A COMPARISON OF TECHNOLOGICAL AND TRADITIONAL METHODS OF MATHEMATICS INSTRUCTION AND ACHIEVEMENT OF SIXTH GRADE STUDENTS

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A COMPARISON OF TECHNOLOGICAL AND TRADITIONAL METHODS OF MATHEMATICS INSTRUCTION AND ACHIEVEMENT OF SIXTH GRADE STUDENTS

A Field Study

Presented to

the Graduate Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Specialist in Education

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by

Barney Hughes

To the Graduate Council:

I am submitting herewith a Field Study written by Barney Hughes entitled "A Comparison of Technological and Traditional Methods of Mathematics Instruction and Achievement of Sixth Grade Students." I recommend that it be accepted in partial fulfillment of the requirement for the Specialist in Education degree.

Allan E. Williams
Major Professor

We have read this field study and recommend its acceptance:

Fred Bunger
Second Committee Member

Curtis B. Burns
Third Committee Member

Accepted for the Graduate Council:

Wayne E. Slamp
Dean of the Graduate School

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Chapter 1

INTRODUCTION

The improvement of mathematics instruction has long been a major concern of educators at all levels of the profession. The continual search for appropriate teaching methods is also apparent in the literature. No aspect of the mathematics process is an exception. Procedures for correcting mathematics deficiencies of students continue to receive attention. Similarly, increased interest has been focused on elementary students and corrective mathematics programs.

One technological system currently employed as a means toward the improvement of students' mathematics performance is Programed Instruction (PI). Although PI is the only method used in this study, it is a type of self-instructional material and a teaching strategy.

Concurrent with the interest in educational technology as a means for teaching mathematics has been the rising concern for consideration of varied student characteristics in the selection of instructional procedures. Among the variables considered for this study when attempting to match learning tasks to individual students were: sex differences, IQ and achievement level. Existing studies of PI (in this study the Hoffman Mathematics Information System was used) have dealt primarily with its effectiveness in raising achievement levels.

There have been relatively few studies emphasizing the interaction of PI and student characteristic variables.

The primary purpose of this study was to compare the effectiveness of a commercial technological system of mathematics instruction to traditional methods employed by the school system. The achievement of common cognitive objectives of both programs was assessed.

The second purpose of this study was to compare the achievement of students with common characteristics. The selection of characteristics studied was based on affective objectives and motivational orientation of subjects in both programs. The interaction of sex and treatment of variables was examined.

THE PROBLEM

Statement of the Problem

This study proposed to compare the effectiveness of the application of a technological system for teaching mathematics to the method of instruction presently used in the school system's mathematics program (hereafter referred to as traditional) for selected sixth grade students achieving in stanine 2, 3 and 4 according to the mathematics section of the California Test of Basic Skills, hereafter referred to as C.T.B.S.

Hypothesis

Sixth grade students who were identified as low achievers in mathematics computation achieved higher stanine scores, when provided with a supplementary program of technological instruction, than similar students who were instructed in the traditional method only.

Significance and Need for the Study

Recent publications by the U. S. Department of Health, Education, and Welfare have reported student achievement in mathematic skills has declined in recent years.

The purpose of this study was to test the validity of current theories which state mathematics achievement by students can be increased through the use of a technological system of instruction that is supplementary to the regular mathematics instructional program. Significantly, schools today, must, therefore, provide appropriate programs that lead to academic success and provide experiences for children before they experience failure.

Limitations of the Study

Since this study was conducted in a rural public school setting the inability to control all variables was expected. Thus, the following restrictions were accepted as limiting the study:

1. Although all teachers taught mathematics classes and were identified by the school system as regular classroom teachers, variances in experience and competence were expected. To limit these variables only one sixth grade teacher was assigned to teach the experimental group (E_1). Subjects in the control group (C_1) were taught by another sixth grade teacher.

2. The study was also limited to a selection of twenty sixth-grade students, both male and female, who met the specific criterion of scoring in 2, 3 and 4 stanines of the mathematics computation section of the C.T.B.S. and whose raw scores ranged from fifteen to thirty-three.

3. The actual treatment time for the project was six weeks. Interpretation of final results had to be in relation to this time factor.

4. The amount of error inherent in the validity and reliability of any measuring instrument, including those used in this study, may also be considered a limitation.

DEFINITION OF TERMS

Traditional Method

The control or traditional method used is the usual approach to teach mathematics skills in the project school providing the setting for this study. Emphasis is primarily on mathematics instruction. This method may include any teaching strategy or material except those included in the Hoffman Mathematics Information System. Each teacher is provided a course of study by the school system. A specific program of treatment was not planned for these individual students.

Technological Methods

The technological method is the Hoffman Mathematics Information System, a commercial program for mathematics instruction. It is a program of mathematics skills sequentially ordered by level of difficulty and presented in small steps. A film strip containing several frames is inserted into an electro-mechanical device which projects a colored picture or numbers on a small screen. A disc inserted into the machine provides a recorded audio narrative. Lessons recorded on the disc are synchronized with each frame presented on the screen. Students write answers on paper in response to instructions projected on the screen which are simultaneously heard through ear phones. A junction box is provided so that ten students may participate with ear phones during a regular sitting.

Stanine

The California Test of Basic Skills was used to assess the achievement of the subjects in this study. The test assessed the pupil's vocabulary, comprehension, spelling, mechanics and expression in the reading section. It assessed the computation, concepts and application of achievement skills in mathematics. Reference skills, science and social studies achievement are also assessed.

An individual test profile card is furnished for each student for recording the achievement of each of the areas tested. On the card is recorded, horizontally, the students' raw score from 00 to 99. The card is also divided into nine areas with numbers 1 to 9 horizontally. The lowest area of achievement is numbered 1, 2, and 3. The achievement scores falling within this range are labeled below average or in Stanine 1, 2 or 3. Achievement scores falling within the area of numbers 4, 5 and 6 are labeled average; scores falling within the achievement range of 7, 8 and 9 are labeled above average. The subjects selected for this study were chosen from the achievement area of Stanine 2, 3 and 4.

METHOD AND PROCEDURE

Procedures for the collection and analysis of data for this study are described as follows.

Collection of Data

The California Test of Basic Skills (C.T.B.S.) was administered as a screening device to two sixth-grade classes, consisting of 75 students, prior to the selection of subjects used in this study. Data for final analysis purposes were collected through the administration of a posttest, namely the C.T.B.S. As information was collected on the groups listed below, forms were designed for this particular investigation.

Selection of Subjects

From a total sample of 75 sixth-grade students, ten matched pairs, both male and female, were chosen for this study. An experimental group (E_1), consisting of ten students, were assigned to receive supplemental technological instruction by the use of the Hoffman Mathematics Information System. A complete description and use of this machine will be found in Chapter 3 of this study. The control group (C_1) also consisted of ten students and were instructed in the traditional method only. Subjects in both groups were matched on age, sex, and raw scores achieved on the C.T.B.S., and on stanines 2, 3 and 4 of the same test.

Instrumentation

The California Test of Basic Skills was administered as a pre-screening device of two sixth grade classes. The selected subjects for groups E_1 and C_1 were given post-tests after six weeks of instruction to determine progress and to measure performance, change and achievement.

Tabulation and Treatment of Data

As tests were administered and scored, results were recorded on collection forms designed for this study. Procedures used in the selection of data-gathering instruments and general administration of this study are described in Chapter 3.

