THE EFFECTIVENESS OF COMPUTER-ASSISTED INSTRUCTION AND ITS RELATIONSHIP TO SELECTED LEARNING STYLE ELEMENTS

DISSERTATION

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF EDUCATION

By

Gladys L. Williams, B. S., M. Ed.
Denton, Texas

August, 1984

N.W.E.

Williams, Gladys L., The Effectiveness of Computer-Assisted Instruction and Its Relationship to Selected Learning Style Elements. Doctor of Education (Elementary Education), August, 1984, 147 pp., 21 tables, bibliography, 98 titles.

The problem was to assess the effectiveness of computer-assisted instruction (CAI) in reading and math and to determine the relationship between achievement using CAI and selected learning style elements. Learning style elements were limited to motivation, learning alone or with peers, auditory, visual, tactual, and kinesthetic perceptions.

The Learning Style Inventory provided learning style data and The Iowa Tests of Basic Skills measured achievement. Both tests were administered in the classroom.

Three hundred (300) fourth-grade students in six suburban schools were divided into experimental and control groups. The treatment was CAI in reading or mathematics for fifteen minutes per day and regular instruction.

The nonequivalent control group design allowed for testing and treatment conditions for intact groups. Pre- and post-test achievement measures were administered to all subjects.

An analysis of covariance was computed for the achievement measures. A correlation coefficient was

calculated to determine the relationship between achievement and each learning style element. The Manova multiple regression procedure was used to determine which combination of selected learning style elements could predict achievement. The pre-test and time on task were used as covariates to control for initial differences between groups.

The findings were: (1) the experimental groups gained significantly higher scores (.05 level) than the control groups in math achievement; (2) the control groups made significantly more reading gain (.05 level) than the experimental groups; (3) there was no significant relationship between achievement and selected learning style elements; (4) there was no significant relationship between any combination of selected learning style elements and achievement.

It was concluded that computer-assisted instruction (1) can be expected to positively affect math achievement for fourth-grade students, (2) can be expected to result in less achievement in reading than math, (3) cannot be expected to produce a relationship between achievement and selected learning style elements.

Recommendations included: (1) utilization of CAI for teaching math, (2) further research to determine effectiveness of reading computer programs, (3) further research to determine characteristics of an effective CAI program.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The computerized information age has made drastic changes in all areas of life. Educators across the nation must respond to the responsibility of preparing youth to function in this rapidly changing technological society. A survey released in 1982 by the National Center for Education Statistics showed that of 82,000 public schools in the United States, 29,000 of these schools had at least one small computer or computer terminal for instructional use by students (23).

Computers are permeating every aspect of American society so deeply that some degree of literacy concerning them seems a growing necessity for participating in the economic system and for being an effective citizen (21). The computer offers untapped potential as a learning tool for students in the areas of basic skills, problem solving, and critical thinking skills. Offerman (24) notes that the use of computer-assisted instruction (CAI) has been proven to be a great benefit in teaching or reinforcing the basic skills, and the ability to use a computer is rapidly becoming a basic skill.

Deringer (7) concludes that observational and quantitative evaluation results show that using computers for instruction is educationally sound. Students learn fast and like learning in addition to learning about a technology that will increasingly dominate the economy and society.

Understanding the ways students learn has been another relatively new area of research and study during the past decade. As Schmeck indicated, there are consistent differences in learning styles among students (26). Knowledge about learning styles is a fundamental tool for the educator to use in designing and delivering an instructional program to meet the individual needs of students.

According to Dunn, Dunn, and Price (15), in many experiments that were conducted where students were permitted to study in ways that were harmonious with their identified learning styles, academic achievement and retention were invariably increased. Dunn (9) further notes that prize-winning studies revealed that students learn more with less difficulty when taught through their learning styles.

Canfield (2) reports that differential learning styles appear to be a significant factor in achievement; therefore, expanded research is needed. Perhaps as educators become more informed concerning learning styles, students will benefit from appropriate strategies being identified and matched to specific identified needs. Research should provide more knowledge and understanding concerning the learning process and its implications for education.

Research concerning the appropriateness of computer instruction to specific learning characteristics is limited. A comprehensive study that identifies the learning style elements of individual students who benefit from computer-assisted instruction not only would bring two relatively new phenomena together, but could impact educational practices that would allow students to reach maximum potential achievement levels.

Statement of the Problem

The problem of this study was to assess the effectiveness of computer instruction in reading and math and to determine the relationship between achievement of students using computer-assisted instruction (CAI) in reading and math and selected learning style elements of students.

Purposes of the Study

The purposes of the study were (1) to determine if students produce significantly higher achievement scores, as measured by _The Iowa Tests of Basic Skills_ (ITBS), with computer-assisted instruction in reading and math; (2) to determine the significance of the relationship (r^2) between the possession of one or more selected learning style elements and achievement with computer-assisted instruction in reading and math; and (3) to determine the most statistically significant combination of selected learning style elements which are positively correlated to achievement with computer-assisted instruction in reading and math.

Hypotheses

To accomplish the purposes of the study, the following hypotheses were tested.

1. There will be no difference in reading achievement as measured by ITBS between fourth-grade students who receive instruction by the computer and fourth-grade students whose instruction is limited to conventional methods.

2. There will be no difference in mathematical achievement as measured by ITBS between fourth-grade students who receive instruction by the computer and fourth-grade students whose instruction is limited to conventional methods.

3. There will be no significant relationship (r^2) between selected learning style elements and reading achievement with CAI as measured by ITBS.

4. There will be no significant relationship (r^2) between selected learning style elements and mathematics achievement with CAI as measured by ITBS.

5. No combination of selected learning style elements will be statistically significant in the prediction of reading achievement with CAI as measured by ITBS.

6. No combination of selected learning style elements will be statistically significant in the prediction of mathematics achievement with CAI as measured by ITBS.

Background and Significance

Educators are becoming increasingly aware of the versatility, power, and potential of computers used in the classroom for the student learning process. Melmed (23) reports that among the information technologies that may be used to improve educational productivity, the microcomputer holds powerful promise for improving student learning. Carruth (5) notes that technology can supplement and enhance existing techniques, thus providing a significant alternative to current instructional methodologies.

Research findings indicate that most educators view this era as the frontier of a new future. This idea was supported by Goodlad as he stated, "If we merely ask computers and schools to share identical tasks and fail to rethink the entire educational enterprise, we have lost a rare opportunity" (19, p. 455). Estes (17) agrees that technology may revolutionize the delivery of education of quality. According to Papert (25), the younger children will benefit most from computer learning because it will introduce to them a new dimension of thinking and allow them to overcome many stigmas associated with certain subjects.

The literature reveals that long-term research concerning the effectiveness of computer-assisted instruction is limited; however, the number of studies has increased in recent years. Many findings indicate that the slow learning students will benefit by being taught with the computer. Researchers in the Cupertino Union School District, Cupertino, California, found that children who had learning problems began finding success and teachers were discovering new avenues for teaching by using the computer (31). CAI allows students to learn at their own rate, thus avoiding the pressure of group pacing. Sullivan (28) reports that with traditional instructional methods, anxiety created by observed disparities in learning rates will adversely impact the slower students' performance by directing energy into fear and other negative attitudes.

A long-term study of computer-assisted instruction that was conducted by the Educational Testing Service led to the conclusion that computers assist learning. Students being taught with the computer learn faster than with traditional methods of instruction (32). Melmed (23) notes that student learning by computer will need to be determined empirically for students at various age levels and for various curriculum levels.

Computer-assisted instruction allows the student to have individualized drill and practice for the skills and concepts previously taught by the teacher. Most of the literature reflects that technology will supplement current practices in education and not supplant the teacher. Tyack (30) believes that the computer can be a useful tool for instruction when properly used. Fantini (18) agrees that the imaginative application of technology could contribute significantly to a new effectiveness in learning.

Educators are not only concerned with measurable achievement of students but are showing increasing interest in how students learn. Shane warns that information must not be confused with education, as "one is an item and the other is a process to which the item may contribute" (27, p. 306). Papert states that "the most important change will not come through what the computers can do for us, but through their effect on how people learn" (25, p. 5).

Many educators believe that schools should provide responsive instructional environments based on individual learning styles and skill differences among learners. There are conflicting opinions concerning how to identify learning styles and there is disagreement of specific characteristics of learning; however, most researchers agree with Barbe when he suggests that students vary in their learning (1).

According to Keefe, learning styles may be defined as characteristic cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (22). Information-processing habits, affective styles, motivational processes, physiological styles, and biologically based response modes are considered cognitive styles. While researchers approach the analysis of the learning process from various views, the concept of learning style involves interrelatedness of the cognitive, affective, and physiological dimensions.

Several studies reveal that when students are taught through methods that are appropriate to their learning style, achievement increases. Such findings were revealed in research that was conducted at Worthington High School, Worthington, Ohio, in 1974. Cavanaugh (6) reports that the teachers indicated that improved academic achievement and attitudes toward school resulted from the learning style approach. Dunn (8) noted that attendance, achievement, and attitude improved at Madison Prep School in New York when curriculum was developed based on individual learning style preferences.

Modality or perception is reported as one of the most important factors to consider when identifying learning style characteristics. Barbe notes that the most thoroughly investigated of the learning styles are those involving perception, the process most intimately associated with learning (1). According to Dunn and Carbo (13), many studies indicate achievement increases when students are taught through their perceptual preferences. Thies (29) reveals that the simple preference for perceptual modality involves the largest and most complex portion of brain functioning.

According to Dunn (10), a second-grade class of learning disabled students showed significant progress after being diagnosed to identify their learning styles and instruction was matched to the students' modality preferences. Carbo (4) concludes that the research indicates achievement increases when youngsters are taught according to their individual learning styles. Numerous studies that support increased achievement when instruction is matched to the learning needs of the student are cited by this researcher.

A review of the research findings reveals that no studies exist that explore the appropriateness of computer-assisted instruction to a student's learning style characteristics as identified by Dunn, Dunn, and Price (16). During a personal interview, Dunn (11) indicated that there was a need for a study of this nature.

The question becomes whether all students will learn faster with computer-assisted instruction or whether computer teaching will be more effective for students with specific learning characteristics. If there are varied degrees of effectiveness with certain kinds of learners, then which combination of learning style elements results in optimum achievement with computer-assisted instruction in math and reading? Additional knowledge is needed concerning the effectiveness of learning with the computer and the relationship of student achievement with learning style elements.

Definition of Terms

The following terms have restricted meaning and were thus defined for this study.

1. Computer refers to the Apple IIe microcomputer.

2. Computer-assisted instruction (CAI) refers to the *Milliken Math* or *Diascriptive Reading* software packages when used in pilot schools. CAI is reported in the review of the literature and means the use of a computer to provide instruction through the presentation or management of learning experiences by way of interactive dialogue.

3. Learning style elements refers to those elements identified by Dunn, Dunn, and Price (16) that are characteristics which affect learners in the learning process and have been categorized as (1) environment (sound, light, temperature, and design); (2) emotional (motivation, persistence, responsibility, and structure); (3) sociological (self, pair, peers, team, adult, or varied); and (4) physical (perceptual, intake, time, and mobility) (14).

4. Selected learning style elements refer to those elements that were selected for this study from the learning style elements as defined by Dunn, Dunn, and Price (14). Motivation, peers, self, and perception which includes visual, auditory, kinesthetic, and tactual are the selected learning style characteristics that were identified for examination in this study.

a. Motivation refers to the learning style element that identifies those students who are eager to learn or who desire to achieve academically. The motivated student demonstrates a sense of accomplishment from achieving (12).

b. Unmotivated students refers to those students who are usually unenthusiastic about learning.

c. Peers refers to the learning style element that indicates a student prefers to work with peers rather than working alone or with an adult.

d. Self refers to the learning style element that indicates a student prefers to work alone on new and difficult material.

e. Perception refers to the learning style element that identifies the modality: visual, auditory, kinesthetic, or tactual, which the student prefers to use for learning new and difficult information.

. Visual perception refers to the process of internalizing information by seeing.

. *Auditory perception* refers to the process of gaining knowledge by hearing.

. *Kinesthetic perception* refers to the use of the whole body for learning.

. *Tactual perception* refers to the use of the sense of touch for learning.

5. *The Iowa Tests of Basic Skills* (ITBS) refers to the instrument that was used for measuring achievement in reading and math. The ITBS are intended to provide objective information about skills performance that will constitute a partial basis for making instructional decisions for individual students (20).

6. *Conventional methods of instruction* refers to the most commonly observed strategies and materials including teacher-directed activities, textbooks, paper-pencil tasks, and other widely-used techniques.

Limitations

The experimental subjects in this study were limited to five pilot schools for computer-assisted instruction, thus preventing a random sample.

The sample size was limited in this study by the enrollment of the fourth-grade students in five pilot schools for computer-assisted instruction, thus limiting the generalizability of the results to one school district.

In this study, seven learning style elements were selected for examination from the twenty-four identified by Dunn, Dunn, and Price (16). The sample size of approximately 380 subjects did not justify studying all twenty-four elements identified by the *Learning Style Inventory* (LSI).

Assumptions

It was assumed that the students reflected their preference for learning when taking the LSI.

It was assumed that the students performed to the best of their ability on the pretest and posttest measurements.

Summary

In this chapter, studies are reviewed which indicate that computers are being used as effective tools for instruction. Other research findings indicate that achievement increases when students are taught according to their individual learning styles. The problem was to assess the effectiveness of computer instruction in reading and math and to determine the relationship between achievement of students using computer-assisted instruction in reading and math and selected learning style elements of students. Specific purposes, hypotheses, limitations, and assumptions of the study are also presented. In addition, the terms which are unique to the study are briefly defined.

CHAPTER BIBLIOGRAPHY

1. Barbe, Walter B. and Michael N. Milone, Jr., "What We Know About Modality Strengths," Educational Leadership, XXXVIII (February, 1981), 378-380.

2. Canfield, Albert A., "Learning Styles: Whither Thou Goest?," Learning Styles Network Newsletter, IV (Summer, 1983), 4.

3. Carbo, Marie, "Reading Styles Change Between Second and Eighth Grade," Educational Leadership, XL (February, 1983), 56-59.

4. ___________, "Reading Styles: Key to Preventing Reading Failure," Student Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

5. Carruth, Ronald E., "An Alternative; Not a Solution," Phi Delta Kappan, LVIII (February, 1977), 455.

6. Cavanaugh, David P., "Student Learning Styles: A Diagnostic/Prescriptive Approach to Instruction," Phi Delta Kappan, LXIII (November, 1981), 202-203.

7. Deringer, Dorothy K., "The New Federalism: A Do-It-Yourself Approach to Computers in Education," T.H.E. Journal, IX (May, 1982), 90-94.

8. Dunn, Kenneth, "Madison Prep: Alternative to Teenage Disaster," Educational Leadership, XXXVIII (February, 1981), 386-387.

9. Dunn, Rita, "Coming to Grips with Misconceptions: Who is Most Alert in the Morning," Learning Styles Network Newsletter, IV (Summer, 1983), 2.

10. _________, "Learning Styles," Educational Leadership, XXXVIII (May, 1981), 663.

11. _________, St. John's University, New York City, New York, Interview held in Dallas, Texas, June, 1983.

12. _________, "You've Got Style," Early Years, XIII (January, 1983), 25-27.

13. __________ and Marie Carbo, "Modalities: An Open Letter to Walter Barbe, Michael Milone, and Raymond Swassing," Educational Leadership, XXXVIII (February, 1981), 381-382.

14. __________ and Kenneth Dunn, Teaching Students Through Their Individual Learning Styles: A Practical Approach, Reston Publishing Company, Inc., Reston, Virginia, 1978.

15. ________________________, and Gary E. Price, "Diagnosing Learning Styles: A Prescription for Avoiding Malpractice Suits," Phi Delta Kappan, LVIII (January, 1977), 418-420.

16. ________________________, and ____________, Learning Style Inventory Manual, Price Systems, Inc., Lawrence, Kansas, 1981, 2-3.

17. Estes, Nolan, "Dallas at the Forefront," Phi Delta Kappan, LVIII (February, 1977), 456.

18. Fantini, Mario D., "Comprehensive, Timely, Feasible," Phi Delta Kappan, LVIII (February, 1977), 459.

19. Goodlad, John I., "An Array of Education Agencies," Phi Delta Kappan, LVIII (February, 1977), 454-455.

20. Hieronymus, A. N. and others, The Iowa Tests of Basic Skills Teachers Guide, University of Iowa at Iowa City, 1979.

21. Howe, Harold, II, "Computers: The New Kick in the Schools," The College Board Review, CXXVIII (Summer, 1983), 24-31.

22. Keefe, James W., "Learning Style: An Overview," Student Learning Styles: Diagnosing and Prescribing Programs, National Association of Secondary School Principals, Reston, Virginia, 1979, 1-17.

23. Melmed, Arthur S., "Productivity and Technology in Education," Educational Leadership, XL (February, 1983), 4-6.

24. Offerman, Donald H., "TAEDS Promotes Computer Literacy," Texas Lone Star, I (February, 1983), 14.

25. Papert, Seymour, "Society Will Balk, But the Future May Demand a Computer for Each Child," Electronic Education, I (December, 1981), 5-6, 31.

26. Schmeck, Ronald R., "Improving Learning by Improving Thinking," _Educational Leadership_, XXXVIII (February, 1981), 384-385.

27. Shane, Harold G., "The Silicon Age and Education," _Phi Delta Kappan_, LXIII (January, 1982), 303-308.

28. Sullivan, Janet, "Design Can Turn Micros Into Maxis," _Electronic Education_, I (December, 1981), 20-21.

29. Thies, Armin P., "A Brain Behavior Analysis of Learning Styles," _Student Learning Styles: Diagnosing and Prescribing Programs_, National Association of Secondary School Principals, Reston, Virginia, 1979.

30. Tyack, David B., "Educational Moonshot?," _Phi Delta Kappan_, LVIII (February, 1977), 457-458.

31. Von Feldt, James B., "An Introduction to Computer Applications in Support of Education," ED 160 044, (August, 1977).

32. White, Mary Alice, "Synthesis of Research on Electronic Learning," _Educational Leadership_, XL (May, 1983), 13-15.

CHAPTER II

REVIEW OF RELATED LITERATURE

In this chapter various research studies and other pertinent literature related to the effectiveness of computer-assisted instruction (CAI) and student learning styles are presented. Since these two areas of study are relatively new, long-term research is limited; however, many publications of recent years are included. The purpose of this review is to show the current "state of the art" and to provide a basis for the theoretical formulation tested in this study. Studies and statements concerning the effectiveness of computer-assisted instruction are presented first. The second part of this review deals with learning styles of students. Various learning characteristics are described and studies are reported that reveal the impact of student achievement when learning styles are considered for instruction. An explication of the theoretical position of this study based on a synthesis of previous research and current thinking concludes this chapter.

The Effectiveness of Computer-Assisted Instruction

Educational Impacts

The purpose of this search of related literature is to determine the past effects of CAI and to report the positions expressed by educators and other members of society. Shane challenged educators to develop an understanding of the new life patterns and interactions of school, thinking, global awareness, concepts of power, and political priorities (60). With this awareness and understanding, the microprocessor is likely to encourage a number of desirable changes and innovations in the overall scope of school. The computer has the potential for improving communications, for more rapid problem identification, and for more effective problem solving that will assist professionals in the preparation of students for coping in society.

