technique which combines the concepts of analysis of variance and regression to handle situations where the researcher cannot completely control all the variables of the study. Covariance adjusts for initial differences in the data by using premeasure information as a base. By making this adjustment, the sampling error is reduced and precision increased (p. 249). The premeasure in this study was the pretest criterion.

Assumptions necessary for use of analysis of covariance are:

1. Within each distribution, the values of both the dependent variable and the independent variable(s) are normally distributed.
2. In the assignment of individuals to groups, sampling must be random.
3. The regression line depicting the data must be linear and the regression slope for the dependent variable on the independent variable must be equal for all treatment groups.
4. The dependent variable must represent data of the interval scale type.
5. There should be a rational need to adjust the post-measure means using covariance (Courtney, 1983, p. 250).

The following table is used in analysis of covariance.

Source of Variation	df	Sum of Products xx	xy	yy
Groups				
Error				
Total				

ANOVA was used to compare the groups on age and sex. The "F" statistic was used to determine the probability that observed differences among the sample means occurred by chance, and Tukey's Method was used to compare pretest means. The Statistical Package for the Social Sciences (SPSS) by Nie, Hull, Jenkins, Steinbrenner, and Bent (1975) was the computer program used for the analysis.

Mathematical Model

The mathematical model appropriate to the one-way analysis of covariance fixed design is:

$$Y_{ij} = \mu + \alpha_i + \beta(X_{ij} - \overline{X}) + \varepsilon_{ij}$$

where, μ is a fixed constant representing the overall mean,

α_i represents the effect of the treatment,

$\beta(X_{ij} - \overline{X})$ is the adjustment of the postmeasure,

and,

ε_{ij} is a residual variable (NID, $0, \sigma^2$).

The components of the model allow for the testing of a single hypothesis for the treatment effect.

CHAPTER IV

ANALYSIS OF DATA

Introduction

This study compared the effect of computer-assisted-instruction (CAI) drill and practice and same-age peer-tutoring drill and practice on math achievement of fourth grade students. The purpose was to determine which of these strategies most effectively promoted mastery of basic math facts. The findings of the study are presented in this chapter under the following sections: subjects, attrition, absenteeism, duration, age comparisons, sex comparisons, pretest results, posttest results, hypotheses, and summary.

Subjects

The subjects in the study were fourth grade students from Reedville School District, Aloha, Oregon. Reedville is a small suburban area of average to below average economic level. The school district includes five elementary schools. Total enrollment of the school used in this study was 450 students. The subjects were from three fourth grade classrooms. Two of the classes were randomly assigned to the treatment conditons: CAI and same-age peer-tutoring. The third class was designated as a control group. A total of 52 students participated in the experiment.

Attrition

Total attrition for the study was seven students (13.5). Forty-five students of the original 52 students completed the treatment and posttest. In the total sample, one student moved from the district and six students were absent on the day of the posttest. For the individual groups, one student from the computer-assisted-instruction group was absent the day of the posttest. In the same-age peer-tutor group, one student was absent. Four students were absent from the control group.

Pretests of the absentees were not used in the analysis. Table I reports sample size and percentages for the combined groups after attrition.

TABLE I

SAMPLE SIZE AND PERCENTAGES FOR COMBINED GROUPS AFTER ATTRITION

Groups	Original Number	Student Attrition	Group Attrition	Percentage After Attrition
CAI	15	1	14	31.1
Peer-Tutor	18	2	16	35.6
Control	19	4	15	33.3
Total	52	7	45	100.0

Absenteeism

Absenteeism totaled 28 days for the combined groups. The number of absences for the individual groups were: CAI group 10, peer-tutor group 9, and control group 9. The absences in the CAI group represented 8 students. The 9 absences in the peer-tutor group included 5 students and the 9 absences in the control group were represented by 5 students. Of the 28 total absences 12 students were absent 1 day. Four students were absent 2 days. One students was absent 3 days and one student missed 5 days of treatment. Table II reports absenteeim for the individual groups.

TABLE II

ABSENTEEISM FOR INDIVIDUAL GROUPS

Groups	Original Number	Absences	Students Represented
CAI	15	10	8
Peer-tutor	18	9	5
Control	19	9	5
Total	52	28	18

Duration

The experiment was concluded in 25 days rather than in 6 weeks as planned. This was necessitated by the CAI treatment group's desire to begin the multiplication unit in the textbook. To do so at the time of the experiment would have contaminated the results. The total length of the experiment was 27 days: 25 days of treatment, 1 day for pretesting, and 1 day for posttesting.

Age Comparisons

A one-way analysis of variance (ANOVA) showed no two groups were significantly different at the .05 level for age. Ages were converted to base 10 for computational purposes. The mean age of all subjects was 9.750 or 9 years 8 months. The range of ages for all groups was 9.080 to 11.080 years or 9 years 1 month to 11 years 1 month.

For the individual groups, the mean age of the CAI group was 9.593 or 9 years 6 months. The range was 9.080 to 10.670 years or 9 years 1 month to 10 years 8 months. The mean for the peer-tutor group was 9.804 years or 9 years 10 months. The range was 9.160 to 10.830 or 9 years 2 months to 10 years 9 months. The control group mean was 9.839 years or 9 years 10 months. The range was 9.250 to 11.080 years or 9 years 4 months to 11 years 1 month. The CAI group was approximately 4 months younger than the peer-tutor and control group, however, this difference was not significantly different at the ($F = 1.0909$, $p = < .05$) level. Tables III, IV, and V report means, standard deviations, and frequency distributions for age within individual groups. Table VI shows mean, standard deviation, and frequency distribution for age of combined groups.