ORGANIZATION OF THE STUDY

A general introduction, statement of the problem, hypothesis, significance of the study, limitations of the study, definition of terms, procedures and organization of the study are provided in Chapter 1.

A review of related literature and selected research, dealing with technological instruction are discussed in Chapter 2.

Detailed information related to selection of subjects, assignment to instructional groups, types of instruments used, treatment of methods and the research design to be used in the analysis of data, are presented in Chapter 3.

The analysis of data collected in the investigation with appropriate descriptive information regarding its interpretation is included in Chapter 4.

A final summary of findings, conclusions, implications and recommendations related to the investigation are contained in Chapter 5.

Chapter 2

REVIEW OF RELATED LITERATURE

The review of related literature presented in this chapter deals primarily with the evolution of Programed Instruction (PI) and current research concerning its application. It provides a brief summary of two divergent theoretical views of learning and teaching, one of which serves as a basis of PI. The remainder of the review presents the varying characteristics of PI, current research relative to its instructional effectiveness, and its relationship to specific characteristics of learners.

Historical Perspective

A study of the historical perspective of instructional technology clarifies its contemporary educational meaning. Saettler[1] has traced its origin to the ancient Greeks, who used a crude behaviorial taxonomy to teach rhetoric. Systematic instruction extended into the Middle Ages. Catechisms were often dictated by the teacher for students to memorize. The cathechetical form sequenced behaviors to produce an imitative response. Comenius maintained all things could be taught to all people

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[1]Paul A. Saettler, A History of Instructional Technology (New York: McGraw-Hill Book Company, 1968), pp. 12-17.

by the use of the proper methods. His method set forth in The Great Didactic is illustrated in Orbis Sensualism Pictus (The World of Sense Objects) published in 1658.[2] His ideas for presenting picture and word symbol associations have been incorporated into many current textbooks. Little was done to implement Comenius' instructional method in the classroom until Pestalozzi focused in providing content and ideas through first hand experiences. Elizabeth Lawrence built on the development of concepts through sense perceptions espoused by Comenius and Froebel. Her theory of apperception was a major force which gave impetus to the first modern psychology of learning.[3]

William James called for a science of education and the congruence of teaching and psychology. James stated ". . . and so everywhere the teaching must agree with psychology, but need not necessarily be the only kind of teaching that would so agree with psychological laws."[4]

G. Stanley Hall initiated the child study movement and provided data and ideas that were one of the roots of the child centered school. His recapitulation theory which stressed the determining force of racial

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[2]Johann Comenius, "The Methodology of Comenius," Readings in the History of Education, ed. by Harry J. Siceluff (Berkeley, Calif.: McCutchan Publishing Corporation, 1970), p. 91.

[3]Elizabeth Lawrence, The Origins and Growth of Modern Education (Baltimore, Md.: Penquin Books, 1970), pp. 236-43.

[4]William James, Talks to Teachers (New York: W. W. Norton and Company, Inc., 1958), p. 24.

heredity placed limiting power on education.[5]

The turn of the twentieth century marked the emergence of contrasting learning theories. Dewey and other social reformers and progressives turned from a biological to a psychological basis of learning. Dewey posited that educational aims are derived from emerging needs, are met by life experiences, and are verified by their functionality when applied to the life construct. Dewey's conception of the interrelationships between aim, interest and intelligent action presented the mainstream of his psychology of learning.[6]

Thorndike's theoretical views of learning emerged simultaneously with those of Dewey. The two views were oppositional in nature and source. Thorndike has been called "the prototype of the successful appliers of scientific methods to educational problems." The inductive process employed to study facts to answer questions validated by objective assessment characterized Thorndike's position. The publication of Thorndike's handwriting scale has, in general, been recognized as the inception of contemporary scientific measurement in education. This objective evidence was used to formulate his principles of learning:

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[5] G. Stanley Hall, Adolescence (New York: D. Appleton Company, 1904).

[6] John Dewey, Democracy and Education (New York: The MacMillan Company, 1961).

connect and positively reward what should go together; separate and negatively reward what should not go together.[7]

The contributions of Thorndike and Dewey during the scientific movement have had a lasting impact upon education in contemporary society. McDonald summarized the influence of the two as follows:

> Thorndike and Dewey in this early period can be seen pitted against the same foes--Dewey providing penetrating analyses, Thorndike his own analyses and overwhelming mounds of data. The unperceptive observer would have seen only the clash with an outmoded tradition, the demolition of unscientific ideas. But Dewey caught the spirit of the times in a way Thorndike did not, so that when the differences between them became apparent, Dewey was chosen by the educators.[8]

The national concern for the preservation of a democratic society was a major force which influenced the decision of educators in this issue. Dewey perceived the classroom as the appropriate setting for demonstrating this abstract concept of democracy. Thus during the thirties and forties the shift was away from functional psychology, associationism, and behaviorism toward Gestalt psychology: field theory, organismic psychology and psychoanalysis.

The Progressive Education Movement, which ended during the latter thirties, was the major reform. From this period until the mid-

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[7]E. L. Thorndike, Educational Psychology (New York: Mason Printing Corporation, 1914).

[8]Frederick J. McDonald, "Influence of Learning Theories," Theories of Learning and Instruction, ed. by Ernest R. Hilgard. Sixty-Third Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1967), p. 5.

fifties, there was nothing in America identified as a reform movement. Following World War II the schools underwent two major attacks. The first wave of criticism was political, during which schools were charged with un-Americanism and subversive practices; the second wave of criticism stemmed from divergent educational philosophies. The public debate, compounded by intense international conflict, led to the new reform during the latter fifties and has continued. New curricula emerged. In some cases, the programs were built on sound psychological theories, yet many were not. On this point Woodring wrote:

> The new programs are being promoted with imagination, flair, and enthusiasm but without a great deal of psychological sophistication. They are pushed by a few vigorous school superintendents and principals who are eager to meet the new challenges facing the schools and cannot wait until psychologists have completed their research and have come to agreement about the proper theoretical basis for classroom learning.[9]

Educational technology has been defined as two distinct and interrelated concepts: physical science (media) and behavioral sciences. The physical science concept refers to the application of electromechanical equipment to aid instruction, viz., tape recorders, motion picture projectors, television, teaching machines and computer-based teaching systems. The major distinction between the two is the primary independence of psychological learning theory in the development of the

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[9] Ibid, p. 14.

media concept upon which the behavioral science concept is based.[10]

The development of teaching machines and programed instruction is prominent in educational technology. The initial and recent developments in this instructional approach illustrate theoretical dependence on behavioral sciences in contrast to its physical counterpart.

Programed Instruction

Various types of programed instruction (PI) are available. Pressey, who published the first reference to a teaching machine, is cited as a pioneer in the field. His device was a box containing a revolving drum with multiple-choice questions printed on the face of the drum. Each item was exposed through a slot as the drum rotated. Responses were made by pressing a button corresponding to the choice. The mechanism was not released for rotation to the next item until the correct response was made. Pressey maintained that tests could aid instruction. The step size and program sequence were not clearly defined. Errors were recorded and a score was derived at the end of the test. The main concern was not the rate of error but the warning against wrong answers during the test. Thus the machine was not popular, although

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[10]Edgar Dale, "Historical Setting of Programed Instruction," Programed Instruction, ed. by Phil C. Lange. Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II (Chicago: University of Chicago Press, 1967), p. 32.

several studies reported positive results of its use by Pressey and his students.[11]

Skinner's theory of operant conditioning is the basis for his approach to PI. The frames provide information, questions, and space for writing constructed responses. Their sequence is the same for all learners (Linear). The correct answer on a printed tape is advanced and compared with the constructed response for immediate reinforcement. The reduced error rate is controlled by small successive steps and rewards for behavior as it approaches the desired pattern.[12]

Although opinions differ on the principles involved in PI, Stolurow cities four basic common features: a limited amount of material (frame or step) receives the learner's focus of attention at one time; each segment of material requires a response that is usually observable; immediate feedback of results follows each response; the learner responds at his own rate.[13]

The number of published articles written on PI offers some indication of its current use during the past decade. Corey, in counting entries in the Education Index, found no title listed under programed

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[11]S. L. Pressey, "A Simple Apparatus Which Gives Tests and Scores--and Teaches," School and Society, XXIII (March, 1926), pp. 373-76.