The computers will impact the schools by providing individualized instruction during the time a student spends at a computer terminal. Callison (6) reports that the student benefits from immediate feedback, small, well-defined units of instruction, diagnostic and prescriptive lessons, a multisensory format, and a variety of instructional approaches. Callison further notes that it is advantageous for students to be expected to acquire competencies that are defined in learning outcomes. Each objective must be achieved before moving onto more complex material.

According to Melmed, new demands are placed on educators to produce workers with greater knowledge of science and technology and with thinking skills to make the best use of constantly developing information technologies. Melmed further concludes that the new information technology creates not only new educational needs but also new and relatively inexpensive ways to meet these needs. The combination of new knowledge from research in cognitive science and the revolution in low-cost information technology could significantly improve the quality of education, thereby increasing human capital and improving productivity. Melmed adds that advances in cognitive science will contribute to the understanding of human intellectual processes, such as comprehension and problem solving. This understanding will allow better design of instruction, testing, and matching of teaching to the background of students. By using new information technology, students can be kept actively engaged in learning for sustained periods of time, teaching can be adjusted to the rate and learning style of the individual student, and a wide variety of direct problem-solving experiences can be provided through simulations and modeling (53).

Papert (56) agrees that the computer has tremendous potential for improving the process of learning. According to Papert, the new technology leads to a global, holistic rethinking of education; of how and where it happens, and of what is learned by whom. Papert further notes that the computer offers the possibility of broadening the definition of education to include the learning society.

Papert reports that at the Massachusetts Institute of Technology (MIT) studies were conducted concerning ways in which the process of learning and intellectual development could be enhanced by the computer. These studies concluded that children of elementary ages were able to use computer concepts and to understand processes of learning and logic. The children in these studies were observed to be using psychological ideas that would normally be considered too abstract and sophisticated for students of this young age. This research included observations of how these children were able to acquire an articulate approach to the process of learning by taking the computer as a simplified model of certain aspects of their own minds. This observed process leads to not only great improvements in the basic skills, but also in children's images of themselves as intellectual agents, and the improvement of self-image leads to improvement in learning. Papert (56) concludes that the computer can be a cornerstone of a new learning society if society embraces the fact that the computer offers some radically new possibilities for its truly becoming a learning society.

Von Feldt notes that early uses of the computer for instruction tended to focus primarily on computer-assisted instruction due to the trend toward individualization and accountability. Work in CAI continues to focus on decision models and strategies which use the learner's past performance for choosing new materials to optimize learning through drill and practice. There is some disagreement among educators concerning the effectiveness of programmer-controlled materials versus learner-controlled programs. Programmer-prepared materials use computerized decision models that usually require relatively large amounts of diagnostic testing in order to decide what to present next. Learner-controlled techniques use prepared materials; however, the student is permitted to select the lessons, the level of explanation, and control the pace of presentation. Von Feldt (64) concludes that quality control is critical to the validity and effectiveness of any unit of instruction regardless of the chosen technique or strategy.

Increased applications are being developed for the use of the computer as an instructional tool in a variety of disciplines. In mathematics, computer programs or algorithms may be accepted in the same way as mathematical proofs. The fields of artificial intelligence, algorithmic problem solving, and cognitive learning are all converging to influence instructional pedagogy and computer applications in education (64).

A number of interactive dialogues using a computer terminal which has special graphic display characteristics have been developed at the University of California at Irvine. These dialogues are used to teach physics. The programs provide the student with assistance for problem solving, or the student may query the computer in natural language for reasonable approaches to a particular problem. The graphics are designed to help the student understand visual concepts and assist in developing problem-solving skills (64).

Von Feldt (64) further reports that the Huntington Computer Simulation Materials were designed to support high school curricula in biology, physics, and the social sciences. In biology, the student conducts genetic experiments and observes the simulated nature of Mendel's law. In physics, the student learns to operate a nuclear reactor, and social science simulations allow the students to treat the growth and development of an urban area.

Simulation permits students to manipulate ideas, materials, or situations which would not be available due to cost, danger, or other restrictions.

The Education Management Information System (EMIS), developed at the New York Institution of Technology, is an example of drill and practice through problem solving combined with management of student data. This system has addressed the mathematics, physics, and English curriculum by allowing instructors to adapt units to student needs (63).

The Seattle Public Schools have reported success in individualizing instruction and administering the program through a comprehensive computer learning management system (LMS). This system was designed for elementary and secondary levels; however, it has been expanded for community college and university students. Curriculum, teacher training, student needs, and parent needs are being serviced through the LMS (63).

According to Von Feldt (63), the Stanford drill and practice programs in mathematics and reading for elementary school children have been recognized on a national level. The uses of audio and natural language processing in computer-assisted instruction are the subjects of research at this university.

Von Feldt (63) concludes that a significant increase in the number of computers being used for instruction has occurred in recent years, thus affecting all levels of education in public and private schools. The primary implementation has been directed at increased productivity, meeting individual student needs, and increasing the quality of instruction. Von Feldt believes that the question is not focused upon the effectiveness of the media CAI, but upon the effectiveness of specific curricula designed and developed for the computer.

Effects on Achievement

To determine the effectiveness of computer-assisted instruction, the Chicago School System placed a CAI Univac 418-III system in twenty-one schools during the 1970's to teach reading, language arts, and math. The drill and practice strands of the Computer Curriculum Corporation were used for instructing students who qualified under the Elementary and Secondary Education Act Title I guidelines for compensatory education. All students were achieving at least one year below grade level and many students were at least one year and five months (1.5) below grade level in reading. After being instructed with the computer for eight months, the students showed a gain of approximately one year and one month (1.1) in reading achievement rather than the national average of five months for compensatory students (46).

A study was conducted at the Log Cabin Elementary School in Jackson County, North Carolina, of fourth, fifth, and sixth grade students in the area of mathematics. Students who were in the lower forty-five percent of a class in mathematics achievement were scheduled for ten minutes per day of computer instruction. The upper fifty-five percent of the students were given instruction with the computer for ten minutes per week. Analysis of the data revealed that both categories of students showed higher achievement; however, the lower group had greater gains than those students in the upper part of the class. The _Iowa Tests of Basic Skills_ were used for measuring achievement (17).

The Fort Worth Independent School District, Fort Worth, Texas, implemented a CAI program in eight elementary schools and four middle schools. The drill and practice program focused on reading and mathematics skills using a computerized curriculum developed by Computer Curriculum Corporation. Students who qualified as being educationally disadvantaged under the Title I guidelines in grades three through seven were provided with ten minutes of computer practice daily. Lysiak reports that students in all grades made at least a month gain per month of instruction by using the computer for learning. Middle school students being taught with the computer made significantly higher standardized test gains than did the control group of students who did not receive computer instruction. Elementary students made more gain in the area of mathematics than reading. Elementary teacher responses to questionnaires indicated that the teachers perceived CAI as beneficial to student achievement; however, middle school teachers were less positive but moderately supportive (47).

Computer-assisted instruction was provided by the Los Angeles County Superintendent to fourteen school districts as a means of improving students' math achievement and to assist teachers in managing diagnostic and prescriptive information. The California Test of Basic Skills (CTBS) and the California Arithmetic Test (CAT) were administered before and after instruction to both experimental and control groups. In general, the results indicated that the mean post-test scores for the experimental groups exceeded those of the control groups. A higher percentage of experimental group students as compared to control group students exceeded their expected growth rates for the period of study, and the students receiving CAI drill and practice experienced growth rates substantially beyond normal expectations. Control group students performed better on tests of reasoning ability; however, the CAI did not stress that skill. It was concluded that this program promoted student learning, reduced the teachers' remedial work, and aided in diagnosis and prescription of student academic needs (55).

According to Grocke, computer-based reading programs have been used at the City Educational Clinic in Canberra, Australia, to improve the reading skills of children who are identified as learning disabled. Children interacted with the computer via a graphic display, touch sensitive screen, and synthesized speech. The first program taught a basic sight vocabulary and allowed children to construct sentences from word lists. A modified cloze procedure in which the child chose the missing word in a paragraph from a number of alternatives presented was used in the second program. If the child could not read a word in the displayed paragraph, the audio component of the computer reproduced the word. Spoken or visual feedback was given to all student responses. Evaluation studies indicated significant gains in sight vocabulary and reading comprehension scores after four to five hours of computer-based instruction (34).

Another study was designed to determine the effects of providing special education teachers with computer programs to assist in developing appropriate math education programs for students. The experiment demonstrated that math learning could be accelerated; however, the study did not address whether the accelerated rate could be maintained (9).

In the 1982-83 school year, microcomputers were introduced into the primary school program in the Central School District, Mahopac, New York. Students at all three grade levels in this 5,000 student district demonstrated mastery of objectives faster than anticipated. This acceleration of learning was reported at all ability levels and in students who had learning or emotional problems. It was noted that CAI is best viewed as a supplement to traditional instruction (12).

The Association for Supervision and Curriculum Update reports that early results from the first year of a new computer-based reading and writing program, Writing to Read, show that after six months, sixty percent of kindergarten children and ninety-two percent of first graders could independently write sentences. Mean class scores on standardized reading tests for thousands of kindergarten children ranged from the 72nd percentile to above the 90th percentile. The program is being tested with more than

8,000 students in twenty-two school districts in nine states. The students work in pairs with the computer for twelve minutes per day and use electric typewriters, hear and see stories at a listening center, play word building games, and do a variety of multisensory activities. These findings were reported in an independent evaluation project that was conducted by the Educational Testing Service of Princeton, New Jersey (4).

Kulik, Bangert, and Williams (45) investigated the literature for effectiveness of computer-assisted instruction. These reviewers found two basic types of research appearing in the literature. One type, the box-score reviews, usually reported the proportion of studies favorable and unfavorable toward computer-based instruction and often provided narrative comments about the studies. Another method using Glass's meta-analysis took a more quantitative approach. Meta-analysis used objective procedures to locate studies, quantitative or quasi-quantitative techniques to describe study features and outcomes, and statistical procedures to summarize findings and explore relationships.

According to Kulik (44), the first systematic reviews designed to integrate findings from the various evaluation studies concluded that computer-based instruction is effective in raising student achievement especially when it is used to supplement regular instruction in elementary schools. Later reviewers using meta-analysis reported findings on mathematics in the elementary and secondary schools. This researcher noted that the average effect of computer-based instruction was to increase student achievement from the 50th percentile to the 66th percentile.

Fifty-one studies concerning computer-based instruction were reviewed by Kulik, Bangert, and Williams (45) using the meta-analysis method. It was found that in more than eighty percent of the studies, students with computer-based instruction received better scores than did students from the control group. In more than ninety percent of twenty-five studies it was reported that significant increases in achievement occurred. These reviewers found that the literature indicated that instruction with the computer saved from thirty-nine percent to eighty-eight percent of student learning time. It was concluded that the trend of more recent studies produce stronger results; thus, it seems likely that instructional technology has been used more appropriately in recent years (44).

Saracho (59) reports that a study was conducted to investigate the effects of computer-assisted instruction on basic skills achievement of Spanish-speaking migrant children. Two comparable groups of third, fourth, fifth, and sixth grade, Spanish-speaking migrant students served as subjects of this research. One group used CAI to supplement instruction while the second group functioned as a control. The academic achievement gains were compared. Two hundred fifty-six (256) children were administered the Comprehensive Tests of Basic Skills (CTBS) as a pre-test during March of one year and a post-test in March the following year. The CTBS post-test scores for reading, language, and mathematics were analyzed by means of a multivariate analysis of covariance, as well as separately using an analysis of covariance, with the appropriate CTBS pre-test variable as a covariate in each analysis. The results indicated that students who were taught with the Computer Curriculum Corporation (CCC) instructional program had greater achievement gains than did students who participated in the regular classroom program.

Saracho (59, p. 202) states that "CAI is one of the leading instructional techniques available to individualize instruction." The computer can analyze students' responses, scores, and work, as well as update their records on a regular basis. Children are required to use their tactile skills when interacting with the computer. Therefore, this researcher concludes that the use of CAI as a supplement to the regular classroom program can improve achievement in reading, language, and mathematics for Spanish-speaking migrant children. It was added that this difference probably resulted from individualized instruction, active participation, analysis of student responses, and instant feedback to the student (59). According to Bracey, students learn more, retain more, or learn the same amount faster by using computers for instruction (3).

Effects on Motivation

Many educators have shown an interest in using the computer as a tool for motivation. It was reported by Papert (57) that computers will permit children to learn by testing hypotheses and exploring concepts at an early age. Papert further notes that young children will become friends with numbers after having an experience with the computer that allows the child to master clearly-defined mathematical skills. According to Carrier, "the capacity of computer-based activity to stimulate and motivate has always been heralded as a highly positive attribute" (11, p. 22). Swenson and Anderson indicate that the "most important function of reinforcement in a CAI program is a motivational one" (62, p. 137).

Blakeway (2) reports that a computer program was developed that consisted of problem sets, student checking capability, and student testing. Topics in this software included addition of non-negative integers, coordinate geometry, binomial expansion, and other upper-level subjects. It was observed that even reluctant learners were motivated to use the computer to receive instruction. As previously cited, Grocke (34) reported that a program which was designed to provide student motivation through immediate feedback was used for teaching disabled students to read. Reports from classroom teachers indicated that the program improved self-confidence and interest in reading for many children.

In a study of primary school children in Mahopac, New York, that was previously cited, it was noted that some students preferred specific, directed learning experiences while other students preferred to experiment with the computer. Also, it was observed that students at all grade levels tended to ask other students for help and appeared to prefer assistance of another student to that of a teacher. Pupils in grades two and three preferred to work with the computer independently, rather than in pairs or groups. Time on task seemed to increase as the students worked with the computers. Also, it was indicated that the third-grade students seemed to be able to carry-over skills in the regular classroom; however, this was not found with first-grade students. Students in first grade who had been medically diagnosed as hyperactive engaged themselves attentively while working with the computers (12).

According to Hopmeier, a personality study revealed that computer-assisted instruction programs favor those students who concentrate on details, memorize facts, and stay with a task until it is completed. The Myers-Briggs Type Indicator which identifies personality preferences in four opposite pairs (introvert/extrovert, thinking/feeling, sensing/intuition, and judgmental/perception) was used to determine the introvert personality as defined in this study (37). Lysiak (47), as reported earlier, notes that student responses to questionnaires indicated that the students perceived CAI drill and practice as personally beneficial and an enjoyable activity. In another study previously cited, Saracho found that Spanish-speaking migrant children consistently report that they enjoy the ability to move at their own pace and appreciate the lack of embarrassment about mistakes (59).

Studies in the area of human learning have repeatedly demonstrated that the best teaching methods are those that rely most heavily on positive techniques to motivate people. Since motivation has been identified as a critical component in learning, knowledge about motivation should be applied to one of the newest and most promising forms of education, computer-assisted instruction (62). Swenson and Anderson further note that in order to affect motivation, the role of reinforcement must be individualized, timing of reinforcement must be addressed, and appropriateness of reinforcement must be considered.

Effects on Instructional Techniques

Educators have recently become increasingly interested in understanding how individual differences affect the instructional process. The process of thinking about student differences systematically and in relation to characteristics of the instruction to be delivered is a relatively recent phenomenon. The basic premise of this research is that people who differ with respect to a particular characteristic such as an aptitude, a personality variable, or a preference may learn better from alternative instructional methods, delivery systems, or strategies. According to Carrier, the computer has the potential to accommodate individual needs in the areas of performance pacing, student differences concerning prior knowledge of content, differences of student visual and verbal abilities, and various learner characteristics. Because the computer can manage individual progress, has branching capabilities, and can provide different kinds and amounts of informational feedback, software must be designed that is appropriate to the audience to be served (11).

A study concerning computer-based instruction and cognitive styles was reported by Cosky (14). The conclusion of this research indicated that cognitive styles of learners should be considered when programs are developed and could be matched to instructional strategies and assessment tools.

Hayes (35) notes that out of respect for different learning styles, the uses of the computer for instruction must become optional. Hayes further adds that the microcomputer is a powerful intellectual tool, and if it is used properly it can speed acquisition of basic skills, transform ways of thinking, develop new metaphors, and accelerate students toward synthesis, analysis, and evaluation of knowledge.

A study was conducted to investigate two computer-assisted instructional design formats and determine if there was a correlation between performance and individual learning style. Forty second-year medical students at the Rockford and Chicago campuses of the University of Illinois were randomly divided into an experimental group and a control group. Two different computer instructional design formats dealing with the same content were assigned to the subjects. The control group used a low feedback format while the experimental group used a high feedback format. Both groups were administered one of the lesson formats, a post-test, and a learning style inventory. The data were collected and the results were analyzed by using analysis of variance and the Spearman correlation coefficient. Findings indicated that there were no significant differences in performance as a result of the instructional design format; however, significant differences were reported in some areas as a result of learning style. These findings tend to suggest that active learners, student-oriented learners, and individual study-oriented learners would perform better utilizing the high feedback format approach. Magero (48) concluded that the study recommends that learning style should be considered when designing instructional strategies.

As courseware is being developed for computer-assisted instruction, the human information processing abilities are being considered. Wilde (67) suggests that the issue of cognitive style deserves further consideration as educators consider CAI. Jay (40) agrees by translating cognitive research into guidelines for designing and evaluating computer courseware. Jay recommends that teachers be trained in human psychology, that research be conducted on learning processes, that instructional materials be field-tested with students, that desired outcomes be matched with teaching strategies, and that researchers be prepared to prove the outcomes were obtained.

Even though widespread use of the computer for instruction has mushroomed in the last few years, there seems to be agreement among educators and professionals who are interested in the process of learning that computers will impact education. The literature suggests that the computer cannot be compared to other audio-visual media since the computer allows for interaction by the learner, thus increasing its functions. The National Science Foundation sponsored a series of studies during the sixties utilizing the Plato program. After examining the test data, the following conclusions were stated.

- CAI absorbs the interest of students of all ages.
- Feedback of the information provided by the computer can be applied not only to the learning processes of the student, but to the teaching process of the teacher as well.
- CAI lessons can be easily modified for other applications.
- CAI is a plausible way to individualize instruction in a wide array of subject material areas (63, p. 4).

Summary

CAI affects the way students think and learn, provides an expansion of instructional experiences in a variety of disciplines, and utilizes a teaching tool that increases educational productivity and effectiveness. It has been found that students make significant gains in achievement at an accelerated pace when using the computer for instruction. The computer is believed to play an important role in student motivation as immediate feedback, reinforcement, and interaction with the learner is provided. As educators become increasingly interested in understanding how individuals learn, the computer allows a systematic approach to education where instructional strategies are developed and matched to the learner characteristics. The effects of technology on educational practices, student achievement, motivation, and instructional techniques have been reported as a powerful force that will impact learning for students and become a challenge for educators.

In order to provide educators with adequate data to make educationally sound decisions, it will be necessary to replicate research studies concerning computer-assisted instruction. Since changes in technology are occurring at a rapid pace, educators must have access to current practices and outcomes. The potential for the effectiveness of instruction with computers is limited by the appropriateness of its use; therefore, much information is needed to make these choices. Since society has the responsibility for preparing boys and girls to function in a technological environment by providing quality education based on tested practice, continued research is essential.