TABLE III

MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR AGE OF CAI GROUP

Group	Age	Frequency	Valid Percent	Cum Percent
CAI	9.080	1	7.1	7.1
	9.160	1	7.1	14.3
	9.240	1	7.1	21.4
	9.250	2	14.3	35.7
	9.500	2	14.3	50.0
	9.580	2	14.3	64.3
	9.830	3	21.4	85.7
	10.000	1	7.1	92.9
	10.670	1	7.1	100.0
Total		14	100.0	100.0

$\overline{X} = 9.594$ $S = .423$

TABLE IV

MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR AGE OF PEER-TUTOR GROUP

Group	Age	Frequency	Valid Percent	Cum Percent
Peer-Tutor	9.160	2	12.5	12.5
	9.250	1	6.3	18.8
	9.330	2	12.5	31.3
	9.580	3	18.8	50.0
	9.830	1	6.3	56.3
	10.000	2	12.5	68.8
	10.080	1	6.3	75.0
	10.160	1	6.3	81.3
	10.250	1	6.3	87.5
	10.750	1	6.3	93.8
	10.830	1	6.3	100.0
Total		16	100.0	

$\overline{X}$ = 9.804 S = .527

TABLE V

MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION
FOR AGE OF CONTROL GROUP

Group	Age	Frequency	Valid Percent	Cum Percent
Control	9.250	1	6.7	6.7
	9.330	1	6.7	13.3
	9.500	2	13.3	26.7
	9.580	1	6.7	33.3
	9.670	2	13.3	46.7
	9.750	3	20.0	66.7
	9.920	1	6.7	73.3
	10.000	1	6.7	80.0
	10.160	1	6.7	86.7
	10.670	1	6.7	93.3
	11.080	1	6.7	100.0
Total		15	100.0	

$\bar{X}$ = 9.839   S = .489

TABLE VI

MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR AGE OF COMBINED GROUPS

Group	Age	Frequency	Valid Percent	Cum Percent
Combined	9.080	1	2.2	2.2
	9.160	3	6.7	8.9
	9.240	1	2.2	11.1
	9.250	4	8.9	20.0
	9.330	3	6.7	26.7
	9.500	4	8.9	35.6
	9.580	6	13.3	48.9
	9.670	2	4.4	53.3
	9.750	3	6.7	60.0
	9.830	4	8.9	68.9
	9.920	1	2.2	71.1
	10.000	4	8.9	80.0
	10.080	1	2.2	82.2
	10.160	2	4.4	86.7
	10.250	1	2.2	88.9
	10.670	2	4.4	93.3
	10.750	1	2.2	95.6
	10.830	1	2.2	97.8
	11.080	1	2.2	100.0
Total		45	100.0	

$\overline{X}$ = 9.750 S = .485

Analysis of variance was used to compare the age of the three groups. Students in the control group were, on average, the oldest ($\overline{X}$ = 9.839). Students in the peer-tutor group were only slightly younger ($\overline{X}$ = 9.804) than the control group. The CAI group students averaged 4 months younger than the other groups ($\overline{X}$ = 9.593). This difference of 4 months was not, however, significantly different at (F = 1.0909, p = $<$.05) as determined by analysis of variance. Table VII reports the analysis of variance indicating no significant difference in age among the three groups.

TABLE VII

ANOVA COMPARISON OF AGE DIFFERENCE BETWEEN GROUPS

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	.5109	.2555	1.0909	.3452
Within Groups	42	9.8355	.2342		
Total	44	10.3464			

Sex Comparisons

A one-way analysis of variance was used to determine whether the groups differed on percentages of boys and girls. The analysis indicated no significant difference at the ($F = .0548$, $p = < .05$) level. For the combined groups, 21 were girls (46.7%) and 24 were boys (53.3%). The CAI group included an equal number of girls (7) and boys (7). The peer-tutor group consisted of 7 girls (43.8%) and 9 boys (56.3%). The control group included 7 girls (46.7%) and 8 boys (53.3%). Tables VIII, IX, and X report individual means, frequency distributions, and percentages for sex. Table XI reports the mean, frequency distribution, and percentage for the combined groups for sex. Table XII reports results of the analysis of variance showing no significant difference between the groups for sex.

TABLE VIII

SEX OF CAI GROUP: FREQUENCY DISTRIBUTION, PERCENTAGES, AND MEAN

Group	Sex	Frequency	Valid Percent	Cum Percent
CAI	Girls	7	50	50
	Boys	7	50	50
Total		14	100	100

$\overline{X}$ = 1.500

TABLE IX

SEX OF PEER-TUTOR GROUP: FREQUENCY DISTRIBUTION, PERCENTAGES, AND MEAN

Group	Sex	Frequency	Valid Percent	Cum Percent
Peer-tutor	Girls	7	43.8	43.8
	Boys	9	56.3	100.0
Total		16	100.0	100.0

$\overline{X}$ = 1.563

TABLE X

SEX OF CONTROL GROUP: FREQUENCY DISTRIBUTION, PERCENTAGES, AND MEAN

Group	Sex	Frequency	Valid Percent	Cum Percent
Control	Girls	7	46.7	46.7
	Boys	8	53.3	100.0
Total		15	100.0	

$\overline{X}$ = 89.533

TABLE XI

SEX OF COMBINED GROUPS: FREQUENCY DISTRIBUTION, PERCENTAGES, AND MEAN

Group	Sex	Frequency	Valid Percent	Cum Percent
Combined	Girls	21	46.7	46.7
	Boys	24	53.3	100.0
Total		45	100.0	

$\overline{X}$ = 1.533

TABLE XII

ANOVA COMPARISON OF AGE DIFFERENCE BETWEEN GROUPS

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	.0292	.0146	.0548	.9467
Within Groups	42	11.1708	.2660		
Total	44	11.2000			

Pretest Results

The pretest for the study was a computer constructed test (Gardner,1982) consisting of 100 randomly ordered multiplication facts with multipliers 0-9 and multiplicands 6-9. The means of the individual group scores were CAI group (48.000), peer-tutor group (50.750), and control group (67.600). Tables XIII, XIV, and XV report frequency distributions, means, and standard deviations for the pretest scores of CAI, peer-tutor and control groups respectively.