[12]B. F. Skinner, "Teaching Machines," Science, CXXVIII, (October, 1958), pp. 969-77.

[13]Lawrence M. Stolurow, "Programed Instruction," Encyclopedia of Educational Research, 4th ed.: ed. by Robert L. Ebel (Toronto: The MacMillan Company, 1969), p. 1017.

teaching or teaching machines prior to 1959; between 1959-1961 there were 130 articles; 440 articles appeared in the 1961-1963 editions; and 342 between 1963-1965. A similar curve was found in the number of entries in the Psychological Index, which indicated a peak in 1964.[14] Fry extended the count from 1965 to 1967 and reported a decline to 232 articles listed during the two-year period.[15] This writer located 203 entries listed in the 1967-1969 editions of Education Index, and 94 in the 1969-1971 volumes. This small sample selected from these reference indexes indicates a pattern of growth and decline in the quantity of published articles on the subject of programed instruction.

Stolurow viewed PI and audio-visual instruction as a major influence on curriculum planning, instructional organization and research. He pointed to the need for further exploration of its appropriate use and its use as a means for better understanding of teaching and learning as it exists. Concerning current and future trends of PI, Stolurow wrote: "Current trends suggest that linear teaching is out, branching machines

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[14]Stephen M. Corey, "The Nature of Instruction," Programed Instruction, Edited by Phil C. Lange, Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II. (Chicago: University of Chicago Press, 1967), p. 24.

[15]Edward B. Fry, "How Effective Is Programed Instruction in Teaching Reading?" Current Issues in Reading, ed. by Nila B. Smith, Proceedings of Thirteenth Annual Convention of International Reading Association, Part II, XIII (Newark, Delaware: International Reading Association, 1969), p. 198.

are being used increasingly, and computer-based learning systems hold the promise of the future."[16]

Baker pointed out the initial enthusiasm generated by Computer Assisted Instruction (CAI) has diminished. The underestimation of the learning process during its initial stages limited its practicality in the individualization of instruction for which it was developed.[17]

There is substantial evidence PI can teach a variety of content. A number of studies indicate it can teach some reading and mathematics skills as well as conventional approaches to some students. There is little in research literature to support its superiority over conventional methods.[18]

A study frequently cited on the effectiveness of PI in beginning reading is one sponsored by the U. S. Office of Education conducted by Ruddell. The Buchanan linguistic programed materials were compared to the Sheldon basal readers as used in Grade 1. Significant differences favored PI on an Oral Reading Test (a word list of phonetically regular

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[16] Lawrence M. Stolurow, "Programed Instruction," Encyclopedia of Education Research, 4th ed.; ed. by Robert L. Ebel (Toronto: The MacMillan Company, 1969), p. 1017.

[17] Frank B. Baker, "Computer-Based Instruction Management Systems: A First Look," Review of Education Research, XXXXI (February, 1971), pp. 51-68.

[18] Wilbur Schraum, The Research on Programed Instruction: An Annotated Bibliography, (Washington, D.C.: Government Printing Office, 1964).

words on the Gilmore Oral Reading Test) and Word Reading on the group Sanford Achievement Test. Raw scores were reported by the investigator. In a review of the study by Fry, scores were converted to grade equivalency by the author. It was noted that the difference between the means of the two groups on Word Reading was one-tenth of a year, significant at the .05 level.[19]

Forces that direct man's actions continue to interest educators and psychologists. Prior to 1920, instinct was cited as a major determinant of behavior. The dominant view was that all animals, including man, were naturally endowed with a few simple biological needs and other behaviors were learned. There were, however, varying definitions of instinct. William James' tests of instincts included crying, curiosity, sociability, shyness, cleanliness, pugnacity, and sympathy.[20] McDougall listed food seeking, sneezing, laughing, escape and repulsion among others in his classification of "innate impulses."[21] Hunting, collecting, fighting,

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[19]Robert B. Ruddell, "The Effect of Four Programs of Reading Instruction with Varying Emphasis of the Regularity of Grapheme-Phoneme Correspondences and the Relation of the Language Structure to the Meaning on Adjustment on First Grade Reading," Report of Research Project No. 2699, (Berkeley: University of California, 1965).

[20]William James, Principles of Psychology, II (New York: Henry Holt and Company, 1890).

[21]William McDougall, An Introduction to Social Psychology, (London: Methuen and Company, Ltd., 1908).

kindliness, greed, and teasing were included among the forty types of instinctive reactions listed by Thorndike.[22] Freud theorized instrumental energy was the source of all activity. Life instincts and death instincts were the basic components. Reproduction (sexual instinct) and life maintenance (hunger and thirst) comprised the life instinct.[23] Aims of the destructive death instincts were oppositional to life instincts.

White included all types of behavior that involve environmental interaction under "COMPETENCE." This general heading encompasses all forms of capabilities and skills which promote an effective interaction with the environment. Competence, according to White, is a motivational force in that appropriate behavior which leads to the acquired ability or skill is directed; and it satisfies an intrinsic need to deal with the environment.[24]

The effects of age, sex, and social class upon individual differences in motivational orientations were studied by Call. Middle-class white, middle-class black, lower-class white, and lower-class black subjects from Grades 4, 6, and 8 comprised the sample. The results

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[22]Edward L. Thorndike, The Psychology of Learning (New York: Teachers College Press, 1913).

[23]Sigmund Freud, "Instincts and Their Vicissitudes," Milestones in Motivation, ed. by Wallace A. Russell (New York: Appleton-Century-Crofts, 1970). Reprinted from Collected Papers, IV, German Edition, 1915.

[24]Robert W. White, "Motivation Reconsidered: The Concept of Competence," Psychological Review, LXVI (September, 1959), pp. 297-333.

indicated differences in social class accounted for a larger proportion of total variance in scores than did differences in race and sex.[25]

Motivation and Programed Instruction

Maehr and Sjogren suggest PI limits motivational effects. They attribute this to programers of PI who assume that this type instruction motivates more than it really does.[26] Kight and Sassenrath used the Iowa Picture Interpretation Test to assess achievement motivation. The experimenters found high-achievement motivated students performed better than did low-achievement students on three criteria: time to complete the program, number of errors, and short-term retention score. High test-anxiety subjects worked faster with fewer errors, but had lower retention scores than did low-anxiety subjects.[27] This technique for assessment has been viewed as a questionable alternative to the traditionally employed thematic apperception measure. Thus, the findings are characterized as suggestive rather than conclusive.

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[25]R. J. Call, "Motivation-Hygiene Orientation as a Function of Socioeconomic-Status, Grade, Race, and Sex" (unpublished Master's Degree thesis, George Peabody College for Teachers, 1968).