Learning Styles

Theories

Much research concerning learning styles and brain behavior is being conducted. The efforts of these studies, as stated by Gregorc (32), have the potential of providing a framework of knowledge and a realm of psychology which will help to promote the development of the holistic human being. Learning styles are cognitive, affective, and physiological traits that characterize how learners typically learn best. Educators have the responsibility to utilize and replicate the current research findings to provide learners with more effective ways to learn. Each person is unique; therefore, more understanding about the learning process and learning styles will enable educators to match appropriate strategies and experiences to individual students. According to Keefe (42), the fields of brain behavior research and learning constitute a significant cutting edge of contemporary efforts to create a more personalized and effective system of education.

The literature reveals that while research is being conducted in the area of learner characteristics, the researchers may approach the study differently. Keefe, coordinator of research for the National Association of

Secondary School Principals (NASSP), represented a philosophy concerning learning styles by stating:

> Learning style is much more than just another innovation. It is a fundamental new tool with which to work. It is a new way of looking at learning and instruction, a deeper and more profound view of the learner than known previously. It is a basic framework upon which a theory and practice of instruction can be built. It makes obsolete any single framework for teaching all students. All recent innovations, whether staff utilization, modular schedulings, independent study, or fundamental education, must be rethought in the light of learning style. It is nothing less than revolutionary to base instructional planning on an analysis of each student's traits (43, p. 131).

Davidman notes that contributors agree that practical knowledge about the diagnosis and application of learning style is available; however, authors disagree regarding the nature of that practical knowledge (15). The Dunn, Dunn, and Price (25) strategy employs a statistical analysis of the opinions a student expresses on a questionnaire to identify student learning styles and the subsequent learning environment. However, Hunt (39) believes that the teacher's experience and classroom observation are the prevailing factors. The differences among definitions of learning styles are less important than how the theory of matching relates to teaching. Hunt adds that the conceptual level theory serves as a guide to practice; therefore, learning styles and corresponding matching models provide an excellent opportunity to develop an appropriate, reciprocal relation between psychological theory and educational practice.

Davidman (15) further raises the question concerning the reliability of students being able to identify their own learning styles. However, Dunn, Dunn, and Price (27) indicate that several well-designed and carefully conducted studies verify that students are capable of accurately reporting the ways in which maximum achievement is acquired. Dunn (20) stresses that after testing more than 175,000 students in grades three through twelve, it was determined that most students not only can tell how they learn but are eager to share their preferences.

According to Davis and Schwimmer, learning style consists of processing systems and input/output factors. The process model determines what learners do with content, how content is organized, how present content is related to past content, and what kind of new connection is made. Davis and Schwimmer further add that learning styles must be identified as a whole rather than small parts. Learning style should not be considered "good" or "bad," but the thinking style of students must be defined as the way individual students organize their world (15).

Fischer and Fischer (31) report that learning style refers to a pervasive quality in the behavior of an individual, a quality that persists though the content may change. These authors identified nine learning styles; the incremental learner who systematically adds information in order to comprehend the concept or the big picture, the intuitive learner who leaps unsystematically in various directions to sudden insights, the sensory specialist whose sense tends to dominate in learning, the emotionally involved whose atmosphere is emotionally charged, the emotionally neutral who remains in "low-key" emotional status, the explicitly structured who requires clear directions, goals, and limits, the open-ended structured who needs to have exploration available, the damaged learner who needs special attention, and the eclectic learner who requires a shift in learning experiences.

Another view is presented by Gregorc (33) who defines learning style as distinctive behaviors which serve as indicators of how a person learns from and adapts to the environment, giving clues as to how one's mind operates. Patterns of adapting to environments are apparently available to each individual through the genetic coding system, environment, and culture. Gregorc concludes that research reveals that learning style appears to be both nature and nurture.

The applications and implications of education tend to vary according to philosophies concerning learning styles. Hopkins notes that diagnosticians have been able to discover what a child knows and at what level of understanding the student is performing; however, there is no indication of how the youngster learns. Hopkins adds that the purpose of diagnosis is to provide information that is essential to the formulation of instructional programs designed to meet specific needs of an individual student. This author encourages the use of on-going records that address appropriate group size for the child to function most effectively, which of the senses the student prefers to use when learning new materials, and what methods of teaching have proved most successful for maximum learning (36).

Dunn further notes that each student's learning style should be identified as early as possible and banks of multisensory instructional resources should be established and made available for teachers to use. Also, it was suggested that teachers should be taught to respond to several different learning styles by providing appropriate instruction after the learning style has been identified. Dunn concludes that faculty evaluations should address how teachers respond to learning styles and should reward teachers who effectively match instruction to learner characteristics (21).

Schmeck and Lockhart (60) also note that the school environment should be adapted to meet the specific needs of students. In a discussion of the introverted and extroverted personalities of students, it was suggested that both a quiet and stimulating learning environment be provided. Because it takes very little stimulation for introverts to perceive a stimulus, their brains become easily overstimulated. Therefore, these introverted students might need to be sheltered at times from other students and activities to provide quiet learning. Extroverts require strong stimulation to perceive a stimulus and tend to prefer environments that provide relatively large amounts of stimulation. The extroverted child should profit from multimedia presentations, group discussions, and frequent changes of topics. These researchers conclude that introversion-extroversion is a continuum; therefore, it is a challenge to educators to provide a proper level of stimulation for both the students and the teacher.

Instruments

Closely related to the various theories of learning style is the variety of instruments designed to measure learning characteristics. Dunn, Dunn, and Price agree that the kinds of decisions concerning instructional choices should relate to student learning style. "The *Learning*

Style Inventory (LSI) was developed in response to the need for identifying how students prefer to learn when provided with an opportunity to choose from among environmental, sociological, and physical conditions" (29, p. 155).

Dunn, Dunn, and Price (27) defend the Learning Style Inventory (LSI) by concluding that diagnosis of an individual's learning style is important and can provide the foundation for the teacher to build learning environments designed to meet the needs of individuals.

It was found by Weinberg that a comparison between the Kirby Modality Index scores and the Learning Style Inventory revealed a positive correlation between subjects' demonstrated abilities to perform tasks and their modality preferences, thus, further corroborating that a preference and a strength are synonymous (65).

Dunn and others reported that in addition to those models previously discussed, Canfield and Lafferty promote a Learning Style Inventory that is a self-report instrument with emphasis on attitudinal and affective dimensions primarily used for counseling. Hill designed a Cognitive Style Interest Inventory that allows for Cognitive Style Mapping which identifies student strengths and weaknesses. This technique utilizes varied instructional modes to match students and the educational task. It is reported that Kolb places emphasis on individual awareness of personal learning style and available alternative modes by using a self-report _Learning Style Inventory_. Ramirez and Castaneda developed the _Child Rating Form_ that is a direct observation checklist which identifies student cognitive style. Schmeck designed the _Inventory of Learning Processes_ that is a self-report inventory which identifies information processing activities (28).

Meaney (52) conducted a study to investigate the relationship between two modes of instruction based on Hill's model of _Educational Cognitive Style_. Four college-level classes were divided into two instructional methods. One group consisted of thirty-six students whose instructional program was based on an interpretation of the _Educational Cognitive Style Map_ plus empirical procedures. The other group consisted of thirty-six students whose educational program was based solely on an interpretation of the _Educational Cognitive Map_. The subject matter area involved the production of a slide/tape presentation by each student. A pre-test was given each subject to determine prior knowledge of the subject and a post-test was administered after the six-week study period. The slide/tape productions were graded by independent raters. An analysis of covariance and a factorial analysis of covariance were performed, and it was determined that there were no significant differences in student achievement between instructional method, sex of student, or learning style. The findings in this study indicated that the Educational Cognitive Style Map, by itself, was effective in prescribing an educational program.

Motivation

The literature reveals that motivation has been identified as a critical component for learning. Dunn and Dunn conclude that motivation increases as children are able to make choices, function through their learning style, form social-learning groups, and at times test and evaluate their progress (23). Dunn and Dunn reported in another publication that data revealed that when taught through methods that complemented individual learning characteristics, students at all levels became increasingly motivated and achieved better academically (24).

Cody (13) found in a study that average students were less motivated than gifted and highly gifted students, while gifted students were most motivated. Dunn adds that motivation is linked to achievement: the higher the individual's achievement, the more motivated the student becomes. According to Dunn, motivation is also linked to a match of the student's learning style, thus changing from teacher to teacher and from class to class. Motivated students appreciate feedback and deserved praise after tasks have been accomplished. Unmotivated students require short assignments with very few objectives, frequent feedback, much supervision, and genuine praise while working (19).

Carbo (8) concludes that most students enter school with high motivation to read; however, this motivation seems to progressively decrease with years in school. According to Carbo, educators must continue to research and experiment with a variety of techniques for matching instruction to individual reading styles.

Students in primary grades were found to be teacher-motivated, but intermediate and junior high students tended not to be teacher-motivated. Dunn, Dunn, and Price (26) reported that students with low reading achievement were unmotivated; however, high achieving students were found to be self-motivated.

Modality

Barbe and Milone (1) note that modality is the process most intimately associated with learning and the most thoroughly investigated learning styles are those involving perception. Barbe and Milone identified modalities as being vision, audition, and kinesthesia. Finally, Barbe and Milone conclude that the channels most efficient for processing information are modality strengths, not preferences. A modality strength implies superior functioning measured by assessment of tasks. Students vary with respect to modality strengths, while the most frequent modality strength is visual or mixed.

According to Barbe and Milone (1), modality strength is not a fixed characteristic but changes with age. Preschool children are found to be more auditory than visual and least kinesthetic. However, between kindergarten and six years of age a modality shift occurs in children, and vision becomes dominant, with kinesthetic overtaking auditory. Modalities become more integrated with age, having more mixed strengths in adults.

Also, it was determined that being able to transfer information from one perception to another accounts for success in reading. The findings reveal that there are no clear differences in modality of boys and girls, right and left handedness could not be related to modality, race and modality were independent, and there was interaction between student and teacher modality strengths (1).

Dunn and Carbo conclude that it is important to understand that new knowledge is being explored concerning how children absorb and retain information and skills. Dunn and Carbo further believe that educators should initially teach children in their perceptual strength, reinforce with the second strength, and then practice with the third strength. The findings reveal that vision is the dominant strength while auditory learning increases after the fourth or fifth grades. The younger child tends to be more tactual/kinesthetic (22).

In another study, Carbo (8) found that perception appears to be the learning style element of greatest importance for most youngsters in the area of reading. Carbo reports that research has demonstrated that performance is strongly related to perceptual abilities and that good readers prefer to learn through their visual and auditory modalities, whereas poor readers prefer learning tactually and kinesthetically.

Weinberg identified the perceptual strengths of third-grade students who were underachievers in arithmetic. Sixty-nine children with either high auditory, high visual, or low auditory and low visual modalities were assigned randomly to treatment groups. These groups were taught a subtraction unit through instructional materials that either complemented or were dissonant from their revealed preferences. A standardized achievement test assessed performance differences between pre-test and post-test scores. The results of the Duncan multiple comparison test evidenced that each group of students performed significantly better when taught through complementary strategies. Low auditory/low visual youngsters achieved only when taught tactually (65).

Effects of Matched Instruction

Carbo found that when reading treatments were matched to perceptual learning styles, higher reading scores resulted. A second-grade class of learning disabled students was diagnosed to identify their learning styles. The sixteen students were taught new words by introducing them through each student's strongest modality and reinforcing the words through multisensory alternative modalities. Achievement was compared to the previous year when the students were instructed by the conventional program, and significant progress was reported. It was concluded that auditory students learned best with phonics instruction, while visual students learned best through word recognition methods. Children with neither auditory or visual strengths learned only through tactual/visual treatment; however, it was projected that these students might have made more achievement gains with tactual/kinesthetic or multisensory approaches (7).

As previously cited, Weinberg found that students performed significantly better when taught through strategies that complemented perceptual strengths. In addition, it was concluded that this research demonstrated that no single approach to teaching is effective for all students; therefore, matching methods and materials to individual characteristics is essential if all students are to perform well academically.

Wheeler (66) conducted a study of fifteen second-grade students in New York City. These students, who were reading at least two years below grade level, were tested to identify the strongest functioning modality for each child. The _Frostig Test of Visual Perception_, the _Motor-Free Visual Perception Test_, and the _Wepman Test of Auditory Discrimination_ were administered to establish individual perception abilities. Each youngster was taught ten randomly selected words through three different instructional methods, each emphasizing a different sensory mode. A split-plot factorial design was used to analyze the data to permit subjects to experience each of the three methods; thus, every student's scores were compared to determine the relative efficiency of the three reading approaches. No significant differences were evidenced between instructional methods and perceptual strengths; however, those results corroborate other studies that report no single method is more or less effective for all students. The students increased their performance at a statistically significant level when their perceptual strengths were matched with complementary sensory approaches to reading. These data corroborate other studies and suggest that students taught through their learning styles are likely to obtain greater achievement than those whose learning characteristics are not considered. Comparison between the Wepman Auditory Discrimination Test scores and the Learning Style Inventory revealed a positive correlation between subjects' demonstrated ability to perform tasks of auditory perception and their performance to use that perceptual strength as the learning mode, further corroborating that a preference and a strength are synonymous (66).

Another study was conducted to determine whether instructional treatments specifically designed to match identifiable learner characteristics can produce significantly better learning than mismatched instruction. Instructional treatments for geometry were developed to match learning patterns of individual students, using field-dependence and field-independence as the learner traits. Eighty-nine suburban third-grade students were tested with the Children's Embedded Figures Tests and were classified as either field-dependent or field-independent. The students were randomly assigned to one of three treatment groups: instruction matched to field-independent cognitive style, instruction matched to field-dependent cognitive style, or no instruction. After the instruction had been completed, four criterion tests developed and validated by the researchers were administered to the students. The data were analyzed in a trait by treatment (2 x 3) factorial analysis of variance. The findings indicated that there was a successful matching of trait and treatment in comparison to the control group in three cases and in comparison to the opposite treatment in one case. Results were interpreted as providing partial support for the theory that matching learner traits and instructional treatments can produce learning gains (30).

Research focusing on the area of cognitive styles and relationship of cognitive styles to learning resources, media attributes, and the development of instructional materials was conducted by Research for Better Schools, Incorporated and was supported by a research grant from Control Data Corporation. The purpose of this research was to investigate certain aspects of a single cognitive style in relation to one learning resource, computer-based education. A field study was designed to investigate interactions between feedback treatments and field-independent/dependent cognitive style. Several hypotheses were tested regarding the error rate of field-independent and field-dependent individuals on maximum feedback, medium feedback, and no feedback treatments. The Group Embedded Figures Test (GEFT), which determines the individual's degree of field-independence or field-dependence, was given to all subjects in the study. To avoid content knowledge interference, an imaginary science system from Plato that had been used in previous studies was chosen as the basis for the computer-based education. Two lessons and accompanying quizzes in the imaginary science system were adapted for the study. Maximum, medium, and no feedback treatments were developed for each question in the lesson and the quizzes. The data from seventy-five subjects were treated by using an analysis of variance and a set of a priori contrasts. The findings of this field study have confirmed a significant difference in the performance of field-dependent and field-independent individuals on a set of scientifically-oriented instructional materials. Further, it was concluded that a maximum feedback treatment can be effective in equalizing the differences between field-dependent and field-independent individuals. Without the high level of feedback, field-dependent individuals made significantly more errors than their field-independent counterparts. These results strengthen the possibility of developing a more truly individualized computer-based education system in which the learning potential for individuals with various cognitive styles can be increased substantially (50).

In an examination of other studies, it was found that in Youngstown, Ohio, 420 students and 19 teachers were involved in the Learning Styles Project. The experiment focused on how children learn and how teachers teach. Faculty members in the experimental group were given staff development on learning styles and modality-specific instruction monthly. The control group teachers were not included in the in-service training sessions; however, they were required to provide complete data on their students. Reading improved for both groups, but youngsters in the experimental group evidenced greater improvement in the amount of reading that was completed (68).

The North Carolina Research Project was conducted with a fourth, fifth, and sixth grade elementary school to determine the extent to which teachers' classroom behavior would change after they were taught how to respond to student learning styles. A comparison of 1980-81 and 1981-82 data evidenced that teachers provided more resources to respond to heavily tactual/kinesthetic traits, students made more choices concerning their learning, students demonstrated increased learning, and students reported that their teacher cared more about them than previously (54).

The literature suggests that few people learn exactly the same way, thus having individual learning styles. A study was conducted in New York City with eighty-five elementary school students from three schools. Thirteen of the subjects were from grade three, and seventy-two subjects were from grade six. The students were given the New York State Pupil Evaluation Program (PEP) in Reading and the Learning Style Inventory by Dunn, Dunn, and Price (26). A stepwise discriminant analysis with reading achievement as the discriminant and the LSI variables serving as predictor variables was used. The statistical analysis was designed to determine which of the LSI variables discriminated significantly between individuals having high and low reading achievement. Eleven LSI variables accounted for significant differences between those subjects having high and low reading achievements, as measured by the New York State PEP test. It was found that individuals with high reading achievement preferred studying in a dimly lit, formal environment, were persistent and responsible, did not require intake while studying, did not function best in late morning, required mobility, and did not prefer to learn through their tactual and kinesthetic senses. In contrast, individuals with low reading achievement preferred a brightly lit, informal environment when studying, functioned best in late morning, did not require mobility, and preferred to learn through their tactual and kinesthetic senses. These researchers concluded that selected learning style characteristics could be used as predictors to identify early those students who are likely to become good readers; therefore, special attention and treatment could be applied to those who are predicted to have difficulties. Since students who were not high achievers in reading preferred learning through their tactual and kinesthetic senses, these students might become high reading achievers if taught through methods using these senses. It was further suggested that the academic achievement level and learning style be identified before teaching a student to read and prescription be made on the basis of these two essentials (58).

Kaley (41) conducted a study that supported other research which revealed that selected learning styles tend to correlate with high and low reading achievement. It was found in this study that reading achievement is a statistically stronger and more efficient predictor of learning style than intelligence quotient (I.Q.). The higher a student's reading level, the more independent is the learning style; thus, a lower level of reading is suggestive of a need for increased dependence and more teacher-directed instruction.

A study conducted by Marcus (49) revealed evidence that students who were ranked above average in a social studies class preferred to work alone, tended to be more auditory than the other members of the class, and had strong preferences as to learning style. In contrast, the below-average achiever preferred to work alone at times, preferred to learn through the tactual/kinesthetic mode, and had fewer strong preferences concerning learning styles than did the above-average achiever. It was suggested that varying instructional strategies based on learning style differences could increase achievement.

According to Dunn (18), the Learning Style Inventory was given to a group of students at Madison Junior High School in New York City. Curriculum was developed based on learning style needs, and assignments were given according to individual learning style preferences. The twenty under-achievers, who had experienced problems in school, made gains of two to four years in reading and math. During the year of instruction the students studied aerospace as an integrated theme for the curriculum base utilizing field trips, projects, group sessions, and student planning. It was reported that students not only increased achievement, but demonstrated an attitude of cooperativeness, improved school attendance, had no dropouts in the program, and conducted "open house" for visitors.

In a study conducted by Martin (51) in an inner-city school with students having diverse language backgrounds, high mobility rate, and attending large classes, it was reported that increased achievement and improved attitudes occurred when using individualized instructional strategies, learning style data, and community involvement. This study revealed that independent students functioned better in an alternative instructional environment. It was suggested that alternative education environments should be made available to high school students to permit both increased achievement and improved attitudes toward education.