The mean average for the combined groups was 55.511. Table XVI reports pretest results for the combined groups. A one-way analysis of variance showed a significant difference between the groups ($F = 3.9538$, $p = .0267$). As indicated by Tukey's multiple comparison test, the significant difference occurred between the CAI group ($\overline{X} = 48.000$) and the control group ($X = 67.600$). The value compared with the means was 14.5425. The table ranges were 3.43. The mean comparison was tested at the .05 level of confidence. Table XVII reports the results of the analysis of variance indicating a significant (F = 3.954, p = .0267) among pretest mean scores of the three groups.

TABLE XIII

PRETEST SCORES: MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR CAI GROUP

Group	Score	Frequency	Valid Percent	Cum Percent
CAI	19	1	7.1	7.1
	23	1	7.1	14.3
	34	1	7.1	21.4
	35	1	7.1	28.6
	36	1	7.1	35.7
	38	1	7.1	42.9
	44	1	7.1	50.0
	50	1	7.1	57.1
	60	2	14.3	71.4
	61	1	7.1	78.6
	64	1	7.1	85.7
	67	1	7.1	92.9
	81	1	7.1	100.0
Total		14	100.0	100.0

$\overline{X}$ = 48.000 S = 18.098

TABLE XIV

PRETEST SCORES: MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR PEER-TUTOR GROUP

Group	Score	Frequency	Valid Percent	Cum Percent
Peer-tutor	14	1	6.3	6.3
	20	1	6.3	12.5
	35	1	6.3	18.8
	37	1	6.3	25.0
	40	1	6.3	31.3
	47	1	6.3	37.5
	51	1	6.3	43.8
	53	1	6.3	50.0
	54	1	6.3	56.3
	56	1	6.3	62.5
	57	1	6.3	68.8
	62	1	6.3	75.0
	64	1	12.5	87.5
	76	1	6.3	93.8
	82	1	6.3	100.0
Total		16	100.0	100.0

$\overline{X}$ = 50.750 S = 18.325

TABLE XV

PRETEST SCORES: MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR CONTROL GROUP

Group	Score	Frequency	Valid Percent	Cum Percent
Control	33	1	6.7	6.7
	35	1	6.7	13.3
	38	1	6.7	20.0
	40	1	6.7	26.7
	51	1	6.7	33.3
	57	1	6.7	40.0
	59	1	6.7	46.7
	67	1	6.7	53.3
	77	1	6.7	60.0
	83	1	6.7	66.7
	89	1	6.7	73.3
	91	1	6.7	80.0
	97	2	13.3	93.3
	100	1	6.7	100.0
Total		15	100.0	

$\bar{X}$ = 67.60 S = 24.596

TABLE XVI

PRETEST SCORES: MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR COMBINED GROUPS

Group	Score	Frequency	Valid Percent	Cum Percent
Combined	14	1	2.2	2.2
	19	1	2.2	4.4
	20	1	2.2	6.7
	23	1	2.2	8.9
	33	1	2.2	11.1
	34	1	2.2	13.3
	35	3	6.7	20.0
	36	1	2.2	22.2
	37	1	2.2	24.4
	38	2	4.4	28.9
	40	2	4.4	33.3
	44	1	2.2	35.6
	47	1	2.2	37.8
	50	1	2.2	40.0
	51	2	4.4	44.4
	53	1	2.2	46.7
	54	1	2.2	48.9
	56	1	2.2	51.1
	57	2	4.4	55.6
	59	1	2.2	57.8
	60	2	4.4	62.2
	61	1	2.2	64.4
	62	1	2.2	66.7
	64	3	6.7	73.3
	67	2	4.4	77.8
	76	1	2.2	80.0
	77	1	2.2	82.2
	81	1	2.2	84.4
	82	1	2.2	86.7
	83	1	2.2	88.9
	89	1	2.2	91.1
	91	1	2.2	93.3
	97	2	4.4	97.8
	100	1	2.2	100.0
Total		45	100.0	

$\overline{X}$ = 55.511 S = 21.903

TABLE XVII

ANOVA COMPARISON OF PRETEST SCORES

Source of Variation	df	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	3344.6444	1672.3222	3.9538	.0267*
Within Groups	42	17764.6000	422.9667		
Total	44	21109.2444			

* Significant beyond the .05 level.

Posttest Results

The posttest, like the pretest, was a computer constructed test (Gardner, 1982) of randomly ordered multiplication facts with multiplication facts with multipliers 0-9 and multiplicands 6-9. The mean averages for the individual groups were: CAI group 90.43, peer-tutor group 91.19, and control group 89.53. Tables XVIII, XIX, and XX report posttest results for CAI, peer-tutor, and control groups respectively.

For the combined groups, the mean average was 90.400 and standard deviation 16.537. Table XXI reports the posttest results for the combined groups. Analysis of covariance (ANCOV) showed that, when adjusted for the covariate (pretest), there was no significant difference among the posttest means of the three groups. As a result, Tukey's multiple comparison test was not needed. Table XXII shows the analysis of covariance results.