[26]Martin L. Maehr and Douglas D. Sjogren, "Atkinson's Theory of Achievement Motivation: First Step Toward a Theory of Academic Motivation?" Review of Educational Research, XLI (April, 1971), p. 155.

[27]Howard R. Kight and M. Julius Sassenrath, "Relation of Achievement Motivation and Test Anxiety to Performance in Programed Instruction," Journal of Educational Psychology, LVII (January, 1966), pp. 14-17.

Allen described the use of the WFF'N Proof Program game to learn problem-solving skills, i.e., abstract thinking and mathematical logic. Experimental subjects using the games scored a mean IQ gain of 17.3 as compared to a 9.2 gain of the contrast group at the end of treatment. The investigators concluded a combination of motivational properties induced by the game was a dominant contributor to increased intellectual skills.[28]

Hartley reported the results of a series of experiments with factors affecting learning efficiency from PI conducted in his laboratory. The summary included a study of pairing pupils for programed learning on the basis of a personality measure. A questionnaire constructed and validated by the investigator was used to establish three groups of pairs: high, low, and average in terms of motivation. The sample was comprised of English secondary school male adolescents. No significant differences in test performances of the three sets of pairs were reported at the end of the program, or on a follow-up six weeks after its completion. The results suggested pairing methods are not crucial for motivating pupils.[29]

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[28]Layman E. Allen, Robert W. Allen, and James C. Miller, "Programed Games and the Learning of Problem Solving," Journal of Educational Research, LX (September, 1966), pp. 22-26.

[29]James Hartley, "Factors Affecting the Efficiency of Learning from Programed Instruction," AV Communication Review, XIX (Summer, 1971), pp. 133-48.

McDonald explored two reinforcements to the television presentation of the teacher to determine the effect on increasing vocabulary skills among seventh- and eighth-graders. Each of four treatments included fifteen words: (1) auditory reinforcement by the teacher; (2) auditory and supraliminal reinforcement (the word and its one-word synonym flashed on the bottom of the television screen every five seconds at one-tenth second exposures) which added to teachers' auditory reinforcement; (3) auditory, supraliminal, and written reinforcement in which subject was required to circle the one-word synonym on paper containing four distractions (treatment as in 2); (4) auditory and written reinforcement as in treatment 2, omitting supraliminal reinforcement; (5) treatments consisted of one twenty-two minute video-taped presentation administered to all groups simultaneously. A sample of 240 comprised the four treatment groups equated by grade, sex, and three levels of ability. Statistically significant differences among treatments and between sexes were revealed in post-treatment scores. Females scored significantly higher than males. All treatments significantly exceeded auditory reinforcements alone.[30]

George compared no reinforcement (A), low fixed-ratio reinforcement (B), high fixed-ratio reinforcement (C), and high variable-ratio

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[30]T. F. McDonald, "The Effect of Auditory Supraliminal and Written Reinforcement of Words Presented by I. T. V. on the Vocabulary Development of Seventh and Eighth Grade Pupils," Reading: Process and Pedagogory, ed., by G. B. Schick and M. M. May. Nineteenth Yearbook of the National Reading Conference, 1971, Part II, pp. 128-33.

reinforcement (D) on pupil progress through four weeks of programed reading. One hundred second-graders from four classrooms were assigned to treatments on the basis of performance during the first week of the program. Group A received no reinforcement; Group B was reinforced after 300 words; Group C was reinforced after 700 words; and Group D was reinforced at random. The dependent variables were weekly means and grand means of responses given. The first groups were equated on the first week means. No significant differences were reported among grand means of groups and within levels. No sex differences were found.[31]

Awkerman paired a fourth- and a sixth-grade student who had similar reading levels. A kit of auto-instructional materials designed to teach elementary school science was used by the pair. Students at a control school received conventional science instruction. The findings were fourth and sixth grade students can learn from auto-instructional materials without teacher assistance. No differences were reported between the two groups in achievement. Neither sex, reading level, nor race affected achievement.[32]

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[31] J. E. George, "Fixed- and Variable-Ratio of Reading Performance," Reading: Process and Pedagogy, ed. by G. B. Schick and M. M. May. Nineteenth Yearbook of the National Reading Conference, Part I (1971), pp. 146-51.

[32] Gary L. Awkerman, "Testing the Effectiveness of Auto-Instruction in a Paired Learning Arrangement," A paper presented at the American Educational Research Association Convention, 1970.

Contrasting Views of Programed Instruction

The growing interest in educational technology is accompanied by a controversy between the behaviorists and the new humanists. A classic presentation of contrasting views of the role of educational technology in a democratic society was presented by Oettinger, a technological scientist, and Marks, followed by reacting discussants.[33] Two major concerns included ramifications of individualized instruction and the role of school in society. Emphasis in this article was on Computer Assisted Instruction (CAI); however, comments are applicable to PI.

Many opinions of PI have been based on emotions or intuition rather than on empirical evidence. Other critics, pro and con, objectively view the approach, if used appropriately, as one which can improve achievement and attitudes of students. There is general agreement that no method can substitute for a competent teacher.[34] PI, however, is claimed to free teachers to perform other duties to assist learners.

Austin and Morrison conducted a survey of reading content, conduct, and practices in 1,023 school systems in which they used question-

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[33]Anthony Oettinger and Sema Marks, et al., "Educational Technology: New Mythis and Old Realities," Harvard Educational Review, XXXVIII (Fall, 1968), pp. 697-755.

[34]Guy L. Bond and Robert Dykstra, "Interpreting the First Grade Reading Studies," The First Grade Reading Studies: Findings of Individual Investigations, ed. by Russell G. Stauffer (Newark, Delaware: International Reading Association, 1967), pp. 1-9.

naires and sixty-five interviews to gather data. Based on their findings, the investigators recommended that programed materials be introduced as diagnostic materials.[35] Other strengths of PI cited on the literature include: specific objectives based on a sound learning rationale and general goals; provisions for individual differences; and student interests developed from a variety of instructional techniques.[36] Gotkin and McSweeney mentioned the teacher personality and the manner in which the material and equipment are used as determiners of the degree of interest developed.[37]

Smith discussed possible consequences of current interest of big business in education and the attitudes of some leaders from both fields. She urged careful selection of electronic devices, consideration of what to use, what to use in them, how and with whom they should be used. She pointed out that often programers are not educators and she saw

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[35]Mary C. Austin and Coleman Morrison, The First R: The Howard Report on Reading in Elementary Schools (New York: The MacMillan Company, 1963).

[36]Edward B. Fry, "How Effective Is Programed Instruction in Teaching Reading?" Current Issues in Reading, ed. by Nila A. Smith, Proceedings of Thirteenth Annual Convention of International Reading Association, Part II, XII (Newark, Delaware: International Reading Association, 1969), p. 204.