Cavanaugh reports that Worthington High School in Ohio was the first schoolwide secondary program to use diagnostic/prescriptive education utilizing the identified learning style elements. Cavanaugh notes that the LSI was chosen to be administered to the students for identifying learning style preferences because

> It can be used easily by classroom teachers; it provides information on individual students and whole classes; it is accompanied by a manual that suggests how to match instruction with various learning style traits; and it has proven to be a reliable and valid diagnostic tool (11, p. 202).

The staff at this high school developed a Methods-Factor Coordination Sheet (MFCS) which matched learning styles to suggested prescriptions. Each teacher used the MFCS as a guide for matching instruction to individuals.

In addition, a computer program was developed that provided suggested prescriptions for each student's LSI printout. A seven-step outline was developed to give an overview of the flexible management plan. The teachers indicated that the learning style approach improved academic achievement and attitudes toward school. Cavanaugh suggests that there is every reason to believe that the staff at Worthington High School has made a breakthrough in high school instruction (11).

Carbo (8) notes than an interesting number of studies support the hypothesis that reading achievement is improved significantly when students are taught to read through their perceptual strengths. The Reading Style Inventory (RSI) (8), based on the Dunn, Dunn, and Price model, was used to diagnose the learning styles in the area of reading. The RSI was administered to 293 students in grades two, four, six, and eight to provide the data for this study. In summary, it was found that the primary grades preferred learning to read by using their tactual and kinesthetic senses. Intermediate and junior high students needed less movement, intake, and structure, but preferred to have more choices of reading materials. The upper-grade students demonstrated greater visual and auditory strengths than primary youngsters and preferred to work alone or with peers. Carbo indicates that educators must continue to research and experiment with a variety of techniques for matching instruction to individual reading styles.

Dunn, Dunn, and Price (25) conclude that in experiments conducted where students were permitted to study in ways that were harmonious with their identified learning styles, academic achievement and retention were increased. However, "examination of the elements that constitute learning style reveals that among the educators, psychologists, and researchers who have published studies, the definitions vary greatly" (25, p. 419). Students are individuals with unique needs. Davidman (15) suggested that some of these needs can be met by diagnosing student learning styles and providing instruction based on the student's identified learning style. Canfield concurs by stating, "As researchers and practitioners identify characteristics that seem related to learner behaviors, the dimensions of measurement expand. Concern for the individual learner has found a home in learning styles measurement" (83, p. 4).

Summary

Learning styles research has the potential of providing a framework of knowledge and understanding for the learning process, thus creating a more personalized and effective system of education. While there are differences among researchers concerning the definition of learning styles, it has been noted that the conceptual level theory serves as a guide for practice. Various theories of learning style provide the basis for the variety of instruments designed to measure learning characteristics. It has been found that motivation increases when students are allowed to make choices in the way they learn. Modality has been identified as the process most intimately associated with learning, and perception is the most thoroughly investigated characteristic of learning styles. Several studies revealed that when learning styles of individual students were matched with instructional strategies and materials, academic achievement increased. The effects of learning style research and practical application of the learning process theories provide a potentially powerful tool for the educator to deliver instruction that is appropriate for each individual student.

Canfield further adds that "marked progress in the use and application of learning styles will come when all parties of interest perceive their value and support their use" (6, p. 4). It is noted by Hruska (38) that learning style research is making significant contributions to effective and supportive education; however, more study is needed to offer better understanding of learning characteristics and useful applications for practitioners. Learning styles research has the potential to help humanize both schools and culture by encouraging more patience, understanding, and appreciation for individual differences.

Conclusion

The present study was an attempt to provide insight concerning computer-assisted instruction and learning styles. Specifically, as electronic technology rapidly advances into the classroom, educators must be assured that the use of computers is the most effective approach for teaching each individual student. Better understanding of individual learner characteristics and the learning process must be acquired in order to provide an opportunity to each student for maximum academic growth. Many educators promote different theories concerning student learning; however, most educators agree that appropriate instruction leads to greater achievement and improved attitudes.

CHAPTER BIBLIOGRAPHY

1. Barbe, Walter B. and Michael N. Milone, Jr., "What We Know About Modality Strengths," Educational Leadership, XXXVIII (February, 1981), 378-380.

2. Blakeway, Edward G., "Drill, Practice, and Testing Applications for the Reluctant Learner and Teacher of Mathematics: Elementary and Secondary," Paper presented at the Annual Conference of the National Association of Users of Computer Applications to Learning, Portland, Oregon, ED 139 621, (October, 1976).

3. Bracey, Gerald W., "What the Research Shows," Electronic Learning, II (November/December, 1982), 51-54.

4. Brandt, Ron, "Early Results of Computer-Based Reading and Writing Program Impressive," ASCD Update, XXVI (February, 1984), 2.

5. Callison, William, "The Potential is Great: Problems and Possibilities for Computer-Assisted Instruction," National Association of Secondary School Principals, CDXLV (May, 1981), 25-27.

6. Canfield, Albert A., "Learning Styles: Whither Thou Goest?," Learning Styles Network Newsletter, IV (Summer, 1983), 4.

7. Carbo, Marie L., "An Analysis of the Relationship Between Modality Preferences of Kindergarteners and Selected Reading Treatments as They Affect the Learning of a Basic Sight-Word Vocabulary," Doctoral Dissertation, St. John's University, 1980.

8. _______________, "Reading Styles Change Between Second and Eighth Grade," Educational Leadership, XL (February, 1983), 56-59.

9. Carman, Gary O. and Bernard Kosberg, "Educational Technology Research: Computer Technology and the Education of Emotionally Handicapped Children," Educational Technology, XXII (February, 1982), 26-30.

10. Carrier, Carol A., "The Role of Learner Characteristics in Computer-Based Instruction," NSPI Journal, XVIII (June, 1979), 25-26.

11. Cavanaugh, David P., "Student Learning Styles: A Diagnostic/Prescriptive Approach to Instruction," Phi Delta Kappan, LXIII (November, 1981), 202-203.

12. Cicchelli, Jerry J. and Edgar L. Richards, "Incorporating Microcomputers into the Classroom: The Mahopac Central School District Experience," ERS Spectrum, I (Summer, 1983), 42-47.

13. Cody, Corinne, "The Gifted Differ Dramatically From Average Students," Learning Styles Network Newsletter, IV (Autumn, 1983), 3.

14. Cosky, Michael J., "Computer-Based Instruction and Cognitive Styles: Do They Make a Difference," Resources In Education, XVI (September, 1981), 1-19.

15. Davidman, Leonard, "Learning Style: The Myth, The Pacacea, The Wisdom," Phi Delta Kappan, LXII (May, 1981), 641-645.

16. Davis, Dorothy S. and Phyllis Chiasson Schwimmer, "Style a Manner of Thinking," Educational Leadership, XXXVIII (February, 1981), 376-377.

17. Delforge, Clarence and Alfred E. Bloeser, "Computer-Assisted Instruction Credited With Raising Low Math Scores," Resources In Education, CXLIII (January, 1981), 1-7.

18. Dunn, Kenneth, "Madison Prep: Alternative to Teenage Disaster," Educational Leadership, XXXVIII (February, 1981), 386-387.

19. Dunn, Rita, "A Learning Styles Primer," Educational Leadership," LX (May, 1981), 31-34.

20. __________, "Can Students Identify Their Own Styles?," Educational Leadership, XL (February, 1983), 60-62.

21. __________, "Learning: A Matter of Style," Educational Leadership, XXXVII (April, 1980), 598-599.

22. Dunn, Rita and Marie Carbo, "Modalities: An Open Letter to Walter Barbe, Michael Milone, and Raymond Swassing," Educational Leadership, XXXVIII (February, 1981), 381-382.

23. Dunn, Rita and Kenneth Dunn, "How to Diagnose Learning Styles," Instructor, LXXXVII (September, 1977), 123-144.

24. ______________________, "Learning Styles/Teaching Styles: Should They...Can They...Be Matched?," Educational Leadership, XXXVI (January, 1979), 238-244.

25. Dunn, Rita, Kenneth Dunn, and Gary E. Price, "Diagnosing Learning Styles: A Prescription for Avoiding Malpractice Suits," Phi Delta Kappan, LVIII (January, 1977), 418-420.

26. ______________________, Learning Styles Inventory (LSI) Manual, Lawrence, Kansas, Price Systems, Inc., 1981.

27. ______________________, "Learning Styles: Research vs. Opinion," Phi Delta Kappan, LXII (May, 1981), 645-646.

28. Dunn, Rita and others, "Learning Style Researchers Define Differences Differently," Educational Leadership, XXXVIII (February, 1981), 372-375.

29. Dunn, Rita, Gary E. Price, Kenneth Dunn, and William Sanders, "Relationship of Learning Style to Self-Concept," The Clearing House, LIII (November, 1979), 155-158.

30. Elliot, Charles A., "The Effects of Instructional Designs Matched to Individual Differences in Cognitive Styles on Concept Learning: A Trait-Treatment Interaction Study," Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, California, (April, 1976).

31. Fischer, Barbara Bree and Louis Fischer, "Styles in Teaching and Learning," Educational Leadership, XXXVI (January, 1979), 245-254.

32. Gregorc, Anthony F., "Learning Style/Brain Research: Harbinger of an Emerging Psychology," Student Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

33. ____________________, "Learning/Teaching Styles: Potent Forces Behind Them," Educational Leadership, XXXVI (January, 1979), 234-236.

34. Grocke, Margaret, "Interactive Development of Reading Skills in an Educational Clinic," Paper presented at the Annual National Conference of the Australian Group for the Scientific Study of Mental Deficiency, ED 223 993 (September, 1982).

35. Hayes, Jeanne, "School Districts Using Microcomputers: A National Survey," ERS Spectrum, I (Summer, 1983), 33-41.

36. Hopkins, Martha H., "The Diagnosis of Learning Styles in Arithmetic," Arithmetic Teacher, XXV (April, 1978), 47.

37. Hopmeier, George, "New Study Says CAI Favors Introverts," Electronic Education, I (September, 1981), 16-17.

38. Hruska, Sheryl Reichman, "Learning Styles: A Personal Approach," Learning Styles Network Newsletter, V (Winter, 1984), 4.

39. Hunt, David E., "Learning Style and the Interdependence of Practice and Theory," Phi Delta Kappan, LXII (May, 1981), 647.

40. Jay, Timothy, "The Cognitive Approach to Computer Courseware Design and Evaluation," Educational Technology, XXIII (January, 1983), 22-25.

41. Kaley, Stephanie Beth, "Field Dependence/Independence and Learning Styles in Sixth Graders," Doctoral Dissertation, Hofstra University, 1977.

42. Keefe, James W., "Assessing Student Learning Styles: An Overview," Student Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

43. _______________, "Learning Style: An Overview," Student Learning Styles, Diagnosing and Prescribing Programs, National Association of Secondary School Principals, Reston, Virginia, 1979.

44. Kulik, James A., "Synthesis of Research on Computer-Based Instruction," Educational Leadership, XLI (September, 1983), 19-21.

45. _______________, Robert L. Bangert, and George W. Williams, "Effects of Computer-Based Teaching on Secondary School Students," Journal of Educational Psychology, LXXV (February, 1983), 19-26.

46. Litman, George H., "CAI In Chicago," Paper presented at the Association for Educational Data Systems Annual Convention, New Orleans, Louisiana, ED 087 423, (April, 1973).

47. Lysiak, Fae and others, "Computer-Assisted Instruction," Evaluation Report, Fort Worth Independent School District, Fort Worth, Texas, ED 140 495, (September, 1976).

48. Magero, James, "Study Comparing the Effectiveness of Two Computer-Assisted Instructional Design Formats and Subsequently Correlating Individual Learning Style to Performance," Dissertation Abstracts International, XL (April, 1980), 5291-A.

49. Marcus, Lee, "Learning Style and Ability Grouping Among Seventh Grade Students," Clearing House, VIII (April, 1979), 377-380.

50. Martin, Marilyn A., "Cognitive Styles and Instructional Variables," Paper presented at the Annual Conference of the American Education Research Association, New York City, New York, 1982.

51. Martin, Michael Kenneth, "Effects of the Interaction Between Students' Learning Styles and High School Instructional Environment," Dissertation Abstracts International, XXXIX (1977), 96-A.

52. Meaney, John Patrick, "An Analysis of Two Modes of Instructional Design Based on Hill's Model of Educational Cognitive Style," Dissertation Abstracts International, XLIII (September, 1982), 1124-A.

53. Melmed, Arthur S., "Information Technology for U.S. Schools," Phi Delta Kappan, LXIII (January, 1982), 308-311.

54. "North Carolina Research Project Changes Teachers' Behaviors," Learning Styles Network Newsletter, IV (Autumn, 1983), 6.

55. Palmer, Henry, "Three Evaluation Reports of Computer-Assisted Instruction in Drill and Practice Mathematics," Paper presented at the Association for Educational Data Systems Annual Convention, New Orleans, Louisiana, ED 087 422, (April, 1973).

56. Papert, Seymour, "Computers and the Learning Society," A statement presented at hearings held by the House of Representatives Science and Technology Subcommittee on International Scientific Planning, Analysis, and Cooperation, ED 162 643, 1978.

57. ______________, "Computers Are Objects to Think With," Instructor, XCI (March, 1982), 86-89.

58. Price, Gary E., Rita Dunn and William Sanders, "Reading Achievement and Learning Style Characteristics," The Clearing House, LIV (January, 1981), 223-226.

59. Saracho, Olivia N., "The Effects of a Computer-Assisted Instruction Program on Basic Skills Achievement and Attitudes Toward Instruction of Spanish-Speaking Migrant Children," American Educational Research Journal, XIX (Summer, 1982), 201-219.

60. Schmeck, Ronald R. and Dan Lockhart, "Introverts and Extroverts Require Different Learning Environments," Educational Leadership, XL (February, 1983), 54-55.

61. Shane, Harold G., "The Silicon Age and Education," Phi Delta Kappan, LXIII (January, 1982), 303-308.

62. Swenson and Anderson, "The Role of Motivation in Computer-Assisted Instruction," Creative Computing, VIII (October, 1982), 134-139.

63. Von Feldt, James B., "An Introduction to Computer Applications in Support of Education," National Technical Institute for the Deaf, Rochester Institute of Technology, 1977.

64. __________________, "An Overview of Computers in Education," National Technical Institute for the Deaf, Rochester, New York, March, 1977.

65. Weinberg, Fredrick H., "An Experimental Investigation of the Interaction Between Modality Preference and Mode of Presentation in the Instruction of Arithmetic Concepts to Third Grade Underachievers," Doctoral Dissertation, St. John's University, 1983.

66. Wheeler, Roberta, "An Investigation of the Degree of Academic Achievement Evidenced When Second Grade, Learning Disabled Students' Perceptual Strengths Are Matched and Mismatched with Complementary Sensory Approaches to Beginning Reading Instruction," Doctoral Dissertation, St. John's University, 1983.

67. Wilde, Jane H., "Computers May Help Basic Skills Students Improve Their Status," Electronic Education, I (December, 1981), 27-28.

68. "Youngstown Experiments With Reading Through Modalities," Learning Styles Network Newsletter, IV (Autumn, 1983), 6.

CHAPTER III

PROCEDURES

The purpose of this study was to assess the effectiveness of computer-assisted instruction (CAI) in reading and math for fourth-grade students and to determine the relationship between achievement of students using CAI in reading and math and selected learning style elements of students. A related purpose was to make recommendations concerning the learning characteristics of students who benefit most by utilizing CAI in reading and math.

This chapter presents a description of the instruments used to measure achievement in reading and math and selected learning style elements of students which are assumed to be related to student learning. A description of the design of the experiment is followed by the testing procedures and the experimental treatments. Finally, the methods used to prepare and analyze the data complete the chapter.

Instrumentation

In the review of the literature presented in Chapter II, it was reported that various research designs similar to the experimental and control treatment employed in this study produced significant achievement scores in reading and math. It was noted that the instruments utilized for measuring the effects of these treatments were well known, established, norm-referenced tests designed to measure achievement of the basic skills. It was further concluded that various studies of similar nature gathered data concerning the conditions under which an individual student is most likely to learn, achieve, create, or solve problems. The tests for measuring achievement generally provide for comprehensive and continuous measurement of growth in the fundamental basic skills. The instruments for diagnosing an individual's learning style usually address the characteristics of the learner and/or the environment that is most appropriate for maximum achievement.

Since it is assumed that teaching the basic skills is important, and it is assumed that knowing the strengths and weaknesses concerning achievement and knowing the individual student's learning style contributes to the effectiveness of this teaching, instruments were chosen to provide these data. The instrument used for measuring achievement was chosen for this study because it is intended to provide objective information about skills performance that will constitute a partial basis for making instructional decisions for individual students (12). A tool for identifying individual student learning style was selected because after careful analysis of the students' data, those elements that are critical to an individual's learning style will be identified (10). These choices were based on the assumption that periodic, reliable measurement of the development of basic skills and learner characteristics provides an incentive to the student, a tool for the teacher, a guide for the school administrator, and an accounting to the parents.

One instrument was utilized for measuring achievement in the basic skills of reading and math. Another instrument was used for determining the individual learning style of students. These instruments have been used extensively by various researchers for many studies, including several studies reported in the review of the literature. Both the achievement test and the inventory for assessing learning style may be administered to classroom groups of subjects.

Iowa Tests of Basic Skills

The ITBS (11) was developed during the 1940's and since then has undergone update and revision. It was designed to provide objective information about skill performance on eleven subtests: vocabulary, reading, spelling, capitalization, punctuation, usage, visual materials, reference materials, math concepts, math problems, and math computation. The form which was used in this study, Form 8, Level 10, has 391 items in the total test; however, only the data from the reading and math components were used. The reading portion of the test, consisting of forty-nine items, is designed to measure the students' understanding of what is read. The math component has ninety-nine items and is intended to measure the students' understanding of the number system, mathematical terms and operations, solving problems, and computation.

This multilevel battery of ITBS is designed for use in grades three through nine, as the tests are nongraded. Each test consists of a continuous scale from low level grade three to superior grade nine performance. All items are in multiple-choice format with the students recording their answers on a separate answer sheet. The appropriate administration of the tests requires that the tests be timed, which allows students forty-two minutes of work time for the reading portion and seventy minutes to answer the math items.

Internal consistency reliability coefficients for the five components of the ITBS range from .89 to .96 with the composite reliability being .97 to .98 for all grades. The content specifications are based upon over forty years of continuous research in curriculum, measurement procedures, and interpretation and use of test results. The validity of skill objectives was determined through systematic consideration of courses of study, statements of authorities in method, and recommendations of national curriculum groups. The item selection process involved a combination of empirical and judgmental procedures, including evaluation by representative professionals from diverse cultural groups. The ITBS were standardized by involving approximately 16,000 to 19,000 students per grade level and by using region, size of school district, family income, and education as criteria for the selection and weighting process (12).

Validity and reliability of the ITBS were accepted as satisfactory for this study. However, only data from the reading and math subscales were used, as they are related to the specific purposes of the study.

Learning Style Inventory

The LSI (9) (see Appendix A) was originally developed in 1975 and revised in 1978 by identifying the variables from research that seemed to affect the ways individuals prefer to learn. Items were written to assess individuals' performance in each of the areas, and responses to those items were analyzed using a factor analysis procedure. The instrument was designed to survey an individual's personal preferences for each of the twenty-four elements (see Appendix B). These elements are grouped according to four basic stimuli: environmental, emotional, sociological, and physical (see Appendix B). This scale does not measure underlying psychological factors, value systems, or the quality of attitudes; rather, it yields information concerned with the patterns through which learning occurs. Therefore, it reveals the environmental, emotional, sociological, and physical preferences a student has for learning, not why they exist. Finally, the scale evidences how an individual prefers to learn, not the specific skills that are used for learning (10, 15, 14).