TABLE XVIII

POSTTEST SCORES: MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR CAI GROUP

Group	Score	Frequency	Valid Percent	Cum Percent
CAI	36	1	7.1	7.1
	61	1	7.1	14.3
	87	1	7.1	21.4
	93	1	7.1	28.6
	95	1	7.1	35.7
	97	1	7.1	42.9
	98	1	7.1	50.0
	99	1	7.1	57.1
	100	6	42.9	100.0
Total		14	100.0	

$\overline{X}$ = 90.429 S = 18.793

TABLE XIX

POSTTEST SCORES: MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR PEER-TUTOR GROUP

Group	Score	Frequency	Valid Percent	Cum Percent
Peer-tutor	52	1	6.3	6.3
	66	1	6.3	12.5
	75	1	6.3	18.8
	82	1	6.3	25.0
	90	1	6.3	31.3
	97	1	6.3	37.5
	99	3	18.8	56.3
	100	7	43.8	100.0
Total		16	100.0	

$\overline{X}$ = 91.19 S = 14.784

TABLE XX

POSTTEST SCORES: MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR CONTROL GROUP

Group	Score	Frequency	Valid Percent	Cum Percent
Control	55	1	6.7	6.7
	57	1	6.7	13.3
	60	1	6.7	20.0
	84	1	6.7	26.7
	94	1	6.7	33.3
	96	1	6.7	40.0
	99	3	20.0	60.0
	100	6	40.0	100.0
Total		15	100.0	

$\overline{X} = 89.533$ $S = 17.200$

TABLE XXI

POSTTEST SCORES: MEAN, STANDARD DEVIATION, AND FREQUENCY DISTRIBUTION FOR COMBINED GROUPS

Group	Score	Frequency	Valid Percent	Cum Percent
Combined	36	1	2.2	2.2
	52	1	2.2	4.4
	55	1	2.2	6.7
	57	1	2.2	8.9
	60	1	2.2	11.1
	61	1	2.2	13.3
	66	1	2.2	15.6
	75	1	2.2	17.8
	82	1	2.2	20.0
	84	1	2.2	22.2
	87	1	2.2	24.4
	90	1	2.2	26.7
	93	1	2.2	28.9
	94	1	2.2	31.1
	95	1	2.2	33.3
	96	1	2.2	35.6
	97	2	4.4	40.0
	98	1	2.2	42.2
	99	7	15.6	57.8
	100	19	42.2	100.0
Total		45	100.0	

$\overline{X}$ = 90.400 S = 16.537

TABLE XXII

ANALYSIS OF COVARIANCE AND ADJUSTED GROUP MEANS FOR POSTTEST

Source of Variation	Sum of Squares	df	Mean Square	F	Signif F
Covariate	3147.225	1	3147.225	15.995	.000
Main Effects	818.495	2	409.247	2.080	.138
Residual	8067.080	41	196.758		
Total	12032.800	44	273.473		

Adjusted Group Means

Group	Adjusted Mean
CAI	93.97
Peer-tutor	93.43
Control	83.84

Hypotheses

Analysis of covariance showed no significant differences in the math posttest mean scores of students receiving drill and practice from CAI, peer-tutoring, and traditional instruction. The computed F value 2.080 was less than the tabulated F value 3.225 for alpha = .05 with 2, 41 degrees of freedom. Therefore, none of the three hypotheses tested in the study could be rejected.

The hypotheses were:

1. There is no significant difference between the math posttest mean scores of students receiving drill and practice from computer-assisted-instruction and the math posttest mean scores of students receiving drill and practice from same-age peer-tutoring (H_0 $\mu 1 = \mu 2$).
2. There is no significant difference between the math posttest mean scores of students receiving drill and practice from computer-assisted-instruction and the math posttest mean scores of students in the control group (H_0 $\mu 1 = \mu 3$).
3. There is no significant difference between the math posttest mean scores of students receiving drill and practice from same-age peer-tutoring and the math posttest mean scores of students in the control group (H_0 $\mu 2 = \mu 3$).

Homogeneity of Variance

The Bartlett-Box F test of homogeneity of variance was used to determine whether the variances of the three sets of scores differed significantly from one another. The test indicated no significant differences at the .05 level. The probability of the calculated F of .860 was .423. Therefore, the model assumption of equality of variance needed to use ANCOV as the statistical technique was met.

Regression Statistics

The regression statistics for the pretest with the posttest on a two-tailed test of significance, showed a positive linear relation between the pretest and posttest as attested to by a significant correlation coefficient of .511 ($p < .001$). Forty five cases were plotted. The intercept (S.E.) was -5.72421 and the slope (S.E.) was (6.7738). Table XXIII shows the plot of the pretest with the posttest.

TABLE XXIII

REGRESSION STATISTICS OF PRETEST ON POSTTEST

```
                         PLOT OF PRE WITH POST
        ++----+----+----+----+----+----+----+--+
        |                                  1   |
        |                                  2   |
      90+                               1  1   +
  p     |                                 12   |
  r     |                                  2   |
  e     |                                      |
  t     |                               11 3   R
  e   60+                                 16   +
  s     |                         1       13   |
  t     |                 1                1   |
        |                          1  1    1   |
        |   1        111       1     1   1 2   |
      30+                                      +
        |               1                      |
        |          1                       1   |
        R                                  1   |
        ++----+----+----+----+----+----+----+--+
        30        50        70        90
             40        60        80        100

                          posttest
```

Summary

The study compared the effect of computer-assisted-instruction drill and practice to the effect of same-age peer-tutoring drill and practice on math achievement. Subjects were 52 fourth grade students from the Reedville School District in Aloha, Oregon. Forty-five students completed the treatment and posttest. Analysis of variance showed no significant differences among the groups for age and sex. The average age of the students was nine years and eight months.