[37]Lasser G. Gotkin and Joseph McSweeney, "Learning from Teaching Machines," Programed Instruction, ed. by Phil C. Lange, Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II (Chicago: University of Chicago Press, 1967), pp. 267-68.

greater promise in the use of programs developed by skilled teachers processed through electronic devices.[38]

Miles stated creative problem-solving is affected by an individual's active response when he looks at the problem and his evaluation of possible solutions prior to producing a solution. He thus assumed the same procedure employed by the learner for self evaluation could be used to program creative behavior and possibly to facilitate effectiveness on creative performance.[39]

A major concern of educators is a perceived conflict between humanistic and technological instruction. Combs contends machines should be used to perform what they do best--free human beings to move in their chosen directions. According to Combs, Americans have done this. On the future of technology and education, he wrote:

> In time, we shall learn to use our new hardware and I believe the machines will then increase our humanism. Meanwhile, we ought not to compete with the computers or make computers out for students. What is needed is to stress that which makes us unique, our humanity.[40]

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[38]Nila B. Smith, "Tomorrow's Reading Instruction: Paradox and Promise," Forging Ahead in Reading, ed. by J. Allen Figurel. Proceedings of the Twelfth Annual Convention, International Reading Association, Part I, XII (Newark, Delaware: International Reading Association, 1969), pp. 40-46

[39]David T. Miles, "An Experimental Investigation of Programed Creativity" (unpublished Doctoral Dissertation, Southern Illinois University, 1967).

[40]Arthur Combs, "Humanizing Education: The Person in the Process," Humanizing Education: The Person in the Process, ed. by Robert L. Leeper (Washington, D.C.: Association for Supervision and Curriculum Development, NEA, 1967), p. 75.

Ellson summarized several studies which provided favorable evidence for PI in the teaching of reading. Each study reported results that included at least one measure of mathematics achievement in which the performance of a group taught by PI was significantly better than of a comparable group taught with conventional classroom methods. In each case the balance in favor of PI was large enough, according to Ellson, to have educational significance. He pointed out differences in performance between groups which yield small or no statistical significance are often inferred to have no educational significance. He suggested a conclusion interpreted that classroom instruction is no better than PI has great educational significance, especially for those who favor conventional methods and have a low opinion of PI. Ellson sees this as a challenge to conventional teaching methods: their refinement, the development of new ones, and the evaluation of basic research which "in the long run can only result in the improvement of classroom as well as programed teaching."[41]

The author summarized his belief PI can contribute significantly to education as follows:

> This evidence includes the results of comparative studies which indicate that under some conditions reading achievement benefits more from programed instruction that from classroom instruction and that under other conditions programed instruction is no less effective

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[41]D. G. Ellson, "How Effective is Programed Instruction in Teaching Reading?" Current Issues in Reading, ed. by Nila B. Smith. Proceedings of Thirteenth Annual Convention of International Reading Association, Part II, XIII (Newark, Delaware: International Reading Association, 1969), pp. 214-21.

than conventional instruction. It has remedial value, it can provide an effective means of relieving the overloaded classroom teacher, and it is a useful tool for research aimed at understanding and improving teaching procedures.[42]

[42] Ibid., pp. 210-211.

Summary

This chapter presented a brief historical account of PI as a technological teaching method. It pointed out the controversy that exists between educators and psychologists over the nature of motivation, the learning process, and teaching.

Many opinions have been on emotion or intuition rather than on empirical evidence. Other critics, pro and con, objectively view the approach, if used appropriately, as one which can improve achievement and attitudes of students. There is general agreement no method can substitute for a competent teacher. PI, however, is claimed to free teachers to perform other duties to assist learners.

Finally Chapter II included reviews of studies dealing with PI and mathematics and reading achievement, motivation, race, and sex differences of students.

Chapter 3

METHODS AND PROCEDURES

This chapter is divided into four major sections: (1) the subjects in the study; (2) the methods of instruction; (3) the measuring instruments used in the study; (4) and the treatment of data.

The discussion on the subjects describes the population from which the sample was selected and procedures for establishing the comparison groups. The section on methods of instruction discusses the two methods employed. The Hoffman Mathematics Information System used the experimental group is described in detail. Measuring instruments used in the study are described and the collection of data are discussed.

A profile of the teachers working with students of the experimental group and the control group are to be found in Table 1. An overview of data collection procedures and treatment period of the subjects are to be found in Table 2.

SUBJECTS

All subjects selected for this study were drawn from two sixth-grade classes consisting of seventy-five students, in a rural school setting, who met the specific criterion: achieving below grade level in mathematics computation with placement in Stanine 2, 3 and 4 of the C.T.B.S.

Table 1

Profiles of Teachers Working with Students in the Experimental and Control Groups

Teacher	Age	Sex	Race	Marital Status	Degree Held	Years Experience
EXPERIMENTAL GROUP						
E_1	55	M	W	M	MA	25
CONTROL GROUP						
C_1	50	F	W	M	MA	25

Table 2

OVERVIEW OF DATA COLLECTING PROCEDURES

Pre-Data Collection February, 1976	Treatment Period	Post-Data Collection March, 1976
Group E_1 and C_1		Group E_1 and C_1
1. Jan. 23 - Pre-Screening Survey (C.T.B.S.) Level 2 - Form S	Treatment - Instruction Period 1. (Feb. 2 - March 12) 2. 45 minute periods daily	1. March 15 - Post-Test Screening Survey (C.T.B.S.) Level 2 - Form S 2. March 18 - Matching E_1 Scores to C_1 Scores

The total sample included ten matched pairs; six pair consisted of male and four pair contained female students. Each pair consisted of one student taught by a technological method (E_1) of mathematics computation and one student taught by the system wide or traditional method (C_1).

Subjects were matched by sex, with identical raw scores and stanine numbers on the C.T.B.S. and by age. Thus, it was assumed that the two groups were adequately matched homogeneously and for comparison purposes. Data in Table 3 shows the characteristics of the experimental and control group.

Subjects were not matched by IQ scores because IQ testing is no longer performed in the school system where the students of the study were enrolled. Each group (E_1) and (C_1) were assigned for six weeks of instruction in mathematics computation or one reporting period.

METHODS OF INSTRUCTION

In the definition of terms in Chapter 1, the traditional method and the technological method were defined. The section that follows presents additional information about those methods used.

The Traditional Method

The traditional method permitted the use of any mathematics materials and textbooks available which the teacher felt would provide appropriate instruction. Since students receiving this instruction possess

Table 3

Data Used for Matching Students in Control Group C_1

With Students in Experimental Group E_1

Student	Age Yrs/Mos		1-Male 2-Female Sex	Raw Score	Stanine	Grade
Dean W.	11	11	1	33	4	6
George H.	12	1	1	33	4	6
Rosemary D.	11	3	2	32	4	6
Lori B.	11	8	2	32	4	6
Tommy S.	11	3	1	30	4	6
John S.	12	0	1	31	4	6
Lisa F.	12	5	2	30	4	6
Teresa B.	11	7	2	30	4	6
Connie Y.	12	0	2	28	4	6
Heidi A.	11	7	2	28	4	6
Lisa Mc.	12	8	2	26	4	6
Veronica Q.	12	3	2	26	4	6

Table 3 (Continued)

Student	Age Yrs/Mos	1-Male 2-Female Sex	Raw Score	Stanine	Grade
Tommy A.	11 3	1	22	3	6
Mike H.	11 3	1	22	3	6
Pat B.	12 3	1	22	3	6
Chris W.	12 1	1	22	3	6
Coy W.	12 3	1	19	2	6
Eddie J.	12 7	1	17	2	6
Donnie D.	12 2	1	15	2	6
Phillip S.	12 8	1	15	2	6

mathematic deficiencies, emphasis is on basic arithmetic skills and their application. Topics discussed and taught include addition, subtraction and multiplication in two and three and four place numbers. Long division, decimals and fractions were also taught in the traditional method. Materials included textbooks, workbooks, games, library materials and audio-visual equipment. The flexibility of the method provides options for the selection of instructional procedures, enrichment, and materials by the teacher.