The twenty-four element test with 104 items was determined to be reliable at the $P \leq .01$ level by using factor analysis procedures, test/retest methods, and field testing (13). Dunn, Dunn, and Price (8) cite studies which verify that students are reliable in indicating their own learning style preferences. Barbe and Milone (1) further note that self-report instruments such as the LSI have great potential for many students.

Since the LSI is designed to identify those elements that are critical to an individual's learning style, many of the questions are highly subjective and relative. Learning style is based on a complex set of responses to varied stimuli, preferences, and previously established patterns that tend to have similar meanings when the person concentrates; therefore, the words <u>think</u>, <u>learn</u>, <u>read</u>, <u>write</u>, and <u>concentrate</u> are used interchangeably throughout the LSI. Comparisons of answers to questions that are expressed in a variety of ways contribute to the accuracy of the student's learning style profile (10).

This questionnaire was developed to be given in writing, on tape, or orally. All items are true or false and the students record their answers on a separate answer sheet. The administration of the inventory has no definite time limit; however, it is estimated that most students can complete all of the items in approximately thirty minutes.

Validity and reliability of the LSI appeared to be sufficient for this study, with these data being comparable to such data for instruments used in other studies of this type. The LSI was accepted as being a useful instrument for achieving the purposes of this study.

The sample size of approximately 360 subjects did not justify including all twenty-four elements identified by the LSI; therefore, seven learning style elements were selected for this study. The seven elements were arbitrarily selected; however, the findings in the review of the literature were a basis for the decision. It was determined that research has addressed the concerns of student motivation in many studies. Specifically, Carrier (6) notes that the computer has the capacity to motivate and stimulate students for learning. Swenson and Anderson (16) reinforce this position by reporting that the most important function of CAI is motivation.

Perception was selected for study because according to Carbo (5), perception appears to be the learning style element of greatest importance for most youngsters. Barbe and Milone suggest that perception is the most thoroughly investigated characteristic of learning style and modality is the process most intimately associated with learning (2).

Two learning style elements were selected to address the social characteristics of the learner. The literature reveals that some students prefer to work alone; however, others prefer to work with peers while learning. There has been some concern expressed about social interaction during CAI. White found in a study that students ask more questions when involved with a computer than in the traditional classroom. It was also concluded from this research that more peer interaction concerning the learning task occurred while receiving CAI than in the conventional instructional setting (17).

These selected learning style elements were determined to be sufficient for this study. Only the data from the LSI that address unmotivated/motivated, learning alone, peer oriented, auditory, visual, tactile, and kinesthetic preferences were used in this study.

Design of the Study

The problem of this study was to determine the effectiveness of computer instruction in reading and math and to ascertain the relationship between achievement of students using computer-assisted instruction in reading and math and selected learning style elements of students. The experimental subjects were members of predetermined classes in designated school sites; therefore, intact groups were chosen for this study. It was expected that it would be possible to produce results with a limited sample of fourth-grade students in five pilot schools having computer-assisted instruction; however, the degree of generalizability of results to other districts is unknown. In addition, an effort was made to match experimental and control schools in order to increase the precision for determining the effects of treatment conditions.

One design, the nonequivalent control group design, allows for various comparisons and controls in an effort to determine the source of achievement in the subjects. Borg describes the merits of this design as follows:

> Probably the most widely-used quasi-experimental design in educational research is the non-equivalent control group design. A researcher can test the effect of an educational practice or product whenever the practice or product must be administered to an entire classroom or not at all. The researcher sets up two groups: an experimental group that receives the treatment variable in addition to conventional instruction and a control group that receives only the conventional instruction. All of the students in a given classroom are assigned to either the experimental or the control group. In some studies the teachers in the experimental group are drawn from one school and control teachers are drawn from another school.

> There are several alternatives from which the researcher can select to lessen the initial differences between treatment groups that may arise due to nonrandom assignment. The researcher should attempt to do preliminary matching to equalize the treatment and control groups as much as possible. Instead of using the scores of individual students in analyzing the data, the researcher would use the mean score of all students in a given classroom. Another method to compensate for initial differences between experimental and control groups is the analysis of covariance technique. Covariance analysis is an extremely valuable tool for use by educational research workers (3, p. 559-561).

The nonequivalent control group design allows for nonrandom classroom group assignments of subjects to treatment groups. It provides for an experimental group which is subjected to treatment and a control group that receives no experimental treatment. All subjects complete pre-tests and post-tests. Campbell and Stanley represent the design symbolically as follows:

```
    0           X           0
- - - - - - - - - - - - - - - -
    0                       0      (4, p. 47).
```

In the diagram, reading from left to right, each row represents the sequence of the study. The first row indicates that a group is pre-tested (0), participates in the experimental treatment (X), and is post-tested (0). The broken line shows that the experimental and control groups have not been randomly selected. The second row indicates that a group is pre-tested and post-tested;

however, the absence of the (X) indicates that the control group received no experimental treatment. The columns of the diagram indicate that each event in the column occurs simultaneously.

In discussing this design, Campbell and Stanley stated:

> One of the most widespread experimental designs in educational research involves an experimental group and a control group both given a pre-test and post-test, but in which the control group and the experimental group do not have pre-experimental equivalence (4, p. 47).

The main difficulty with this design is that internal validity can be threatened by the effect of regression and any interaction between selection, maturation, history, and testing. According to Campbell and Stanley, an appropriate safeguard against these threats may be included in the design by preliminary matching to equalize the experimental and control groups as much as possible when comparing pre-test scores. If it is impossible to gain similarity due to the existence of initial differences, it has been suggested that the differences can be statistically adjusted by the analysis of covariance (4). These precautions were taken in this study.

Subjects

This study was conducted in a large suburban school district, which is located near a large metropolitan area.

The district has thirty-one elementary schools with an ethnic population of seven percent Mexican American, seven percent black, three percent Oriental and Indian, and eighty-three percent "other" which includes Anglo. The population of students in grades kindergarten through five is approximately 15,000 students. There are thirteen schools in excess of 500 students, twelve with enrollments between 300 and 500, and six schools below 300 in student population.

The experimental groups were matched to control schools in terms of numbers of students, ethnicity of students, socioeconomic factors of the neighborhoods, and achievement of students. School A has ninety-two fourth graders, while School B has 105 students in fourth grade. School A served as control for School B in the area of math, and School B served as control for School A in the area of reading. Both schools are located in middle-class, predominantly Anglo neighborhoods with mean test scores above the national mean. Schools C and D are also located in middle-class Anglo neighborhoods with School C having forty-eight fourth graders and School D enrolling forty-one fourth-grade students. School C served as control for School D in the area of math, and School D served as control for School C in the area of reading. The students in C and D schools have mean test scores in the upper quartile of national norms. School E was an experimental group for mathematics and did not serve as a control school. School E is located in a lower socioeconomic, predominantly minority neighborhood, as is School F, which served as the control. Since there was not a matching school within the computer pilot schools for School E, School F was identified to serve as control for School E. School F did not serve as an experimental group in this study. The forty students in Schools E and F have mean test scores below the national mean.

Other Design Considerations

The teacher effect was a consideration in this study; however, upon examination of personnel records it was determined that the educational backgrounds and years of experience for teachers were basically the same for experimental and control groups. In four pilot schools the fourth-grade teachers were involved with the experimental group in one academic area and the control group in the other area of study. The remaining experimental group was closely matched to the control school in terms of teachers. The matching of these schools in this design was an attempt to control for teacher effect.

According to Borg (3), the term "Hawthorne effect" has come to refer to any situation in which the experimental conditions are such that the fact that the subjects are participating in an experiment tends to improve performance. With four pilot schools serving as both experimental and control groups, this design tends to aid in eliminating the problem of the Hawthorne effect. The use of control groups that were matched with common characteristics to the experimental groups in this design was intended to bring focus to effects of computer instruction in reading and math. Specifically, the effect of computer instruction is controlled by this design.

Because the nonequivalent control group allows for consideration of sources of threats to internal validity, it was chosen as the design for the present study. The number of subjects available was determined to be sufficient to allow for assignment of the subjects using intact groups.

Preliminary Arrangements

In 1983, the Director of Planning, Research, and Evaluation from a large suburban school district granted permission to use five previously identified pilot schools as subjects. The targeted schools had been selected by school district personnel for computer-assisted instruction.

Since computer-assisted instruction is relatively new to this school district, it was decided that a few elementary schools would be selected as pilot sites for the 1983-84 academic year. This would provide an opportunity to solve problems of computer implementation and make adjustments on a small scale before expanding the program to all schools. A procedure for choosing pilot schools was therefore established.

First, a survey was sent to each elementary school. This survey provided an opportunity for the schools to show interest and commitment for the computer program. Past, present, and future plans for technology staff training were reflected in this survey. The returned surveys were evaluated and a follow-up proposal was sent to the school staffs that demonstrated a desire to become a pilot school. After receiving all of the proposals from interested schools, the proposals and surveys were ranked individually by each of the thirteen computer committee members. These ranks were calculated and the five schools receiving the best scores were selected as the pilot sites.

The committee members who were responsible for planning the CAI program and selecting the pilot schools held various positions and had diverse backgrounds. The thirteen-member committee was chaired by the present researcher, who is the Director of Curriculum and responsible for all district-wide curricular activities. The committee members consisted of the Assistant Superintendent for

Educational Operations, who is responsible for all instructional programs in the district, the Assistant Superintendent for Administration, whose division includes the main-frame computer operation, the Director of Data Processing, who directly controls all administrative computer services, the Director of Elementary Operations, who supervises all of the operational activities in the elementary schools, an elementary principal who is a doctoral student with computer science training, an evaluator from the Planning, Research, and Evaluation Department who has studied computer science on the doctoral level, the Consultant for Media Services, who has completed post-graduate computer science courses, the Consultant of Mathematics, who has studied computers and their functions for several years, an elementary consultant who has implemented a computer-assisted instructional program in reading, an administrator for the district's compensatory program who has studied computer science, an administrative intern in an elementary school who is a doctoral student with a minor in computer science, and a librarian in an elementary school who teaches students simple computer programming.

Following the district level approval of the study, permission to use the fourth-grade students in these designated schools was sought from the principals and teachers of each participating school. The general purposes of the study and specific requests of the teachers were presented on each site. The teachers and principals agreed to cooperate.

Prior to the pre-testing, approximately 360 fourth-grade students were enrolled in sixteen classes at five pilot schools and an additional control group school. This sample was accepted as adequate for this study.

Data Collection Procedures

All students who were enrolled in the fourth grade of this district during the last week of September and the first week of October were given the Iowa Tests of Basic Skills (ITBS), Form 8, Level 10 (11). Scores that were obtained with these district-wide testing procedures were used as pre-test scores in this study. For students who were absent on the days the tests were administered, a make-up session was provided during the following week.

The Learning Style Inventory (LSI), developed by Dunn, Dunn, and Price (9), was used to assess the learning style preference of the subjects in the experimental and control groups during the beginning of the second semester of the 1983-84 school year. The LSI was administered to the subjects by the classroom teachers, who read the items aloud and paused after each item to allow students time to respond on the separate answer sheets. The students were instructed to read the test with the teacher, thus considering both the auditory and visual learner as suggested by Cavanaugh (7). The students' written responses were processed by computer and returned in the format of a student profile, class summary, and area summary.

Similar procedures were followed during the post-tests; however, the ITBS used for the post-test were given only to students in the schools in the study, not to all students in the district. The classroom teachers administered the ITBS, Form 8, Level 10 (11), during the last week in April, 1984, and completed the task during the first week of May, 1984. Make-up sessions for those students who were absent during the testing time were conducted; however, if a student was absent for the tests and the make-up sessions, all data for that individual were omitted from the study.

The Treatments

The subjects in the experimental group received the experimental treatment of computer-assisted instruction in the area of reading or mathematics for fifteen minutes per day every school day during the week for seven months. The students participated in CAI during the regularly scheduled time for instruction. Because instruction time varied from campus to campus, this factor was controlled in the statistical analysis.

Computer-assisted instruction began at the beginning of the 1983-84 school year for the experimental groups. Students in two experimental schools received reading instruction by using the software package Diascriptive Reading in addition to conventional methods of instruction. Math CAI was provided in addition to conventional instruction by using the computer courseware Milliken Math for subjects in three experimental schools.

Computer Instructional Programs

Diascriptive Reading by Educational Activities, Inc., contains thirty-six developmental lessons in reading on seven diskettes for grade levels three through eight. The program diagnoses the reading skills of each student, prescribes what is needed for improvement, and evaluates performance at each level before directing the student to the next level of difficulty. Each lesson is self-directing and self-correcting, and focuses on one reading skill for one specific level. Students receive immediate reward or instruction using graphics animation for reinforcement.

Diagnostic tests for all skills areas and lessons in vocabulary, sequence, main idea, fact/opinion, details, and inference are included in the Diascriptive Reading

Program. An automatic management system records student progress, remediates or advances the student through each skill area, and provides for the teacher a summary of class scores, individual scores, and a summary of diagnostic results.

Milliken Math Sequences by Milliken Publishing Company is a package of software that includes twelve diskettes to be run with the Apple IIe computer. This math program is designed to provide individual drill and practice for students in math operations that have been introduced by the teacher.

Number readiness, addition, subtraction, multiplication, division, laws of arithmetic, integers, fractions, decimals, percents, equations, and measurement formulas are mathematical operations that are included in this program, which was developed for students in grades one through eight. Each sequence contains problems from simple to complex, thus allowing the student to advance after specific achievement criteria are met or move back a level until mastery is achieved. Progress from one problem level to another is constantly monitored by the computer. The built-in management system provides the teacher with the opportunity to make individual and class assignments, review individual and class performance, establish personalized performance levels for each student, and receive printed records of student performance.

Data Analysis Procedures

Student responses for the ITBS pre-test and post-test were computer analyzed. Grade-equivalents (GE) were determined from each student's raw scores. Grade-equivalent scores were considered adequate for this study because

> (1) they indicate the development level of the pupils' performance; (2) they may be averaged for purposes of making group comparisons; and (3) they are suitable for measuring growth (12, p. 25).

Student responses from the LSI were recorded on separate answer sheets that were sent to Price Systems, Inc. for computer scoring. The results of the survey were returned in the format of a computerized individual profile for each subject in addition to a class summary and area summary. Standard scores were used for reporting results of student responses from the LSI. These data were determined to be adequate for this study.

The area summary was returned in two print-outs. One print-out summarized the elements for all individuals in the group who had standard scores of sixty or higher in each of the areas. The other print-out summarized the elements for all individuals in the group who had standard scores of forty or lower in each of the areas. The print-outs also indicated the number and percent of the group who scored sixty or higher and forty or below. This information indicates which elements are most and least important for the total group.

The group summary print-out showed the individual students who had standard scores of sixty or above and the students who had standard scores of forty or lower. These print-outs were used to identify individual students who have similar preferences (10).

To determine student achievement in the areas of mathematics and reading after applying the treatment of CAI, analysis of covariance was used. The pre-test and the amount of time on task were used as the covariates for this study. Borg (3) notes that the statistical technique of analysis of covariance is used to control for initial differences between groups. The effect of analysis of covariance is to make the two groups equal with respect to one or more control variables. The adjusted mean score for each group was calculated by the computer services at North Texas State University to determine achievement after controlling for time and pre-test. The adjusted achievement scores of the experimental treatment groups were compared to the control group achievement scores. To determine statistical differences in the achievement of the experimental group and the control group, an F value was calculated.

In an attempt to identify the relationship of selected learning style elements and achievement with computer-assisted instruction in reading and math, a Pearson product-moment correlation was calculated. The data were processed at the computer center at North Texas State University by using the Statistical Package for the Social Sciences (SPSS). The relationship of each independent variable, representing the selected learning style elements, and the dependent variable, achievement in reading and math, was determined. A relationship of an independent variable to the criterion variable was considered to be significant at the .05 level of significance.

The step-wise method of the multiple regression procedure was used to determine which combination of selected learning style elements resulted in optimum achievement. This procedure yields a multiple regression equation that combines the predictive value of several measures into a single formula which weights each variable in terms of importance (3). The degree of relationship between the selected learning style elements, or predictor variables, in the multiple regression equation and the criterion variable, achievement, was designated by the coefficient R^2. The relationship for any combination of predictor variables to the criterion variable was considered to be significant at the .05 level of significance. An R^2 was calculated for all combinations of the selected learning style elements in order to test each model.

To adjust for differences in the population, the pre-test score and time on task were entered as factors. The step-wise regression procedure was used to partial out the effects of these variables from the other factors. The most statistically significant combination of selected learning style elements which are positively correlated to achievement with CAI in reading and math and the strength of relationship of the independent variables and dependent variable were determined.

In summary, Borg described this procedure as desirable in certain research problems, particularly those involving prediction, as follows:

> It was found that two predictor variables in combination predicted the criterion better than either predictor variable by itself. The procedure used to combine the predictor variables is described as multiple regression. This procedure yields a multiple-regression equation that combines the predictive values of several measures into a single formula. The multiple-regression equation weights each variable in terms of its importance in making the desired prediction. The score of each person on each predictor measure can be placed into the formula to yield a prediction of the person's score on the criterion variable (3, p. 498).

These procedures were considered adequate for analyzing the data in this study.

Summary

A description of the ITBS and LSI indicated that these instruments appeared to be suitable for gathering data to test the six hypotheses. The nonequivalent control group design was selected because it allowed the testing of effects of pre-testing on the criterion measured and it considered unequated groups. The testing procedures and treatments are presented in a description of computer-assisted instruction at pilot schools during the 1983-84 school year in a large suburban school district. The procedures for preparing and analyzing the data are outlined.

CHAPTER BIBLIOGRAPHY

1. Barbe, Walter B. and Michael N. Milone, Jr., "Teaching Through Modality Strengths: Look Before You Leap," Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

2. ______________________________, "What We Know About Modality Strengths," Educational Leadership, XXXVIII (February, 1981), 378-380.

3. Borg, Walter R. and Meredith Damien Gall, Educational Research An Introduction, Longman, Inc., New York, 1979.

4. Campbell, D. R. and J. C. Stanley, Experimental and Quasi-Experimental Designs for Research, Chicago, Rand McNally and Co., 1963.

5. Carbo, Marie, "Reading Styles Change Between Second and Eighth Grade," Educational Leadership, XL (February, 1983), 56-59.

6. Carrier, Carol A., "The Role of Learner Characteristics in Computer-Based Instruction," NSPI Journal, XVIII (June, 1979), 25-26.

7. Cavanaugh, David P., "Meeting the Needs of Individuals Through Their Learning Styles," Student Learning Styles: Diagnosing and Prescribing Programs, National Association of Secondary School Principals, Reston, Virginia, 1979.

8. Dunn, Rita, Kenneth Dunn, and Gary E. Price, "Diagnosing Learning Styles: A Prescription for Avoiding Malpractice Suits," Phi Delta Kappan, LVIII (January, 1977), 418-420.

9. ______________________________, Learning Style Inventory, Price Systems, Inc., Lawrence, Kansas, 1978.

10. ______________________________, Learning Style Inventory Manual, Price Systems, Inc., Lawrence, Kansas, 1981.