Tukey's multiple comparison test showed a significant difference between the CAI and control group on the pretest. However, on the posttest, analysis of covariance revealed no significant difference among any of the groups after posttest means were adjusted. The pretest and posttest were computer constructed criterion tests consisting of 100 randomly ordered multiplication facts with multipliers 0-9 and multiplicands 6-9.

The assumptions of linearity and variance necessary for the use of covariance were met. The Bartlett-Box F maximum test of homogeneity of variance showed no significant difference in the three sets of math scores at the $p = .05$ level. Regression analysis showed a positive linear relation between the pretest and posttest on a two-tailed test of significance at the $p = .05$ level.

Three hypotheses were tested in this study. These stated there would be no significant difference among the math posttest means of students receiving drill and practice from CAI, same-age peer-tutoring, and traditional instruction (control group). The computed

F value was less than the tabulated F value. Therefore, none of the null hypotheses could be rejected.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

Introduction

The major purpose of this study was to compare the effect of computer-assisted-instruction drill and practice to the effect of same-age peer-tutor drill and practice on math achievement of fourth grade students. In comparing the effectiveness of the two strategies, the study provided information to aid teachers in selection of drill and practice methods and in their decisions regarding the use of computers for instruction. Conclusions and implications in this chapter are divided into the following sections: restatement of the problem, the dependent variable, conclusions, implications, and suggestions for further study.

Restatement of the Problem

Elementary-school students are expected to learn many basic facts for recall from memory. Regular drill and practice sessions are essential to the development of immediate recall. Memorization and recall, however, make up the lowest and least challenging cognitive level of the learning hierarchy (Bloom, 1965). According to Kennedy (1984), drill and practice programs offer little or no opportunity for children to be creative (p. 130). For these reasons, many teachers consider drill one of the least desirable aspects of instruction. As a result, drill and practice is often assigned as homework. Consequently, only highly motivated students with outside help, keep pace with the memorization demands of the curriculum.

Since basic facts are the foundation for higher level cognitive learning, they should be mastered by all students. Therefore, it is important that teachers are consistent in providing adequate amounts of in-class time for drill. It is also important, for optimum utilization of class time, that drill and practice strategies be selected on the basis of proven benefit to development of mastery. Proof of such effectiveness is best provided through experimental research.

This study sought to provide experimentally obtained evidence regarding the comparative effectiveness of two types of drill and practice: computer-assisted-instruction and same-age peer-tutoring. Typically, studies of both CAI and peer-tutoring have compared these strategies with traditional instruction. Rarely have the two methods been compared with one another. Therefore, it is not known whether CAI or same-age peer-tutor drill and practice most effectively promostes mastery of basic facts. The present study examined their comparative effectiveness. In comparing the two strategies, the study provided information to aid teachers in selection of drill and practice methods and in their decisions regarding efficient uses of computers for instruction.

The Dependent Variable

The dependent variable for the study was the subjects' adjusted math test scores on the computer constructed criterion test. The scores were used to measure the effectiveness of the independent variables, computer-assisted-instruction and same-age peer-tutoring, on math achievement. Steve Gardner's computer program, Speed Drill Maker (1982) was used to create the posttest. The test consisted of 100 randomly ordered multiplication facts with multipliers 0-9 and multiplicands 6-9.

Pretest scores were used as the covariate to adjust for initial differences in the groups. The pretest mean scores for the individual groups were: CAI group 48.000, peer-tutor group 50.750, and control group 67.600. Analysis of variance showed a significant difference between the CAI group and the control group on the pretest $F = 3.954$, $p = .0267$. On the posttest, this difference was reversed in favor of the CAI group, however, the difference was not significant at the .05 level. The unadjusted mean of the CAI group was 90.43, and the unadjusted mean of the control group was 89.53.

Analysis of covariance was used to adjust for the pretest scores. The adjusted means were: CAI group 93.97, peer-tutor group 93.43, and control group 83.84. Although a difference of 10.13 points existed between the CAI group and the control group, in favor of the CAI group, the difference was not significant at the .05 level. No significant differences were found among any of the groups on the posttest. The computed F value (2.080) was smaller than the tabular F value (3.23), therefore, the null hypotheses tested in the study could not be rejected. The hypotheses predicted there would be no significant differences in the math posttest mean scores of students receiving drill and practice from CAI, same-age peer-tutoring, and traditional instruction (control group).

Conclusions

Elementary school curriculum includes basic facts which must be mastered if students are to achieve success at higher cognitive learning levels. Experimental evidence relating to the effectiveness of drill and practice strategies is needed to aid teachers in selection of effective and efficient methods for promoting memorization of basic facts. This research examined the comparative effectiveness of CAI drill and practice and same-age peer-tutor drill and practice in promoting mastery of multiplication facts.

ANOVA and Tukey's multiple comparison test showed a significant difference between the CAI and control group on the pretest in favor of the control group. This difference occurred as a result of the self-paced format of the math instruction used by the control group. Students memorized facts on their own time and at their own pace. One-minute mastery tests were taken daily. At the time of the pretest, five students in the control group had already achieved a mastery level which included multiplication facts within the treatment set (multipliers 0-9 and multiplicands 6-9) This resulted in a pretest mean for the control group (67.60) which was significantly higher than the CAI group mean (48.00). Analysis of covariance was used to adjust for this difference.