The Technological Method

As mentioned in the definition of terms, Chapter 1, the technological method used in this study was the Hoffman Mathematics Information System, a commercial program for mathematics instruction. It is a program of mathematics skills sequentially ordered by level of difficulty and presented in small steps. Emphasis is on the use of media-audio-visual, electromechanical devices, and programed workbooks for skill development. The content of the supplementary materials used for independent mathematics activities is correlated with the content of material presented on the slides and audio tapes provided with the machine. A detailed description of the machine and its operation are to be found in the appendix.

MEASURING INSTRUMENTS

All data gathering devices selected for use in a project must be valid, reliable and discriminating. While the researcher has the option to develop some of his own instruments, he also has the responsibility of determining their validity and reliability before using them. Most standardized tests today already have established norms, and their validity and reliability have been checked and rechecked across a wide national population. Therefore, the use of an appropriate standardized test would have certain advantages for the researcher in terms of time and effort saved and would also make it possible for the results of his study to be compared and interpreted with respect to those of other similar studies using the same instrument. In selecting the test instruments used in this study, consideration was given to: (1) the purpose for which projects outcomes were to be measured; (2) the extent and nature of the objectives to be measured; and (3) the appropriateness of the test in terms of administration and/or data collection.

The author chose to use the California Test of Basic Skills, a nationally known standardized test for this study. The test was administered as a pre-testing device to assess, select and match subjects before the project began and as a post-test to measure achievement of the subjects at the completion of the project.

California Test of Basic Skills

Published by McGraw-Hill Inc., revised in 1974, the test is an expanded edition of Forms Q and R, published in 1973. The present form used in this study is Level 2, Form S. The tests are intended for national use, by students who have been taught by many various approaches.

The objectives of the tests are to measure, therefore, those skills common to all curricula and are classified under five broad intellectual processes: Recognition, Translation, Interpretation, Application and Analysis. The emphasis in the process dimension is on the measurement of comprehension and application of concepts and principals rather than on measurement of knowledge per se. Within each of the five broad classifications are categories expressed in terms of specific intellectual activities. The items in each of the five skill areas of the C.T.B.S. measure the following:

1. The ability to recognize or recall information.

2. The ability to translate or convert concepts, from one kind of language (verbal or symbolic) to another.

3. The ability to comprehend concepts and their inter-relationships.

4. The ability to apply techniques, including performing fundamental operations.

5. The ability to extend interpretation beyond stated information.

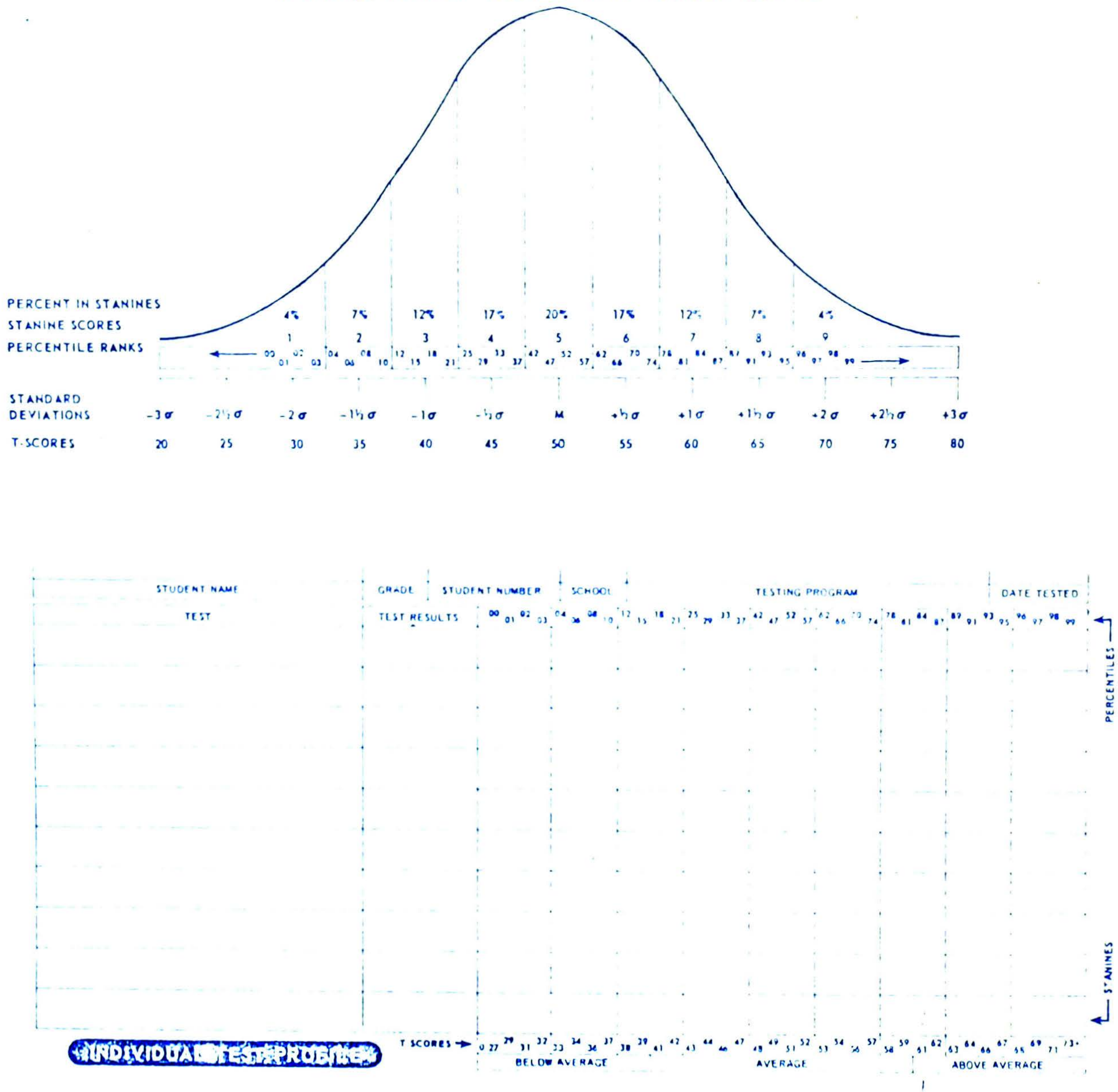
The total battery consists of 288 responses. A right response is one for which the correct alternative, and only the correct alternative, is marked. A wrong response is one for which an incorrect alternative, and no other alternative, is marked. The scores are recorded on an individual profile card termed the Stanine Card. On the card are scoring spaces for the raw score obtained, which is recorded horizontally, the percentile rank and the stanine.

The stanine is another meaningful score that can be derived from the raw score. It draws its name from the fact it is a standard score from a scale of nine units. The mean stanine of the norming population is five and the standard deviation is two. The scale ranges from one through nine. Nine is the highest level (top 4%), eight is high level (next 7%), seven is above average (12%), six is slightly above average (17%), and five is average (next 17%). Three, two and one are the stanines defined as below average level with three being the next 12% in the sequence, two is a low level (next 7% lower) and one is the lowest level (last 4%). The stanine is arrived at by matching the raw score to the stanine divisions on the card one through nine, which is also recorded horizontally. Figure 1 shows the C.T.B.S. individual profile Stanine Card. These cards are usually filed by the classroom teacher to refer to when the need arises.