11. Hieronymus, A. N. and others, The Iowa Tests of Basic Skills, University of Iowa at Iowa City, 1979.

12. ______________________________, The Iowa Tests of Basic Skills Teachers Guide, University of Iowa at Iowa City, 1979.

13. Price, Gary E., "Learning Style Inventory Development and Continuing Research," Student Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

14. Price, Gary E., Rita Dunn, and Kenneth Dunn, Learning Style Inventory/Productivity Environmental Preference Survey, Interpretive Booklet, Price Systems, Inc., Lawrence, Kansas, 1982.

15. ______________________________, Learning Style Inventory, Research Report, Price Systems, Inc., Lawrence, Kansas, 1977.

16. Swenson and Anderson, "The Role of Motivation in Computer-Assisted Instruction," Creative Computing, (October, 1982), 137.

17. White, Mary Alice, "Synthesis of Research on Electronic Learning," Educational Leadership, XL (May, 1983), 13-15.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The assumption that computer-assisted instruction can affect student learning underlies the present investigation. Whether the learning style of an individual student is related to achievement with CAI is of specific interest and concern. The ultimate objective is to make recommendations concerning the practice of computer-assisted instruction for elementary students.

In the first three chapters of this report, the background and conduct of the experiment are described. This chapter is an exposition of the findings which resulted from the procedures previously described. The findings relevant to each hypothesis are presented in order. Following presentation of selected data resulting from the statistical analysis, a brief discussion about the findings is included.

Hypothesis I

This hypothesis was restated in null form for statistical testing. In null form, Hypothesis I states that the experimental treatment groups will not differ significantly from the control treatment groups on the post-test measure of reading achievement using The Iowa Tests of Basic Skills.

Reading Achievement

Table I presents selected data relevant to the effects of the experimental treatment and the testing condition on the measure of reading achievement. Analysis of covariance was applied to control for initial differences between groups. The pre-test and the amount of time on task were used as the covariates for calculating the adjusted scores.

The adjusted reading achievement scores of the experimental treatment group were compared to the reading achievement scores of the control group and an F value was calculated. The F-ratio of 7.20265 reached the prescribed .05 level of significance, indicating that the control group post-test scores in the area of reading did significantly differ from the post-test scores of the subjects in the experimental treatment group. The control group scores were significantly higher than the scores of the experimental treatment group. These findings indicate that the control group who received only the conventional methods of instruction made significantly more achievement gains than did the students who received the experimental treatment of CAI in addition to conventional instruction.

TABLE I

SUMMARY OF TESTS OF SIGNIFICANCE FOR READING ACHIEVEMENT*

Source of Variation	Sum of Squares	DF	Mean Square	F Ratio	Significance of F (P)
Within cells	275.25906	238	1.15655	....	....
Regression	210.59360	2	5.29680	1.04383	.000
Constant	25.23594	1	25.23594	21.82000	.000
Reading achievement	8.33023	1	8.33023	7.20265	.008**

*Manova analysis of covariance for post-test scores with pre-test scores and time on task as the covariates.

** $>$ .05 level of significance

Table II presents selected data that describes reading achievement of Schools A and C in the experimental group and Schools B and D in the control group. These findings indicate that the control groups made greater grade-equivalent achievement gains than did the experimental groups.

Also, after the adjusted scores were calculated by using the analysis of covariance to control for pre-test scores and time on task, it was found that the control group scores were significantly higher than those of the experimental treatment group on the post-test scores. Table III presents the observed means for the experimental group and control group. These findings indicate that the experimental group did not make greater gains in reading when compared to the control group that received conventional methods of instruction.

The findings that related to Hypothesis I indicate that the control group obtained significantly higher scores than did the experimental treatment group on the adjusted post-test measures of reading achievement. The null hypothesis which stated that there would be no difference in reading achievement as measured by ITBS between fourth-grade students who receive instruction by the computer and fourth-grade students whose instruction is limited to conventional methods must be rejected for these measures.

TABLE II

SUMMARY OF MEAN SCORES, STANDARD DEVIATION, AND VARIATION OF READING ACHIEVEMENT BY SCHOOLS*

Schools	N	Mean Scores			Standard Deviation		Variance	
		Pre-Test	Post-Test	Achievement	Pre-Test	Post-Test	Pre-Test	Post-Test
Experimental A	77	5.5026	5.9234	0.4208	1.3654	1.3772	1.8642	1.8968
Control B	94	5.2128	5.9468	0.7340	1.3865	1.4530	1.9224	2.1111
Experimental C	38	5.3368	5.6526	0.3158	1.3765	1.5905	1.8948	2.5296
Control D	33	5.0939	6.1273	1.0334	1.2306	1.2388	1.5143	1.5345

*Grade-equivalent scores

TABLE III

SUMMARY OF OBSERVED MEANS, STANDARD DEVIATION, AND ADJUSTED MEANS FOR READING ACHIEVEMENT

Groups	Observed Means	Standard Deviation	Adjusted Means
Experimental Pre-Test	5.44783	1.36525	....
Experimental Post-Test	5.83391	1.44980	5.71836
Control Pre-Test	5.18189	1.34397	....
Control Post-Test	5.99370	1.39794	6.09833

Hypothesis II

This hypothesis was restated in null form for statistical testing. In null form, Hypothesis II states that the experimental treatment groups will not differ significantly from the control treatment groups on the post-test measure of math achievement using _The Iowa Tests of Basic Skills_.

Math Achievement

Table IV presents selected data relevant to the effects of the experimental treatment and the testing condition on the measure of math achievement. Analysis of covariance was applied to control for initial differences between groups. The pre-test and the amount of time on task were used as the covariates for calculating the adjusted scores.

The adjusted math achievement scores of the experimental treatment group were compared to the math achievement scores of the control group and an F value was calculated. The F-ratio of 21.88590 reached the prescribed .05 level of significance, indicating that the experimental treatment of computer-assisted instruction in the area of math did significantly affect the post-test scores of the subjects in the experimental treatment group.

TABLE IV

SUMMARY OF TESTS OF SIGNIFICANCE
FOR MATH ACHIEVEMENT*

Source of Variation	Sum of Squares	DF	Mean Square	F Ratio	Significance of F (P)
Within cells	126.31255	295	.42818	....	....
Regression	45.79772	2	122.89886	287.02742	.000
Constant	18.97899	1	18.97899	44.32498	.000
Math achievement	9.37106	1	9.37106	21.88590	.001**

*Manova analysis of covariance for post-test scores with pre-test scores and time on task as the covariates.

**$>$ .05 level of significance

Table V presents selected data that describes math achievement of Schools B, D, and E in the experimental group and Schools A, C, and F in the control group. These findings indicate that the experimental groups made greater grade-equivalent achievement gains than did the control groups. This data supports the findings of the adjusted scores after calculation by using the analysis of covariance to control for pre-test scores and time on task. Table VI presents the observed means, standard deviation, and adjusted means for the experimental group and control group. These findings indicate that the experimental treatment of computer-assisted instruction was effective in assisting these subjects to make greater gains in math when compared to conventional methods of instruction.

The findings that related to Hypothesis II indicate that the experimental treatment group obtained significantly higher scores than did the control group on the post-test measures of math achievement. The null hypothesis which stated that there would be no difference in math achievement as measured by ITBS between fourth-grade students who receive instruction by the computer and fourth-grade students whose instruction is limited to conventional methods must be rejected for these measures.

Hypothesis III

This hypothesis was restated in null form for statistical testing. In null form, Hypothesis III states

TABLE V

SUMMARY OF MEAN SCORES, STANDARD DEVIATION, AND VARIANCE OF MATH ACHIEVEMENT BY SCHOOLS*

		Mean Scores			Standard Deviation		Variance	
Schools	N	Pre-Test	Post-Test	Achievement	Pre-Test	Post-Test	Pre-Test	Post-Test
Experimental B	94	5.0181	5.7596	0.7415	1.0420	1.1360	1.0858	1.2904
Control A	77	4.9961	5.6909	0.6948	0.8419	0.9832	0.7088	0.9666
Experimental D	33	4.9424	5.9061	0.9637	0.8008	1.4232	0.6413	2.0256
Control C	38	4.8474	5.5421	0.6947	0.9099	1.0023	0.8280	1.0047
Experimental E	21	3.8857	4.8286	0.9429	0.4127	0.6987	0.1703	0.4881
Control F	37	3.6595	4.2703	0.6108	0.7837	0.8894	0.6141	0.7910

*Grade-equivalent scores

TABLE VI

SUMMARY OF OBSERVED MEANS, STANDARD DEVIATION, AND ADJUSTED MEANS FOR MATH ACHIEVEMENT

Groups	Observed Means	Standard Deviation	Adjusted Means
Experimental Pre-Test	4.82993	.99625	....
Experimental Post-Test	5.69864	1.10967	5.76187
Control Pre-Test	4.63355	1.00850	....
Control Post-Test	5.30789	1.12859	5.24674

that there will be no significant relationship between selected learning style elements and reading achievement with CAI as measured by *The Iowa Tests of Basic Skills*.

Relationship Between Reading Achievement and Selected Learning Style Elements

Learning style elements were defined as those elements identified by Dunn, Dunn, and Price that are characteristics which affect learners in the learning process and have been categorized as (1) environment (sound, light, temperature, and design); (2) emotional (motivation, persistence, responsibility, and structure); (3) sociological (self, pair, peers, team, adult, or varied); and (4) physical (perceptual, intake, time, mobility) (1) (see Appendix B). The elements -- motivation, prefers working alone or with peers, auditory, visual, tactile, and kinesthetic perceptions -- were chosen for this study.

A Pearson product-moment correlation coefficient (r) was calculated to determine the relationship between reading achievement and each selected learning style element. The reading pre-test was used as a control for the reading post-test achievement scores. These findings failed to establish a significant relationship at the .05 level of significance between any of the selected learning style elements and reading achievement.

Table VII presents the correlation coefficient, the r^2, and the probability level of the relationship between each selected learning style element and reading achievement. The probability level did not reach the prescribed .05 level of significance required to reject the null hypothesis.

In the case of relationship between selected learning style elements and reading achievement, the null hypothesis of no significant relationship is retained on the basis of these findings. None of the independent variables -- learning style elements -- related significantly to the post-test measures of the dependent variable, reading achievement.

Hypothesis IV

This hypothesis was restated in null form for statistical testing. In null form, Hypothesis IV states that there will be no significant relationship between selected learning style elements and math achievement with CAI as measured by _The Iowa Tests of Basic Skills_.

Relationship Between Math Achievement and Selected Learning Style Elements

As discussed previously, the selected learning style elements were chosen from those characteristics identified by Dunn, Dunn, and Price which affect learners in the learning process (1). An illustration representing

TABLE VII

SUMMARY OF PARTIAL CORRELATION COEFFICIENTS, r^2, AND PROBABILITY LEVELS FOR MEASURES TO SHOW RELATIONSHIP BETWEEN LEARNING STYLE ELEMENTS AND READING ACHIEVEMENT*

Learning Style Elements	Reading Achievement		
	Correlation	r^2	P
Motivation	.0544	.0000088	.565
Learning Alone	-.0061	.0000372	.949
Auditory	.0537	.0028837	.570
Visual	.0271	.0007344	.775
Tactile	.0105	.0001103	.912
Kinesthetic	.0626	.0039188	.508
Learning with Peers	.0313	.0009797	.741

*Controlled for reading pre-test

these learning style factors and their categories has been included in this study (see Appendix B).

A Pearson product-moment correlation coefficient was calculated to determine the relationship between math achievement and each selected learning style element. The math pre-test was used as a control for the math post-test achievement scores. These findings failed to establish a significant relationship at the .05 level of significance between any of the selected learning style elements and math achievement.

Table VIII presents the correlation coefficient, the r^2, and the probability level of the relationship between each selected learning style element and math achievement. The probability level did not reach the prescribed level of significance required to reject the null hypothesis.

In the case of relationship between selected learning style elements and math achievement, the null hypothesis of no significant relationship is retained on the basis of these findings. None of the independent variables, learning style elements, related significantly to the post-test measures of the dependent variable, math achievement.

Hypothesis V

This hypothesis was restated in null form for statistical testing. As such, Hypothesis V states that

TABLE VIII

SUMMARY OF PARTIAL CORRELATION COEFFICIENTS, r^2, AND PROBABILITY LEVELS FOR MEASURES TO SHOW RELATIONSHIP BETWEEN LEARNING STYLE ELEMENTS AND MATH ACHIEVEMENT*

Learning Style Elements	Math Achievement		
	Correlation	r^2	P
Motivation	-.0878	.0077088	.290
Learning Alone	.0067	.0000449	.936
Auditory	-.0489	.0023912	.557
Visual	-.0832	.0069222	.316
Tactile	.0432	.0018662	.603
Kinesthetic	-.0639	.0040832	.442
Learning with Peers	-.0208	.0004326	.803

*Controlled for math pre-test

no combination of selected learning style elements will be statistically significant in the prediction of reading achievement with CAI as measured by *The Iowa Tests of Basic Skills*.

Prediction of Reading Achievement

The selected learning style elements, as previously discussed, were chosen from those characteristics identified by Dunn, Dunn, and Price which affect learners in the learning process (1). As previously referenced, an illustration representing these learning style elements is included in this study (see Appendix B).

The Manova multiple regression procedure was used to determine which combination of selected learning style elements resulted in optimum reading achievement. This procedure is a mathematical method for predicting the most likely value of one variable from the values of other variables for a given case. The correlation coefficient measures the degree to which the regression equation produces accurate predictions. Also, the correlation coefficient is interpreted as a measure of the degree of relationship between variables (2).

In the multiple regression procedure, the strength of the predictor variables for predicting reading achievement was tested using all possible combinations of the selected learning style elements. Although these findings indicate that there was much variability among the selected learning style elements, the correlation coefficient failed to reach the .05 level of significance.

Table IX presents means and standard deviations of the dependent variable reading achievement and the independent variables learning style elements and the reading pre-test. These data provided the measures for the step-wise multiple regression procedure.

To adjust for differences in the population, the pre-test scores and time on task were entered as factors. Table X presents a summary of measures of the data as tested with the multiple regression procedure. The F-ratio failed to reach the prescribed .05 level of significance. Table XI presents a summary of the analysis of variance tested in the multiple regression. The obtained F-ratio failed to establish a relationship at the prescribed .05 level of significance.

A summary of the variables not in the equation of the multiple regression procedure is presented in Table XII. Also, Table XIII presents a summary of the variables in the equation of the multiple regression statistical procedure used for testing the predictive value for reading achievement and the strength of relationship between selected learning style elements and reading achievement. The only obtained T-ratio in these procedures which reached the .05 level of significance was the reading pre-test.

TABLE IX

SUMMARY OF MEANS AND STANDARD DEVIATIONS FOR READING ACHIEVEMENT AS TESTED BY MULTIPLE REGRESSION PROCEDURES*

Variable	Mean	Standard Deviation
Motivation	55.304	22.470
Learning Alone	.739	.441
Auditory	50.122	9.443
Visual	50.226	13.901
Tactile	52.786	13.481
Kinesthetic	56.165	12.778
Learning with Peers	.104	.307
Reading Pre-Test	5.448	1.365
Reading Post-Test	5.834	1.450

*N=115

TABLE X

SUMMARY OF MULTIPLE REGRESSION DATA
FOR PREDICTING READING ACHIEVEMENT

Measures	Coefficients
Multiple R	.66447
R Square	.44152
Adjusted R Square	.43657
Standard Error	1.08824
R Square Change	.44152
F Change	89.33329
Significance F Change	.00001

TABLE XI

SUMMARY OF ANALYSIS OF VARIANCE IN MULTIPLE REGRESSION
FOR PREDICTING READING ACHIEVEMENT

Procedures	DF	Mean Square	F	Significance of F
Regression	1	105.79595		
Residual	113	1.18427		
			89.33329	.001

TABLE XII

SUMMARY OF VARIABLES NOT IN THE EQUATION OF THE MULTIPLE REGRESSION FOR PREDICTING READING ACHIEVEMENT

Variable	Beta In	Partial	Min Toler	T	Significance of T
Motivation	.04096	.05443	.98620	.577	.5651
Learning Alone	-4.584E-03	.00608	.98229	-.064	.9488
Auditory	.04026	.05373	.99470	.569	.5702
Visual	.02027	.02712	.99997	.287	.7746
Tactile	8.041E-03	.01045	.94378	.111	.9121
Kinesthetic	.04678	.06257	.99901	.663	.5084
Learning with Peers	.02341	.03131	.99911	.331	.7409

TABLE XIII

SUMMARY OF VARIABLES IN THE EQUATION OF THE MULTIPLE REGRESSION FOR PREDICTING READING ACHIEVEMENT

Variable	B	Standard Error B	Beta	T	Significance of T
Reading Pre-Test	.70561	.07466	.66447	9.452	.001

On the basis of these analyses, the null hypothesis cannot be rejected in the case of significant predictive value of reading achievement with any possible combination of selected learning style elements and significant strength of relationship between selected learning style elements and reading achievement. None of the combinations of selected learning style elements significantly affected reading achievement post-test scores. On this basis, the null is retained.

Hypothesis VI

This hypothesis was restated in null form for statistical testing. In this case, Hypothesis VI states that no combination of selected learning style elements will be statistically significant in the prediction of math achievement with CAI as measured by *The Iowa Tests of Basic Skills*.

Prediction of Math Achievement

As previously discussed, the selected learning style elements were chosen from those characteristics identified by Dunn, Dunn, and Price which affect student learners in the learning process (1). As previously cited, a representation of these learning style elements is presented in this study (see Appendix B).

The Manova multiple regression procedure was used to determine which combination of selected learning style elements resulted in optimum math achievement. This procedure, as previously discussed, is a mathematical method used for predicting the most likely value of one variable from the values of other variables for a particular situation. The degree to which the regression equation produces accurate predictions is measured by the correlation coefficient. Also, the degree of relationship between variables is measured by the correlation coefficient (2).

The strength of the predictor variables for predicting math achievement was tested using all possible combinations of the selected learning style elements in the multiple regression procedure. Although these findings indicate that there was much variability among the selected learning style elements, the correlation coefficient failed to reach the .05 level of significance.

Table XIV presents means and standard deviations of the dependent variable, math achievement, and the independent variables, learning style elements, and the reading pre-test. These data provided the measures for the step-wise multiple regression procedure.

TABLE XIV

SUMMARY OF MEANS AND STANDARD DEVIATIONS
FOR MATH ACHIEVEMENT AS TESTED BY
MULTIPLE REGRESSION PROCEDURES*

Variable	Mean	Standard Deviation
Motivation	58.608	20.331
Learning Alone	.723	.449
Auditory	49.480	11.703
Visual	53.831	11.412
Tactile	52.297	11.586
Kinesthetic	56.574	10.416
Learning with Peers	.068	.252
Math Pre-Test	4.841	1.001
Math Post-Test	5.660	1.201

*N=148

In order to adjust for differences in the population, the pre-test scores and time on task were entered as factors. Table XV presents a summary of measures of the data as tested using the multiple regression procedures. The F-ratio failed to reach the prescribed .05 level of significance. Table XVI presents a summary of the analysis of variance tested in the multiple regression. The obtained F-ratio failed to establish a relationship at the .05 level of significance.