Analysis of covariance showed no significant difference among the posttest mean math scores of students taught via CAI drill and practice, same-age peer-tutor drill and practice, and traditional instruction. Therefore, the null hypotheses for the study--predicting no significant differences between the group means--were accepted (retained). The adjusted posttest means for the groups were CAI, 93.97, peer-tutor, 93.43, and control, 83.84.

Although the study did not identify CAI or same-age peer-tutoring as more effective than the other, it did show both strategies to be equally effective drill and practice methods. Using the adjusted means of posttest scores to compute overall gains within groups, the CAI group gained 45.97 points. The peer-tutor group gained 42.68 points. These gains were double the gain made by the control group (21.933).

Given the evidence, CAI and same-age peer-tutoring were equally effective drill and practice strategies, teachers may begin to consider the relative merits of other aspects of the two strategies. These include scheduling convenience, cost effectiveness, and efficiency. Currently, scheduling convenience favors same-age peer-tutoring. Although the number of computers in elementary schools continues to increase, few classrooms have exclusive use of even one computer. Relatively small numbers of computers must be shared among entire staffs. Same-age peer-tutoring maximizes scheduling convenience through use of intact classes in which teachers have scheduling control of the day's activities.

Cost effectiveness and efficiency also favor same-age peer-tutoring drill and practice. Levin, Glass, and Meister (1984) found cross-age tutoring to be more cost effective than CAI. Same-age peer-tutoring drill and practice requires duplication of existing materials, a comparatively minor expense in comparison with the cost of computers and software.

Educational efficiency is maximized by same-age peer-tutoring through use of "cooperative learning structures" and increased "academic engaged time." Proponents of computer-assisted-instruction maintain these same benefits are derived from CAI. However, until computers are in greater supply in schools, efficiency will continue to favor same-age peer-tutoring.

Educational efficiency must also be considered in terms of utilizing computers for their greater capabilities. Efficiency is increased through programs which provide students with opportunities to use higher cognitive learning levels such as application, analysis, synthesis, and evaluation. These programs include simulation, LOGO, problem solving, and educational gaming. CAI drill and practice programs offer simple retrieval of facts for memorization, a function which can be easily and inexpensively duplicated by peer-tutors and flashcards.

The finding that same-age peer-tutoring drill and practice and CAI drill and practice were equally effective in promoting mastery of basic math facts, makes apparent the lack of efficiency and cost effectiveness in using computers for drill and practice when a much less expensive method is available in same-age peer-tutoring. Until computers are in much greater supply in schools, they should be reserved for uses which promote higher level cognitive skills rather than be underutilized for retrival of facts for memorization. By substituting same-age peer-tutoring for CAI drill and practice, schools could free computers to be used for their greater potential in developing upper level thinking skills.

Implications

This research examined the comparative effectiveness of CAI drill and practice and same-age peer-tutor drill and practice in promoting mastery of basic math facts. Analysis of covariance revealed no significant difference between the adjusted posttest mean math scores of students who received drill and practice via CAI and those who received drill and practice from same-age peer-tutors. However, the findings did show that both CAI and same-age peer-tutoring were effective drill and practice strategies as evidenced by the adjusted group means: CAI, 93.97 and same-age peer-tutoring, 93.43. In finding the two strategies to be equally effective, the study identified same-age peer-tutoring as an inexpensive alternative to CAI drill and practice. This finding has implications for staff development, curriculum planning, and for teachers' selection of drill and practice methods.

Implications of the study for staff development relate to inservice training in both same-age peer-tutoring and CAI. Inservice programs could be used to introduce teachers to the educational benefits of both instructional methods. Cohen (1986) outlines the following conceptualizations for guiding teachers in making effective choices when implementing peer-tutoring. Used as a basis for inservice, these conceptualizations could aid teachers in implementing peer-tutoring programs. They are: (1) matching tutors and tutees, (2) choosing tutoring materials, (3) frequency and length of tutoring programs, (4) amount of structure and supervision, (5) external feedback, and motivation for tutor and tutee, (5) preparation for tutoring, (6) training of tutors, and (7) selection of physical environment (pp. 182-184).

Schiffman (1986) describes the need for teacher inservice that prepares teachers to design and implement lesson plans which "infuse" the use of computer software into instruction. She states teachers should be taught to identify areas in the curriculum where the computer can make a contribution to instructional effectiveness. They need to be able to select software that contributes to the effectiveness of specific curriculum objectives (p. 44).

Schiffman (1986) has identified the competencies needed to determine where and how to use software to enhance teaching. She says teachers must be knowledgeable about: (1) instructional capabilities of the computer, (2) the wide range of potential software, and (3) ways in which software can be utilized for instructional purposes. Given the curriculum objectives for their subject/grade level, teachers must be able to (4) determine where and how the instructional capability of the computer can be beneficially infused into lessons,

(5) identify software with the greatest potential for enhancing instruction, (6) evaluate software in relation to the needs of specific lessons, and (7) design and implement lesson plans that infuse software where appropriate (p. 9).

Schiffman (1986) describes software infusion as a complex skill. It requires matching of knowledge about computers, software, and utilization strategies to the stated objectives of the curriculum. Schiffman suggests the following objective for teacher training: "Given the curriculum objectives for a particular discipline, what kind of software would be most desirable as means of increasing instructional effectiveness?" (p. 9). When computer literacy programs begin to adopt this objective as the basis of instruction, the greater educational benefits of computers will be realized.