FIGURE 1

INDIVIDUAL TEST PROFILE STANINE CARD

DISTRIBUTION OF SCORES ON A NORMAL CURVE



TREATMENT OF DATA

The purpose of this chapter was to describe the population from which the subjects of the study were selected and the procedures used for establishing the comparison groups. The two methods of instruction employed and the measuring instruments used in the study were described. Collection and treatment of data was discussed and a profile of the teachers working with the experimental and control groups is shown in Table 1. An overview of data and collecting procedures and the treatment period of the subjects are discussed.

Further treatment and interpretation of data will be found in Chapter 4.

Chapter 4

ANALYSIS OF DATA

The purpose of this chapter was to present and interpret the collected data of the study. The following headings identify each section: Statement of the Hypothesis, Analysis of Data, Validation of the Hypothesis and Summary.

The experimental and control groups each contained ten students matched by age, sex, by raw score achieved on the pretest of the C.T.B.S, and on stanine scores of 2, 3 and 4 of the same test. Data generated by the pre and posttests are presented herein by tables and figures for analysis and interpretation.

Hypothesis

Sixth grade students who were identified as low achievers in mathematics computation will achieve higher stanine scores when provided with a supplementary program of technological instruction, than similar students who were instructed only in the traditional method.

Analysis of Data

The subjects of this study were divided into two groups, the experimental group E_1 and the control group C_1. Both groups were instructed for six weeks, or one reporting period. Group E_1 was assigned to receive supplementary technological instruction while group C_1 was instructed in the traditional method only.

At the end of the instructional period both groups were again administered the C.T.B.S. to determine progress and achievement. The results of the pretest and posttest scores are to be found in Table 4. The data from this table is presented and analysed as follows for students in group E_1:

1. One female student, whose pretest raw score was 28 was in stanine 4, scored a posttest score of 22 and dropped to stanine 3.

2. The remaining female students in group E_1, whose pretest raw scores were 26, 30, and 32, each in stanine 4, raised their scores on the posttest to 38, 40 and 42 and to stanine 5.

3. One male student in group E_1, whose pretest raw score was 33 in stanine 4, raised his posttest raw score only one point to 34 to remain in stanine 4.

4. One male student with a pretest raw score of 15 in stanine 2 scored a posttest raw score of 24 and raised his stanine to 3.

5. One male student whose pretest raw score was 19 in stanine 2 raised his posttest score to 36 and to stanine 5.

6. Two male students whose pretest scores were 22 in stanine 3 raised their posttest scores to 30 and to stanine 4.

7. One male student whose pretest raw score was 30 in stanine 4 raised his posttest score 16 points to 46 and to stanine 8.

8. One male student whose pretest raw score was 32 in stanine 4, raised his posttest score to 40 and to stanine 5.

Table 4

COMPARISON OF PRE- AND POST-TEST SCORES OF MATCHED STUDENTS IN CONTROL GROUP C_1 AND STUDENTS IN THE EXPERIMENTAL GROUP E_1

Student	Group	1-Male 2-Female	Pre-Test Raw Score	Stanine	Post-Test Raw Score	Stanine
Dean W.	E_1	1	33	4	34	4
George H.	C_1	1	33	4	39	5
Rosemary D.	E_1	2	32	4	40	5
Lori B.	C_1	2	32	4	42	6
Tommy S.	E_1	1	30	4	46	8
John S.	C_1	1	31	4	36	5
Lisa F.	E_1	2	30	4	42	6
Teresa B.	C_1	2	30	4	38	5
Connie Y.	E_1	2	28	4	22	3
Heidi A.	C_1	2	28	4	42	6
Lisa Mc.	E_1	2	26	4	38	5
Veronica Q.	C_1	2	26	4	40	5
Tommy A.	E_1	1	22	3	30	4
Mike H.	C_1	1	22	3	30	4

Table 4 (Continued)

Student	Group	1-Male 2-Female	Pre-Test Raw Score	Stanine	Post-Test Raw Score	Stanine
Pat B.	E_1	1	22	3	30	4
Chris W.	C_1	1	22	3	40	5
Coy W.	E_1	1	19	2	36	5
Eddie J.	C_1	1	17	2	40	5
Donnie D.	E_1	1	15	2	24	3
Phillip S.	C_1	1	15	2	35	5

Pretest and posttest scores are presented and analysed as follows for students in group C_1.

1. One female student whose pretest raw score was 30 in stanine 4, raised her posttest score to 38 and to stanine 5.

2. Two female students whose pretest raw scores were 28 and 32 in stanine 4, raised their posttest scores to 42 and to stanine 6.

3. One female student whose pretest raw score was 26 in stanine 4, raised her posttest score to 40 and to stanine 5.

4. One male student with a pretest raw score of 22 in stanine 3, raised his posttest score to 30 and stanine 4.

5. Five male students whose pretest raw scores were 15, 17, 22, 31 and 33 in stanines 2, 3 and 4 sequentially raised their posttest scores to 35, 36, 39 and 40 to stanine 5 in that order of sequence.

In interpreting the above scores the data would show, in most instances, that both groups, E_1 and C_1, achieved significant progress during the six weeks of instruction. Table 5 presents the pretest and posttest mean, raw scores of both male and female students. This data shows significant gains in mean raw scores for both groups.

Another significant interpretation of pre and posttest mean raw scores and gains in presented in Table 6.

It can probably be interpreted from this data that both groups had significant gains. The data also indicates that group C_1 had somewhat more gain in mean raw scores than did group E_1.

Table 5

PRETEST AND POSTTEST MEAN RAW SCORES AND GAINS OF MALE AND FEMALE STUDENTS IN GROUPS E_1 AND C_1

	EXPERIMENTAL GROUP		CONTROL GROUP	
	Boys	Girls	Boys	Girls
Pretest	23.3	27.5	22.8	29.0
Posttest	33.3	35.5	36.3	40.5
Gains	10.0	8.0	13.5	11.5

Table 6

COMPARISON OF MEAN RAW SCORES
OF MALE AND FEMALE STUDENTS

	EXPERIMENTAL GROUP			CONTROL GROUP		
	Pretest	Posttest	Difference	Pretest	Posttest	Difference
Boys	23.5	33.3	+9.8	23.3	38.7	15.4
Girls	29.0	35.5	+6.5	29.0	40.5	11.5
Average Mean Raw Scores	26.25	34.4	8.15	26.15	39.6	13.45

Table 7 presents the pretest and posttest mean stanines of both groups, E_1 and C_1. Again, it can probably be interpreted that group C_1 had more gain in stanine numbers than did group E_1.

Summary of Results

After having collected, analysed and interpreted all the data, it appears the following statements could be made relative to the study:

1. Pretest-Posttest data in Table 4 would indicate that all students in both groups, E_1 and C_1, except for one female, made progress in raw scores and in stanines during the six weeks instructional period. The one female student, in group E_1, actually scored six points less on the posttest raw score than on the pretest and dropped from stanine 4 to 3. It is the opinion of the writer that this may be attributed to her irregular school attendance and to her home life.

2. From the data in Table 5, presenting the pretest-posttest mean raw scores, it would seem evident that male students in group E_1 made a gain in raw scores of 10.0 points, whereas female students of the same group made a gain of only 8.0 points.

3. Data in Table 5 indicates that male students in group C_1 made a raw score gain of 13.5 points whereas female students of the same group made a gain of only 11.5 points.