A summary of the variables not in the equation of the multiple regression is presented in Table XVII. Also, Table XVIII presents a summary of the variables in the equation of the multiple regression statistical procedures for testing the predictive value for math achievement and the strength of relationship between selected learning style elements and math achievement. The only obtained T-ratio in these procedures which reached the .05 level of significance was the math pre-test.

On the basis of these analyses, the null hypothesis cannot be rejected in the case of significant predictive value for math achievement with any possible combination of selected learning style elements and significant strength of relationship between selected learning style elements and math achievement. None of the possible

TABLE XV

SUMMARY OF MULTIPLE REGRESSION DATA FOR PREDICTING MATH ACHIEVEMENT

Measures	Coefficients
Multiple R	.63582
R Square	.40427
Adjusted R Square	.40019
Standard Error	.93015
R Square Change	.40427
F Change	99.07761
Significance of F Change	.00001

TABLE XVI

SUMMARY OF ANALYSIS OF VARIANCE IN THE MULTIPLE REGRESSION FOR PREDICTING MATH ACHIEVEMENT

Procedures	DF	Mean Square	F	Significance of F
Regression	1	85.71938		
Residual	146	.86517		
			99.07761	.0001

TABLE XVII

SUMMARY OF VARIABLES NOT IN THE EQUATION
OF THE MULTIPLE REGRESSION FOR
PREDICTING MATH ACHIEVEMENT

Variable	Beta In	Partial	Min Toler	T	Significance of T
Motivation	-.06788	-.08783	.99736	-1.062	.2901
Learning Alone	5.194E-03	.00671	.99502	.081	.9357
Auditory	-.03782	-.04889	.99567	-.589	.5565
Visual	-.06440	-.08321	.99450	-1.005	.3164
Tactile	.03338	.04324	.99979	.521	.6030
Kinesthetic	-.04977	-.06390	.98193	-.771	.4420
Learning with Peers	-.01604	-.02077	.99896	-.250	.8028

TABLE XVIII

SUMMARY OF VARIABLES IN THE EQUATION OF THE MULTIPLE REGRESSION FOR PREDICTING MATH ACHIEVEMENT

Variable	B	Standard Error B	Beta	T	Significance of T
Math Pre-Test	.76270	.07662	.63582	9.954	.0001

combinations of selected learning style elements significantly affected math achievement post-test scores. On this basis, the null is retained.

Non-Hypothesized Data

The data presented below provide additional findings of this study. These data were not relevant to any of the hypotheses which were formulated and tested. They are presented below as an ancillary part of the study and are intended to give additional insight into the total context in which the study was conducted.

Selected Learning Style Elements

The Learning Style Inventory measures an individual student's preference for learning by using a raw score which is converted to a standard score that ranges from twenty to eighty with a mean of fifty and a standard deviation of ten. Students who have a standard score of sixty or higher strongly prefer that area as a factor when learning. Individual students who have a standard score of forty or below do not prefer that factor when learning. Students having scores that fall between forty and sixty are varied with respect to how much importance is placed on a factor when learning (1).

Table XIX presents data that shows the number of students who have strong preferences for each selected learning style element. These findings indicate that more than one-half of the students demonstrated a score of being highly motivated. Also, more than fifty percent of the students indicated a preference to learn by using kinesthetic techniques. Almost half of the students showed a strong preference to the tactile learning modality. More students indicated a preference to learn through visual perceptions than auditory modes of learning. Few fourth-grade students show preference to learn with their peers.

Table XX presents data that illustrates the number of students who have indicated strong dislike for each selected learning style element. These data indicate that the majority of the fourth-grade students prefer to work alone while learning. Some students demonstrated scores of being highly unmotivated and some scores indicated a strong dislike for learning by auditory methods. Fewer students showed strong dislike to learn by tactile and kinesthetic techniques.

Table XXI presents the mean scores, standard deviation, and variance of each learning style element that was chosen for this study. These data show that variation was found among the learning style elements; however, the mean score indicates that in all elements, except learning alone or

TABLE XIX

SUMMARY OF STUDENTS BY SCHOOLS WHO HAVE LEARNING STYLE SCORES EQUAL TO OR GREATER THAN SIXTY*

Schools	Total Number of Students	Numbers of Students						
		Motivation	Learning Alone	Learning with Peers	Auditory	Visual	Tactile	Kinesthetic
A	77	51	...	5	16	11	30	48
B	94	69	...	8	25	33	38	58
C	38	16	...	8	15	17	20	30
D	33	16	...	2	9	11	15	21
E	21	15	...	2	4	8	9	15
F	37	20	...	3	12	13	10	17
Total	300	187	...	28	81	93	122	189

*Standard scores range from 20 to 80 with a mean of 50 and a standard deviation of 10. Scores of 60 or higher indicate a strong preference for that factor while learning except the element of learning alone or with peers which is calculated from one score. For this element the score of 60 or above indicates a preference to work with peers rather than work alone.

TABLE XX

SUMMARY OF STUDENTS BY SCHOOLS WHO HAVE LEARNING STYLE SCORES EQUAL TO OR LESS THAN FORTY*

Schools	Total Number of Students	Numbers of Students						
		Motivation	Learning Alone	Learning with Peers	Auditory	Visual	Tactile	Kinesthetic
A	77	13	83	...	15	5	9	11
B	94	15	80	...	13	4	10	10
C	38	17	32	...	5	1	4	6
D	33	9	33	...	6	0	5	6
E	21	3	10	...	0	0	0	0
F	37	9	21	...	22	0	2	4
Total	300	66	259	...	61	10	30	37

*Standard scores range from 20 to 80 with a mean of 50 and a standard deviation of 10. Scores of 40 or below indicate a strong dislike for that factor while learning except the element of learning alone or with peers which is calculated from one score. For this element the score of 40 or below indicates a preference to work alone rather than with peers.

TABLE XXI

SUMMARY OF MEAN SCORES, STANDARD DEVIATION, AND VARIANCE FOR SELECTED LEARNING STYLE ELEMENTS

Learning Style Element	Mean Scores	Standard Deviation	Variance
Motivation	56.9933	21.7265	472.0401
Learning Alone	0.7233	0.4481	0.2008
Auditory	50.0900	10.5451	111.1992
Visual	52.3867	12.3558	152.6660
Tactile	52.6600	11.8994	141.5964
Kinesthetic	56.2333	11.3534	126.3534
Learning with Peers	0.0833	0.2768	0.0766

*Standard scores range from 20 to 80 with a mean of 50 and a standard deviation of 10.

with peers, the score was within the range of not being important to the group.

Discussion of Findings

The data indicate that the subjects in the experimental treatment group had scores on the reading and math achievement measures which were significantly different from those of the control group in both hypothesized instances. The math experimental treatment group made more achievement gains than did the reading experimental treatment group. The reading control group made more achievement gains than did the reading experimental treatment group. In an attempt to account for the differences in achievement for these two experimental treatment groups, an examination of the nature of the academic area indicates a possible explanation.

Computer-assisted instruction is conducive to drill and practice of previously taught math concepts. Reading instruction involves the total communication process and is more difficult to isolate for appropriate drill and practice. The theoretical position of this study included the proposition that appropriate instruction resulted in increased academic achievement gains. To the extent that this argument is plausible, the theoretical position of this study received support.

Another finding in this study indicates that the variance measures increase for both math and reading post-test achievement in most of the experimental treatment groups. A possible explanation for the differences in the variability of scores between experimental treatment groups is the fact that computer-assisted instruction allows for individualization of instruction. The computer allows the student to progress individually without feeling pressure from classmates. This theoretical position was presented in the review of the literature and is supported in this study.

The findings related to the measures of relationship between reading and math achievement and selected learning style elements do support the theoretical position of the study as presented. Although there was no significant difference in reading and math achievement as related to one or any combination of learning styles, an examination of the variance measurements revealed a possible trend. While some students had strong preferences and strong dislikes concerning their mode of learning, the reading and math achievement scores using CAI were not impacted.

Summary

Chapter IV presents the findings of this study. Each of the six hypotheses was restated in null form for statistical analysis. The analysis of covariance using the pre-test scores and time on task as covariates was computed first. The analysis of covariance was used to determine student achievement in the areas of mathematics and reading. Also, this procedure was used to control for initial differences between groups, since the subjects were assigned for treatment by nonrandom classroom groups. This was followed by calculation of a Pearson product-moment correlation to measure relationship between reading and math achievement and each selected learning style element. Finally, multiple regression was used to determine which combination of selected learning style elements resulted in optimum achievement.

Hypotheses I and II were rejected. Significant differences were found between the experimental treatment groups and the control groups. The control groups were found to have significantly higher scores than the experimental treatment groups on post-test measures of reading; however, the math experimental treatment groups made significantly greater achievement gains than did the math control groups.

Hypotheses III, IV, V, and VI, stated in null form, were all retained. No relationship was found between selected learning style elements and achievement with computer-assisted instruction in reading and math. Also, no combination of selected learning style elements was found to be significantly predictive of achievement in math and reading.

CHAPTER BIBLIOGRAPHY

1. Dunn, Rita, Kenneth Dunn, and Gary E. Price, Learning Style Inventory Manual, Price Systems, Inc., Lawrence, Kansas, 1981, 2-3.

2. Klecka, William R., Norman H. Nie, and C. Hadlai Hull, Statistical Package For the Social Sciences Primer, McGraw-Hill Book Company, United States of America, 1975.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Many educators are making decisions to respond appropriately to the computerized information age. This study assessed the effectiveness of computer-assisted instruction in reading and math and attempted to determine the relationship between achievement of students using CAI in reading and math and selected learning style elements.

The broad theoretical basis for the study was a basic framework of learning theory of Dunn, Dunn, Price (1, 2), and others upon which a practice of instruction can be built. Applied to computer-assisted instruction, this theory suggests that learning style preferences affect student learning. Computer-assisted instruction has not been identified as a specific mode of learning; therefore, achievement is dependent on the software program that is presented by this technological tool. The theory further suggests that increased achievement occurs when the student's instruction is matched to the appropriate learning style for that individual. Appropriate instruction results in increased student achievement.

The nonequivalent control group design was employed to test the theoretical position and the six hypotheses resulting from this theory. Fourth-grade students from five pilot schools for computer-assisted instruction were selected as subjects for the study. One hundred fifteen students from two schools were assigned to experimental treatment groups for CAI in reading. The experimental treatment groups in math included 148 students from three schools. A matched control group was designated for each experimental treatment group.

The Iowa Tests of Basic Skills were given as pre-tests to both the experimental and control groups. The same test was administered as post-tests to all of the subjects. Also, the Learning Style Inventory was given to all fourth-grade students assigned to the study.

The reading experimental treatment consisted of the reading software package Diascriptive Reading by Educational Activities, Inc. The math experimental treatment was provided by the software package Milliken Math Sequences by the Milliken Publishing Company. The control groups received no treatment.

To determine achievement, the data from the pre-tests and post-tests were analyzed by computer by applying the analysis of covariance. Experimental treatment was the independent variable and the post-test scores of subjects in all groups were the criterion measures which were tested with the analysis of covariance. The pre-test and time on task were used as covariates. In an attempt to identify the relationship of selected learning style elements and achievement with computer-assisted instruction in reading and math, a Pearson product-moment correlation was calculated.

The relationship between the learning style scores and achievement were analyzed by using the multiple regression procedure. The selected learning style elements were the independent variables, and the dependent variable was achievement in math and reading. The step-wise regression procedure was used in an attempt to determine which combination of selected learning style elements resulted in optimum achievement. To adjust for differences in the population, the pre-test score was entered as a factor. The .05 level of significance was selected as necessary to reject the null hypothesis.

Findings

From the analysis of the statistical data presented in this study, the following findings were apparent.

1. The conventional method of teaching reading resulted in significantly higher scores than the experimental treatment of computer-assisted instruction.

2. The experimental treatment experience resulted in significantly higher scores than instruction by conventional methods in the areas of math.

3. There was no significant relationship between reading achievement and selected learning style elements.

4. There was no significant relationship between math achievement and selected learning style elements.

5. No combination of selected learning style elements was significant in the prediction of reading achievement with CAI.

6. No combination of selected learning style elements was significant in the prediction of math achievement with CAI.

Conclusions

Based on the findings of this investigation, the following conclusions seemed justified.

1. Computer-assisted instruction similar to the reading experimental treatment described in this study can be expected to result in less academic achievement than conventional instruction for fourth-grade students.

2. Computer-assisted instruction in math similar to the experimental treatment in this study can be expected to result in significantly greater achievement gains for fourth-grade students.

3. Reading achievement as a result of computer-assisted instruction similar to the experimental treatment described in this study for fourth-grade students cannot be expected to relate significantly to selected learning style elements.

4. Math achievement as a result of computer-assisted instruction similar to the experimental treatment described in this study for fourth-grade students cannot be expected to relate significantly to selected learning style elements.

5. No combination of selected learning style elements can be expected to significantly predict reading achievement with computer-assisted instruction similar to the experimental treatment described in this study for fourth-grade students.

6. No combination of selected learning style elements can be expected to significantly predict math achievement with computer-assisted instruction similar to the experimental treatment described in this study for fourth-grade students.

Recommendations

On the basis of the findings, conclusions, and personal observations of this study, the ensuing recommendations are tendered.

1. The findings and conclusions indicated that the experimental treatment was effective in increasing student achievement in math but not reading for fourth-grade students. Therefore, it is recommended that computer-assisted instruction in math be offered as a part of the student's instructional program and be considered as a useful tool for the teacher.

2. Since the reading experimental treatment did not result in significant achievement gains, it is recommended that other reading software packages be tested for instructional effectiveness.

3. This study was concerned with identifying learning style elements as measured by one instrument. It is recommended that further research be conducted utilizing other instruments for measuring learner characteristics.

4. The immediate and long term effects of CAI should be compared with conventional methods of instruction to determine sustained effects.

5. Computer-assisted instruction is dependent on the software that is available for the computer. It is recommended that further research be conducted to determine the instructional characteristics of an effective CAI program.

6. The effectiveness of any instructional program is dependent on implementation and management of the program. It is recommended that further research be conducted in an attempt to identify the management characteristics of an effective CAI program.

CHAPTER BIBLIOGRAPHY

1. Dunn, Rita and Kenneth Dunn, Teaching Students Through Their Individual Styles: A Practical Approach, Reston Publishing Company, Inc., Reston, Virginia, 1978.

2. Dunn, Rita, Kenneth Dunn, and Gary E. Price, Learning Style Inventory Manual, Price Systems, Inc., Lawrence, Kansas, 1981, 2-3.

APPENDIX A

LEARNING STYLE INVENTORY

(LSI)

LEARNING STYLE INVENTORY

by
Rita Dunn, Ed. D.

Kenneth Dunn, Ed. D.

Gary E. Price, Ph. D.

Directions:

This inventory has several statements about how people like to learn. Answer each question based on how you would like to study or concentrate, if you had something new or difficult to learn.

If your answer sheet has T and F on it answer T if the statement is usually True for you and F if the statement is usually False for you. If your answer sheet has SD, D, U, A, and SA on it, answer SD if you Strongly Disagree, D if you Disagree, U if you really do not know if the statement is true for you (Undecided), A if you Agree, and SA if you Strongly Agree with the statement.

You should give your immediate or first reaction to each question. Please answer each question on the separate answer sheet. Do not write on this booklet.

Before you begin to answer the questions, blacken the circle for your name, sex, grade and any other information called for in the space provided on the answer sheet with a no. 2 pencil.

Remember, try to answer each question.

Now open the booklet and start with question 1.

P.O. Box 3067, Lawrence, Kansas 66044

1. I study best when it is quiet.
2. My parents want me to get good grades.
3. I like studying with lots of light.
4. I like to be told exactly what to do.
5. I concentrate best when I feel warm.
6. I study best at a table or desk.
7. When I study I like to sit on a soft chair or couch.
8. I like to study with one or two friends.
9. I like to do well in school.
10. I usually feel more comfortable in warm weather than I do in cool weather.
11. Things outside of school are more important to me than my school work.
12. I am able to study best in the morning.
13. I often have trouble finishing everything I ought to do.
14. I have to be reminded often to do something!
15. I like making my teacher proud of me.
16. I study best when the lights are dim.
17. When I really have a lot of studying to do I like to work alone.
18. I do not eat or drink, or chew while I study.
19. I like to sit on a hard chair when I study.
20. Sometimes I like to study alone and sometimes with friends.
21. The things I remember best are the things I read.
22. I think better when I eat while I study.
23. I like others to outline how I should do my school work.
24. I often nibble something as I study.
25. It's hard for me to sit in one place for a long time.
26. I remember things best when I study them early in the morning.
27. I really like people to talk to me.
28. I hardly ever finish all my work.
29. I usually start my homework in the afternoon.
30. There are many things I like doing better than going to school.
31. I like to feel inside what I learn.
32. Sound usually keeps me from concentrating.
33. If I have to learn something new, I like to learn about it by having it told to me.
34. At home I usually study under a shaded lamp while the rest of the room is dim.
35. I really like to do experiments.
36. I usually feel more comfortable in cool weather than I do in warm weather.
37. When I do well in school, grown-ups in my family are proud of me.
38. It is hard for me to do my school work.
39. I concentrate best when I feel cool.
40. I like to sit on carpeting or rugs when I study.
41. I think my teacher feels good when I do well in school.
42. I remember to do what I am told.
43. I really like to watch television.
44. I can block out sound when I work.
45. I am happy when I get good grades.
46. I like to learn most by building, baking or doing things.
47. I usually finish my homework.

GO ON TO NEXT PAGE

48. If I could go to school anytime during the day, I would choose to go in the early morning.
49. I have to be reminded often to do something.
50. It is hard for me to get things done just before lunch.
51. It is easy for me to remember what I learn when I feel it inside of me.
52. I like to be told exactly what to do.
53. My parents are interested in how I do in school.
54. I like my teacher to check my school work.
55. I enjoy learning by going places.
56. When I really have a lot of studying to do I like to work alone.
57. I like adults nearby when I work alone or with a friend.
58. I can sit in one place for a long time.
59. I cannot get interested in my school work.
60. I really like to draw, color, or trace things.
61. The things I remember best are the things I hear.
62. I remember things best when I study them in the afternoon.
63. No one really cares if I do well in school.
64. I really like to shape things with my hands.
65. When I study I put on many lights.
66. I like to eat or drink, or chew while I study.
67. When I really have a lot of studying to do I like to work with a group of friends.
68. When it' s warm outside I like to go out.
69. I remember things best when I study them early in the morning.
70. I can sit in one place for a long time.
71. I often forget to do or finish my homework.
72. I like to make things as I learn.
73. I can think best in the evening.
74. I like exact directions before I begin a task.
75. I think best just before lunch.
76. The things I like doing best in school I do with friends.
77. I like adults nearby when I study.
78. My family wants me to get good grades.
79. Late morning is the best time for me to study.
80. I like to learn most by building, baking or doing things.
81. I often get tired of doing things and want to start something new.
82. I keep forgetting to do the things I' ve been told to do.
83. I like to be able to move and experience the motion and the feel of what I study.
84. When I really have a lot of studying to do I like to work with two friends.
85. I like to learn through real experiences.
86. If I could go to school anytime during the day, I would choose to go in the early morning.
87. The thing I like doing best in school, Ido with a grown-up.
88. I can ignore most sound when I study.
89. If I have to learn something new, I like to learn about it by seeing a filmstrip or film.
90. I study best near lunchtime.
91. I like school most of the time.