Implications of this study for curriculum planners relate to instructional goals. The finding that same-age peer-tutoring with flashcards is as effective as CAI drill and practice should alert curriculum planners to the lack of cost effectiveness in using computers for drill and practice and to the fact that the greater potentials of computers are not being utilized in drill and practice programs. This situation may be corrected if curriculum planners integrate higher level computer uses into the instructional goals of schools.

Implications of the findings for teachers relate to selection of drill and practice methods. The research has identified same-age peer-tutoring as an effective alternative to CAI drill and practice. Use of same-age peer-tutoring for drill and practice not only has the potential to free computers for their greater educational capabilities, it also provides a cooperative learning structure.

Peer-tutoring is one of the most common cooperative learning structures. There is a wealth of literature to support its effectiveness in promoting both cognitive and affective gains. Some educators believe student to student interaction is more important than teacher to student interaction in determining educational achievement (Simpson, 1986, p. 37). The influence of constructive peer-relationships can be seen in increased educational aspirations and achievement; improved social behaviors, attitudes, and perspectives; psychological health; mastery over aggressive impulses; and in greater productivity, higher self-esteem, and concern for people different from one's self (Simpson, 1986, p. 37).

Research in cognitive science indicates that interaction is also important for development of cognitive skills. According to Vygotsky (1978), by verbalizing their ideas, children are required to cognitively restructure information--a process which improves understanding. Research conducted to assess the relative effects of cooperative learning on students' academic achievement identify cooperation as the most effective way to promote both achievement and productivity (Simpson, 1986, p. 39).

These findings and the findings of the present study, support the effectiveness of peer-tutoring. In showing same-age peer-tutoring and CAI to be equally effective drill and practice strategies, this study identified same-age peer-tutoring as an inexpensive alternative to CAI drill and practice. Use of this alternative by educators could lessen the current monopoly of computers for tasks which do not tap their full potential.

Suggestions for Further Study

The findings of this research suggest a need for further study of both computer-assisted-instruction (CAI) and same-age peer-tutoring. No significant difference was found between CAI and same-age peer-tutoring drill and practice on mastery of multiplication facts. The failure of this study to show a difference may have resulted from the low ceiling level on mastery. Nineteen students out of the total sample (N = 45) scored 100% on the posttest (CAI = 6, peer-tutor = 7, and control = 6). Therefore, the ceiling on achievement prevented further potential increases from becoming apparent. Future studies should utilize treatment content with a higher ceiling level.

This study used a computer program in which math facts were randomly presented. Further study is needed to determine how random presentation of facts compares with presentations of multiplication facts in sequence. These types of presentation need to be compared on effectiveness in promoting sequence counting. Sequence counting is a necessary skill for proficiency in long division. Random presentation of facts may prevent students from visualizing multiples in sequence. These presentation methods should also be compared for potential to increase retention of facts. Memorization of multiplication facts in sequential multiples may promote greater retention than random memorization.

Future research is also needed to determine the effectiveness of computers on achievement beyond simple memorization of facts. The majority of studies investigating CAI achievement have used CAI have used drill and practice programs. There is need for information about the comparative effectiveness of other types of computer programs such as simulations, tutorials, problem solving, and educational gaming, and programming. Survey studies determining the extent of teacher use and support of these programs may provide information needed to promote use of higher cognitive level software. Use of such programs would help to correct the misuse of computers in education.

Maddux (1986) says computer use in education is at risk of failure due to the manner in which computers are being used. He classifies educational computer uses as Type I and Type II uses. Presently most educational computer uses are Type I applications or misuses. Type I misuses include programs which provide only acquisition of rote skill and memorization. Type I software tends to be programmer-centered rather than learner centered. Learner involvement is minimal, passive, and largely restricted to pressing a few keys. According to Maddux (1986), if Type I uses continue to predominate, the current backlash against educational uses of computers will become overwhelming and the entire movement will fail. Computers are potentially useful tools which are being misused as simple drill and practice devices. Maddux says the importance of drill and practice cannot be disputed, however, the public should not be required to fund a $2000 electronic flashcard machine when a two dollar deck of flashcards can do as well (p. 35). "Since computers are expensive and require extensive time and effort to learn to use, their success depends heavily on our ability to find important rather than trivial goals to apply them to" (Maddux, 1986, p. 34).

Only the greater educational benefits of Type II software will justify the cost of computerized education. These benefits include: (1) facilitation of more complex cognitive skills such as application, analysis, synthesis, evaluation, and creativity, (2) learner-centeredness, and (3) provision for active involvement controlled by the student (Maddux, 1986, p. 36). Type II programs include simulations, word processing, programming, problem solving, and educational gaming. These programs should be the focus of further research in computer-assisted-instruction. Increased knowledge of these programs may result in improved uses of computers for instruction.

There is also a need for further research on same-age peer-tutoring. The majority of peer-tutoring studies have examined cross-age peer-tutoring. Typically, the subjects have been learning disabled and traditional instruction has been the comparison technique. Treatment has generally consisted of basic math, spelling, and reading facts. Research is needed to determine effectiveness of peer-tutoring with same-age tutors in regular classrooms using higher cognitive level learning as a comparison measure.

The comparative effectiveness of students working alone at computers and same-age peer-tutor dyads working together at computers needs to be investigated. Evidence of the effectiveness of combining CAI and same-age peer-tutoring could increase the cost effectiveness and efficiency of computer instruction by doubling the number of students utilizing computers. It would also generate the benefits of "cooperative learning structures" and increased "academic engaged time."