GO ON TO NEXT PAGE

92. I really like to listen to people talk.

93. I often eat something while I study.

94. I enjoy being with friends when I study.

95. It's hard for me to sit in one place for a long time.

96. I remember things best when I study them before evening.

97. I think my teacher wants me to get good grades.

98. The thing I like doing best in school I do with grown-ups.

99. I really like to build things.

100. I can study best in the afternoon.

101. Sound bothers me when I am studying.

102. When I really have a lot of studying to do I like to work with two friends.

103. When I can, I do my homework in the afternoon.

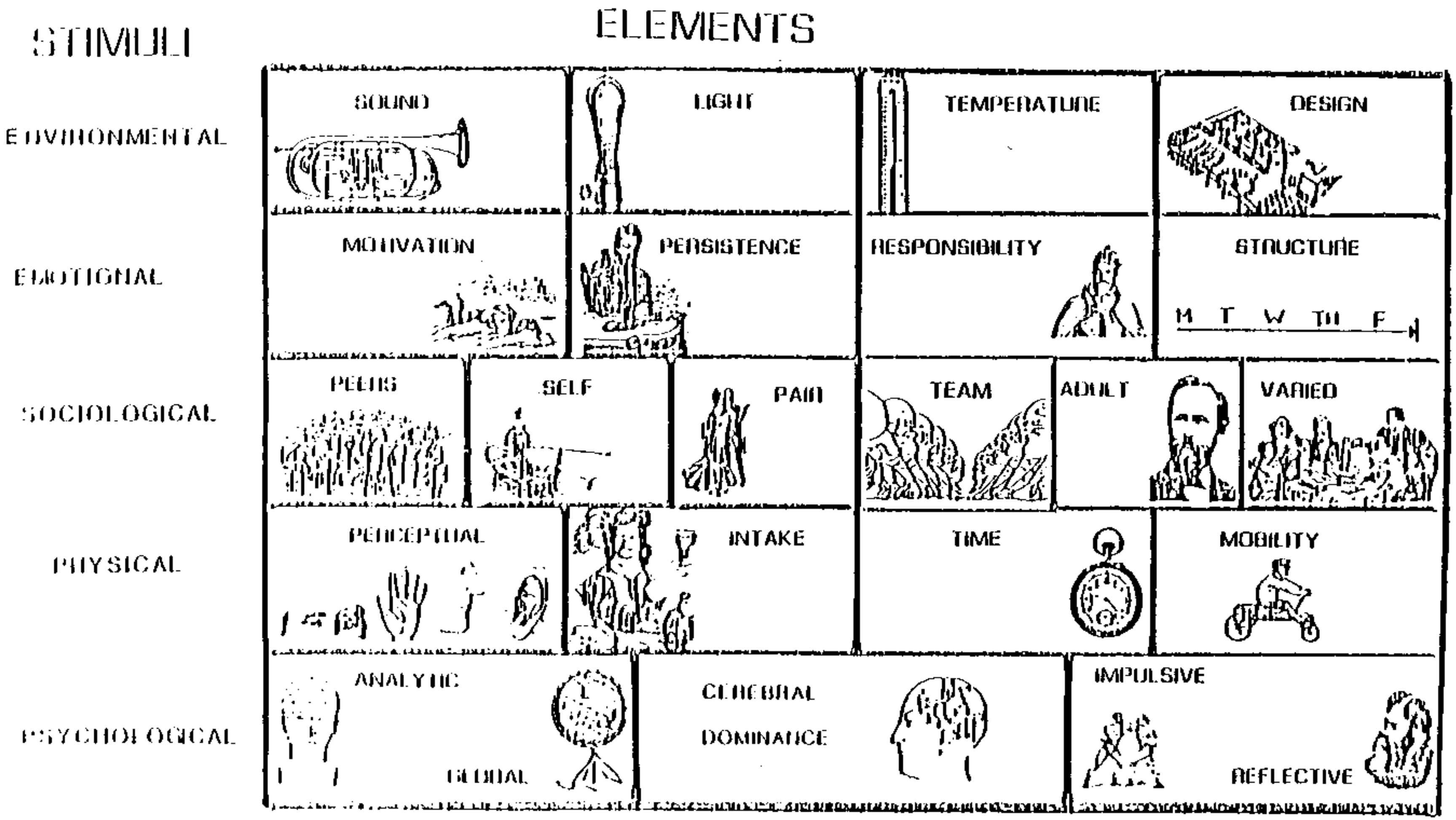
104. I love to learn new things.

STOP

APPENDIX B

DIAGNOSING LEARNING STYLES

DIAGNOSING LEARNING STYLES



DESIGNED BY: RITA DUNN
KENNETH DUNN

BIBLIOGRAPHY

Books

Borg, Walter R. and Meredith Damien Gall, Educational Research An Introduction, Longman, Inc., New York, 1979.

Campbell, D. R. and J. C. Stanley, Experimental and Quasi-Experimental Designs for Research, Chicago, Rand McNally and Co., 1963.

Dunn, Rita and Kenneth Dunn, Teaching Students Through Their Individual Learning Styles: A Practical Approach, Reston Publishing Company, Inc., Reston, Virginia, 1978.

Articles

Barbe, Walter B. and Michael N. Milone, Jr., "Teaching Through Modality Strengths: Look Before You Leap," Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

____________________, "What We Know About Modality Strengths," Educational Leadership, XXXVIII (February, 1981), 378-380.

Bracey, Gerald W., "What the Research Shows," Electronic Learning, II (November/December, 1982), 51-54.

Brandt, Ron, "Early Results of Computer-Based Reading and Writing Program Impressive," ASCD Update, XXVI (February, 1984), 2.

Callison, William, "The Potential is Great: Problems and Possibilities for Computer-Assisted Instruction," National Association of Secondary School Principals, CDXLV (May, 1981), 25-27.

Canfield, Albert A., "Learning Styles: Whither Thou Goest?," Learning Styles Network Newsletter, IV (Summer, 1983), 4.

Carbo, Marie, "Reading Styles Change Between Second and Eighth Grade," Educational Leadership, XL (February, 1983), 56-59.

____________, "Reading Styles: Key to Preventing Reading Failure," Student Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

Carman, Gary O. and Bernard Kosberg, "Educational Technology Research: Computer Technology and the Education of Emotionally Handicapped Children," Educational Technology, XXII (February, 1982), 26-30.

Carrier, Carol A., "The Role of Learner Characteristics in Computer-Based Instruction," NSPI Journal, XVIII (June, 1979), 25-26.

Carruth, Ronald E., "An Alternative; Not a Solution," Phi Delta Kappan, LVIII (February, 1977), 455.

Cavanaugh, David P., "Meeting the Needs of Individuals Through Their Learning Styles," Student Learning Styles: Diagnosing and Prescribing Programs, National Association of Secondary School Principals, Reston, Virginia, 1979.

___________________, "Student Learning Styles: A Diagnostic/Prescriptive Approach to Instruction," Phi Delta Kappan, LXIII (November, 1981), 202-203.

Cicchelli, Jerry J. and Edgar L. Richards, "Incorporating Microcomputers into the Classroom: The Mahopac Central School District Experience," ERS Spectrum, I (Summer, 1983), 42-47.

Cody, Corinne, "The Gifted Differ Dramatically From Average Students," Learning Styles Network Newsletter, IV (Autumn, 1983), 3.

Cosky, Michael J., "Computer-Based Instruction and Cognitive Styles: Do They Make a Difference," Resources In Education, XVI (September, 1981), 1-19.

Davidman, Leonard, "Learning Style: The Myth, The Pacacea, The Wisdom," Phi Delta Kappan, LXII (May, 1981), 641-645.

Davis, Dorothy S. and Phyllis Chiasson Schwimmer, "Style a Manner of Thinking," Educational Leadership, XXXVIII (February, 1981), 376-377.

Delforge, Clarence and Alfred E. Bloeser, "Computer-Assisted Instruction Credited With Raising Low Math Scores," Resources in Education, CXLIII (January, 1981), 1-7.

Deringer, Dorothy K., "The New Federalism: A Do-It-Yourself Approach to Computers in Education," T.H.E. Journal, IX (May, 1982), 90-94.

Dunn, Kenneth, "Madison Prep: Alternative to Teenage Disaster," Educational Leadership, XXXVIII (February, 1981), 386-387.

Dunn, Rita, "A Learning Styles Primer," Educational Leadership, LX (May, 1981), 31-34.

__________, "Can Students Identify Their Own Styles?," Educational Leadership, XL (February, 1983), 60-62.

__________, "Coming to Grips with Misconceptions: Who is Most Alert in the Morning," Learning Styles Network Newsletter, IV (Summer, 1983), 2.

__________, "Learning: A Matter of Style," Educational Leadership, XXXVII (April, 1980), 598-599.

__________, "Learning Styles," Educational Leadership, XXXVIII (May, 1980), 663.

__________, "You've Got Style," Early Years, XIII (January, 1983), 25-27.

Dunn, Rita and Marie Carbo, "Modalities: An Open Letter to Walter Barbe, Michael Milone, and Raymond Swassing," Educational Leadership, XXXVIII (February, 1981), 381-382.

Dunn, Rita and Kenneth Dunn, "How to Diagnose Learning Styles," Instructor, LXXXVII (September, 1977), 123-144.

__________________________, "Learning Styles/Teaching Styles: Should They...Can They...Be Matched?," Educational Leadership, XXXVI (January, 1979), 238-244.

Dunn, Rita, Kenneth Dunn, and Gary E. Price, "Diagnosing Learning Styles: A Prescription for Avoiding Malpractice Suits," Phi Delta Kappan, LVIII (January, 1977), 418-420.

__________, __________, and __________, "Learning Styles: Research vs. Opinion," Phi Delta Kappan, LXII (May, 1981), 645-646.

Dunn, Rita and others, "Learning Style Researchers Define Differences Differently," Educational Leadership, XXXVIII (February, 1981), 372-375.

Dunn, Rita, Gary E. Price, Kenneth Dunn, and William Sanders, "Relationship of Learning Style to Self-Concept," The Clearing House, LIII (November, 1979), 155-158.

Estes, Nolan, "Dallas at the Forefront," Phi Delta Kappan, LVIII (February, 1977), 456.

Fantini, Mario D., "Comprehensive, Timely, Feasible," Phi Delta Kappan, LVIII (February, 1977), 459.

Fischer, Barbara Bree and Louis Fischer, "Styles in Teaching and Learning," Educational Leadership, XXXVI (January, 1979), 245-254.

Goodlad, John I., "An Array of Education Agencies," Phi Delta Kappan, LVIII (February, 1977), 454-455.

Gregorc, Anthony F., "Learning Style/Brain Research: Harbinger of an Emerging Psychology," Student Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

__________, "Learning/Teaching Styles: Potent Forces Behind Them," Educational Leadership, XXXVI (January, 1979), 234-236.

Hayes, Jeanne, "School Districts Using Microcomputers: A National Survey," ERS Spectrum, I (Summer, 1983), 33-41.

Hopkins, Martha H., "The Diagnosis of Learning Styles in Arithmetic," Arithmetic Teacher, XXV (April, 1978), 47.

Hopmeier, George, "New Study Says CAI Favors Introverts," Electronic Education, I (September, 1981), 16-17.

Howe, Harold, II, "Computers: The New Kick in the Schools," The College Board Review, CXXVIII (Summer, 1983), 24-31.

Hruska, Sheryl Reichman, "Learning Styles: A Personal Approach," Learning Styles Network Newsletter, V (Winter, 1984), 4.

Hunt, David E., "Learning Style and the Interdependence of Practice and Theory," Phi Delta Kappan, LXII (May, 1981), 647.

Jay, Timothy, "The Cognitive Approach to Computer Courseware Design and Evaluation," Educational Technology, XXIII (January, 1983), 22-25.

Keefe, James W., "Assessing Student Learning Styles: An Overview," Student Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

_______________, "Learning Styles: An Overview," Student Learning Styles, Diagnosing and Prescribing Programs, National Association of Secondary School Principals, Reston, Virginia, 1979.

Kulik, James A., "Synthesis of Research on Computer-Based Instruction," Educational Leadership, XLI (September, 1983), 19-21.

_______________, Robert L. Bangert, and George W. Williams, "Effects of Computer-Based Teaching on Secondary School Students," Journal of Educational Psychology, LXXV (February, 1983), 19-26.

McKinney, Jane R., "North Carolina Research Project Changes Teachers' Behaviors," Learning Styles Network Newsletter, IV (Autumn, 1983), 6.

Magero, James, "Study Comparing the Effectiveness of Two Computer-Assisted Instructional Design Formats and Subsequently Correlating Individual Learning Style to Performance," Dissertation Abstracts International, XL (April, 1980), 5291-A.

Marcus, Lee, "Learning Style and Ability Grouping Among Seventh Grade Students," Clearing House, VIII (April, 1979), 377-380.

Martin, Michael Kenneth, "Effects of the Interaction Between Students' Learning Styles and High School Instructional Environment," Dissertation Abstracts International, XXXIX (1977), 96-A.

Meaney, John Patrick, "An Analysis of Two Modes of Instructional Design Based on Hill's Model of Educational Cognitive Style," Dissertation Abstracts International, XLIII (September, 1982), 1124-A.

Melmed, Arthur S., "Information Technology for U.S. Schools," Phi Delta Kappan, LXIII (January, 1982), 308-311.

________________, "Productivity and Technology in Education," Educational Leadership, XL (February, 1983), 4-6.

Offerman, Donald H., "TAEDS Promotes Computer Literacy," Texas Lone Star, I (February, 1983), 14.

Papert, Seymour, "Computers Are Objects to Think With," Instructor, XCI (March, 1982), 86-89.

________________, "Society Will Balk, But the Future May Demand a Computer for Each Child," Electronic Education, I (December, 1981), 5-6, 31.

Price, Gary E., "Learning Style Inventory Development and Continuing Research," Student Learning Styles and Brain Behavior, National Association of Secondary School Principals, Reston, Virginia, 1982.

________________, Rita Dunn, and William Sanders, "Reading Achievement and Learning Style Characteristics," The Clearing House, LIV (January, 1981), 223-226.

Saracho, Olivia N., "The Effects of a Computer-Assisted Instruction Program on Basic Skills Achievement and Attitudes Toward Instruction of Spanish-Speaking Migrant Children," American Educational Research Journal, XIX (Summer, 1982), 201-219.

Schmeck, Ronald R., "Improving Learning by Improving Thinking," Educational Leadership, XXXVIII (February, 1981), 384-385.

_______________ and Dan Lockhart, "Introverts and Extroverts Require Different Learning Environments," Educational Leadership, XL (February, 1983), 54-55.

Shane, Harold G., "The Silicon Age and Education," Phi Delta Kappan, LXIII (January, 1982), 303-308.

Sullivan, Janet, "Design Can Turn Micros Into Maxis," Electronic Education, I (December, 1981), 20-21.

Swenson and Anderson, "The Role of Motivation in Computer-Assisted Instruction," Creative Computing, VIII (October, 1982), 134-139.

Thies, Armin P., "A Brain Behavior Analysis of Learning Styles," Student Learning Styles: Diagnosing and Prescribing Programs, National Association of Secondary School Principals, Reston, Virginia, 1979.

Tyack, David B., "Educational Moonshot?," Phi Delta Kappan, LVIII (February, 1977), 457-458.

White, Mary Alice, "Synthesis of Research on Electronic Learning," Educational Leadership, XL (May, 1983), 13-15.

Wilde, Jane H., "Computers May Help Basic Skills Students Improve Their Status," Electronic Education, I (December, 1981), 27-28.

Wren, Matilda, "Youngstown Experiments With Reading Through Modalities," Learning Styles Network Newsletter, IV (Autumn, 1983), 6.

ERIC Materials

Blakeway, Edward G., "Drill, Practice, and Testing Applications for the Reluctant Learner and Teacher of Mathematics: Elementary and Secondary," Paper presented at the Annual Conference of the National Association of Users of Computer Applications to Learning, Portland, Oregon, ED 139 621, (October, 1976).

Grocke, Margaret, "Interactive Development of Reading Skills in an Educational Clinic," Paper presented at the Annual National Conference of the Australian Group for the Scientific Study of Mental Deficiency, ED 223 993 (September, 1982).

Litman, George H., "CAI In Chicago," Paper presented at the Association for Educational Data Systems Annual Convention, New Orleans, Louisiana, ED 087 423, (April, 1973).

Lysiak, Fae and others, "Computer-Assisted Instruction," Evaluation Report, Fort Worth Independent School District, Fort Worth, Texas, ED 140 495, (September, 1976).

Palmer, Henry, "Three Evaluation Reports of Computer-Assisted Instruction in Drill and Practice Mathematics," Paper presented at the Association for Educational Data Systems Annual Convention, New Orleans, Louisiana, ED 087 422, (April, 1973).

Papert, Seymour, "Computers and the Learning Society," A statement presented at hearings held by the House of Representatives Science and Technology Subcommittee on International Scientific Planning, Analysis, and Cooperation, ED 162 643, 1978.

Von Feldt, James B., "An Introduction to Computer Applications in Support of Education," ED 160 044, (August, 1977).

___________________, "An Overview of Computers in Education," ED 160 043, (March, 1977).

Reports and Bulletins

Elliot, Charles A., "The Effects of Instructional Designs Matched to Individual Differences in Cognitive Styles on Concept Learning: A Trait-Treatment Interaction Study," Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, California, (April, 1976).

Martin, Marilyn A., "Cognitive Styles and Instructional Variables," Paper presented at the Annual Conference of the American Education Research Association, New York City, New York, 1982.

Price, Gary E., Rita Dunn, and Kenneth Dunn, Learning Style Inventory, Research Report, Price Systems, Inc., Lawrence, Kansas, 1977.

Manuals and Instruments

Dunn, Rita, Kenneth Dunn, and Gary E. Price, Learning Style Inventory Manual, Price Systems, Inc., Lawrence, Kansas, 1981, 2-3.

________________, Learning Style Inventory, Price Systems, Inc., Lawrence, Kansas, 1978.

Hieronymus, A. N. and others, The Iowa Tests of Basic Skills Teachers Guide, University of Iowa at Iowa City, 1979.

________________, The Iowa Tests of Basic Skills, University of Iowa at Iowa City, 1979.

Price, Gary E., Rita Dunn, and Kenneth Dunn, Learning Style Inventory/Productivity Environmental Preference Survey, Interpretive Booklet, Price Systems, Inc., Lawrence, Kansas, 1982.

Unpublished Materials

Carbo, Marie L., "An Analysis of the Relationship Between Modality Preferences of Kindergarteners and Selected Reading Treatments as They Affect the Learning of a Basic Sight-Word Vocabulary," Doctoral Dissertation, St. John's University, 1980.

Kaley, Stephanie Beth, "Field Dependence/Independence and Learning Styles in Sixth Graders," Doctoral Dissertation, Hofstra University, 1977.

Weinberg, Fredrick H., "An Experimental Investigation of the Interaction Between Modality Preference and Mode of Presentation in the Instruction of Arithmetic Concepts to Third Grade Underachievers," Doctoral Dissertation, St. John's University, 1983.

Wheeler, Roberta, "An Investigation of the Degree of Academic Achievement Evidenced When Second Grade, Learning Disabled Students' Perceptual Strengths Are Matched and Mismatched with Complementary Sensory Approaches to Beginning Reading Instruction," Doctoral Dissertation, St. John's University, 1983.

Interviews

Dunn, Rita, St. John's University, New York City, New York, Interview held in Dallas, Texas, June, 1983.