Other questions needing to be addressed by future researchers include: What are the profiles of teachers and students who use computer instruction and those who avoid its use? What is the profile of the students who benefits most from computer instruction? Are students' learning styles effected differently by computer instruction? Which computer programs most effectively reinforce the items included on college entrance examinations, standardized tests, and intelligence tests? How do popular computer programs compare on discrimination, for example, sexism, racism, and ageism? Further research into both CAI and same-age peer-tutoring will assist teachers in developing effective skill building programs and promote more efficient uses of computers for instruction.

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APPENDICES

APPENDIX A

PRETEST

MULTIPLICATION SHEET 1

NAME________________________________

1.	9 X 1	6 X 0	8 X 2	8 X 5	6 X 2	8 X 3	7 X 7	7 X 4	9 X 3	8 X 3
2.	6 X 7	9 X 1	9 X 0	8 X 1	7 X 7	7 X 8	7 X 6	8 X 3	9 X 3	9 X 8
3.	8 X 3	9 X 3	7 X 8	6 X 7	9 X 4	7 X 2	9 X 6	6 X 4	7 X 8	8 X 7
4.	8 X 4	8 X 3	9 X 0	6 X 2	9 X 4	9 X 4	9 X 0	7 X 0	9 X 2	7 X 7
5.	6 X 5	8 X 7	8 X 3	8 X 0	9 X 6	9 X 3	8 X 2	9 X 8	9 X 2	8 X 2
6.	9 X 4	7 X 9	7 X 0	6 X 4	6 X 4	9 X 0	9 X 4	6 X 6	8 X 5	6 X 7
7.	6 X 3	6 X 0	9 X 1	7 X 3	7 X 8	7 X 5	7 X 7	8 X 5	6 X 9	9 X 6
8.	7 X 6	9 X 5	7 X 0	7 X 0	9 X 6	6 X 0	7 X 4	7 X 4	7 X 9	8 X 5
9.	9 X 9	9 X 1	8 X 3	9 X 7	8 X 0	8 X 8	8 X 4	8 X 9	7 X 5	6 X 5
10.	7 X 6	6 X 2	9 X 2	9 X 7	6 X 1	6 X 6	9 X 9	9 X 4	7 X 7	6 X 9

POSTTEST

MULTIPLICATION SHEET 2

NAME______________________________

1.	8 X 5	6 X 0	7 X 1	8 X 9	8 X 5	7 X 4	7 X 2	7 X 7	6 X 8	6 X 7
2.	7 X 5	8 X 5	6 X 7	6 X 2	6 X 0	7 X 8	6 X 3	7 X 5	6 X 1	7 X 9
3.	8 X 9	6 X 9	6 X 1	6 X 9	8 X 6	9 X 5	6 X 7	8 X 3	7 X 5	7 X 1
4.	8 X 4	8 X 8	6 X 7	9 X 3	6 X 0	6 X 0	7 X 8	8 X 3	6 X 9	7 X 7
5.	6 X 3	7 X 9	6 X 1	8 X 7	7 X 1	6 X 3	6 X 2	8 X 3	6 X 8	8 X 3
6.	9 X 0	7 X 3	7 X 6	8 X 6	8 X 5	7 X 5	7 X 6	8 X 9	7 X 0	8 X 0
7.	6 X 4	7 X 5	6 X 9	6 X 2	9 X 5	7 X 2	9 X 1	6 X 8	9 X 1	7 X 9
8.	7 X 2	9 X 0	6 X 1	9 X 3	6 X 9	6 X 4	7 X 0	7 X 9	9 X 4	8 X 1
9.	9 X 1	9 X 4	9 X 7	8 X 6	8 X 3	8 X 5	9 X 3	8 X 7	8 X 3	8 X 2
10.	9 X 7	6 X 9	7 X 7	8 X 9	8 X 5	9 X 0	9 X 8	6 X 6	9 X 8	7 X 2

APPENDIX B

MATH DRILL PROGRAM (ALEXANDER, 1986)

1. Team 1 members collect their own tutoring folders and then draw a folder from the Team 2 box. The student whose folder is drawn becomes the Team 1 student's tutoring partner for the session. Team 1 and Team 2 alternate this procedure daily.
2. Each Team 1 member flashes multiplication flash cards to his or her tutee. If the tutee answers correctly, the tutor makes a positive comment. If the tutee is incorrect, the tutor says the fact correctly. The tutee repeats the fact. The card is placed in the Stop stack.
3. After the tutor has gone through all the cards, the drill is repeated with those facts which were missed (from the Stop stack).
4. The procedure is then repeated using the entire set of cards until the 5 minute period is over.
5. Facts that are mastered are banded in a Go stack. Facts missed are banded in a Stop stack. Cards that have been in the Go stack for 3 days are reviewed only once a week.
6. At the end of 5 minutes, the tutor records the cards in the Go stack and switches roles with the tutee. The procedure described above is repeated.
7. Students return their folders to the Team 1 and Team 2 boxes on the desk.

APPENDIX C

ROLE PLAYING ACTIVITY

1. Prepare students for role playing appropriate verbal techniques:
    a. Discuss positive and negative feedback.
    b. Brainstorm positive and negative comments.
    c. Discuss how each kind of feedback makes one feel.
2. Select two students to role play the tutoring process using positive comments.
3. Evaluate the role playing performance.
4. Select other dyads to role play until performances are successful.
5. Prepare students for role playing appropriate nonverbal techniques:
    a. Discuss nonverbal positive and negative feedback.
    b. Brainstorm and demonstrate positive and negative nonverbal techniques.
    c. Discuss how each kind of feedback makes one feel.
6. Select two students to role play the tutoring process using positive nonverbal techniques.
7. Evaluate the role playing performance.
8. Select other dyads to role play positive nonverbal techniques until performances are successful.