4. Data in Table 6 indicates that all students, both male and female, in group E_1 had an average pretest raw score of 26.25 and an average posttest raw score of 34.4, a gain of 8.15 points. Students in group C_1 had an average pretest raw score of 26.15 and an average posttest raw score of 39.6, a gain of 12.45 points.

Table 7

PRETEST AND POSTTEST MEANS OF STANINES SCORES FOR GROUP E_1 AND C_1 STUDENTS

	EXPERIMENTAL GROUP		CONTROL GROUP	
	Males	Females	Males	Females
Pretest	3.0	4.0	3.0	4.0
Posttest	4.67	4.75	5.7	5.5
Gains	1.67	.75	2.7	1.5

5. This information indicates that students taught in the traditional method did have higher gains on the posttest than did students taught by the supplementary technological method.

6. Data in Table 7 indicates that male students of group E_1 had an average stanine gain of 1.67, while females of the same group had a gain of .75. The table also indicates that male students of group C_1 had an average gain of 2.70, while females of the same group had a gain of 1.50. Again, it seems evident that students taught only by the traditional method had more stanine gain than did the group taught by the supplementary technological method.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The primary purpose of this study was to compare the effectiveness of a commercial technological system of mathematics instruction to the traditional method employed in the school system. The second purpose was to compare the achievement of sixth grade students with common characteristics. Both the experimental group and the control group were comprised of five matched pairs of students, matched on the basis of age, sex, raw scores achieved on the C.T.B.S. and on stanines 2, 3 and 4 of the same test. An experimental group (E_1) was assigned to receive supplementary technological instruction while a control group (C_1) was assigned to receive instruction in the traditional method only. The instructional period was forty-five minutes daily and continued for a period of six weeks, or one reporting period. At the end of the six weeks instructional period the C.T.B.S. was again administered to both groups to determine their progress and achievement. Both groups were taught by two teachers who were near the same age equivalent, experience, and educational background.

Summary of Findings

A summary of the analysis of the data in the study is stated below:

1. It is evident that both groups, E_1 and C_1, made gains on posttest raw scores and on stanine numbers. It is evident that male students made more gains on both raw scores and stanines than did female students.

2. In the final interpretation and analysis of the data, it is evident that students taught by the traditional method only, showed more achievement on the posttest raw scores of the C.T.B.S. than did students taught by the supplementary technological method.

3. It is also evident that students taught by the traditional method had more gains in supplementary technological method.

Conclusions

The results of this study indicates the following conclusions and inferences.

1. The findings of this study indicated that a supplementary technological method of teaching probably did not prove to be a more effective method of instruction than the traditional method of teaching.

2. The inference here is that the traditional method actually proved to be a more effective instruction process than did the supplementary technological method. There is general agreement that no method can substitute for a competent teacher.

Recommendations

1. Although substantial gains were made by both the experimental group and the control group, it is recommended that the same type study be conducted for a longer period of time with a larger sample of students.

2. It is recommended by the writer that, in his professional opinion, students who are more academically inclined might benefit more with PI than less accelerated students because of their ability to interpret, understand and carry out the instructions of a programed instructional process.

3. The inferences that students taught by the technological method of instruction showed less achievement than students taught by the traditional method leads to the implications that PI probably has greater remedial value and may provide an effective means of relieving the overloaded classroom teacher.

4. One objection to programed instruction, as it was experienced in this study, was the cost, both in terms of materials and equipment needed to equip the program. It is, therefore, recommended that studies be made of alternative approaches that might achieve equivalent results with lower costs. If this can be achieved, it is likely that a greater number of educators will experiment and find ways to employ programed instruction.

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APPENDIX

CHARACTERISTICS OF THE HOFFMAN MATHEMATICS PROGRAM

The Hoffman viewer is a self-contained, solid state, portable, audio-visual unit presenting a synchronous film slide and record instructional program. Students can listen privately using comfortable headsets. Up to six students can use a single Hoffman Viewer at the same time by using a junction or jack box for headsets. This six-way outlet has individual volume controls.

The Hoffman method is a program of mathematics skills ordered by level of difficulty and presented in small steps. A film strip containing several frames is inserted into an electromechanical device or opening which projects a colored picture or numbers on a small screen. A disc or record inserted into the machine provides a recorded audio narrative. Lessons and instructions on the disc are synchronized with each frame presented on the screen. Students write answers on a paper in response to the instructions projected on the screen which are simultaneously heard through ear phones. A junction box is provided so that six students may participate with ear phones during a regular sitting.

The Hoffman Mathematics System employs the basic mathematics used in the home, at school, at work, and at play to prepare the student to master the complex mathematics of an increasingly technological future.

The system also explains and emphasizes the ways in which basic mathematics is essential in solving the problems of everyday society. The Hoffman audiovisual method of teaching modern math makes the fundamentals of mathematics clearer, more meaningful, and more easily learned.

The Hoffman Mathematics System is a complete learning method. The principle underlying this Hoffman audiovisual system design is that the student who is motivated to learn retains more of what he learns.

Active participation by the learner, using meaningful materials, provides an environment where learning takes place more rapidly and tends to be more permanent. Learning also progresses more effectively when the learner is provided with some criterion for determining his progress.

Supplemental materials, correlated to the inter-active machine exercises, provide practice as the student consolidates his newly acquired skills. And, finally, inclusion of Mastery Tests for each lesson, as well as at each Achievement Unit and Level, provides essential feedback to the teacher reflecting student accomplishment.

The Hoffman Mathematics System, though structured by Levels as a convenience to teachers, is totally sequential and can be used in completely nongraded situations as decided by the teacher. Since the student is unaware of a specific study units level, he can work as an individual two or three levels apart either way: challenging the advanced student, or doing remedial work.

These flexible components of the Hoffman Mathematics System offer an extensive variety of teaching strategies which individual teachers, mathematics laboratory directors, or schools may tailor and apply to their particular needs.

A 60-page student answer book accompanies each ten-album Achievement Unit, containing six pages of student activities for each album. The first page of each six-page sequence is completed in conjunction with Filmslide 2. The second page provides seatwork activities learned in Filmslide 2. The third and fourth pages are completed with Filmslides 3 and 4, with the fifth and sixth pages providing seatwork activities learned in Filmslides 3 and 4.

Each study unit starts with a motivational story, contained in the first ten frames of Filmslide 1. The story themes are classified under the headings: The World of Wonderful Things (science content); World Where We Live (social studies content); World of Fantasy (imaginary tales, folklore and animal stories); World of Human Relations (personal interrelations, family life, cultural customs, and peer relations); and World of Feelings, Health, Emotions (psychological situations). In addition, the stories from Levels 3 through 6 provide a rich background in the history, concepts, phenomena, and famous personalities of science and mathematics, imparting to the student the excitement of these fields.

The last four frames of Filmslide 1 provide a transition from the motivational theme to the teaching objectives of the first half of the study unit. Student involvement is continued in Filmslide 2 by his active participation in the lesson. The pattern of audiovisual question, student response, and audiovisual reinforcement is continued throughout Filmslide 2, not as a rote testing vehicle, but as a constructive, concept-skill-fact building experience.

The student then practices the skill learned at the machine on his own, at his seat, or at home, completing the assignment on the next page of his Answer Book. The pattern of interactive machine activity, followed by answer book practice, is repeated for Filmslides 3 and 4.

The teacher's manual brings together the elements of the study unit into a complete learning system. It contains comprehensive activities and instructions that enable the teacher to make maximum use of the Hoffman Mathematics System. It assists the teacher in presenting the subject matter in such a way that each student can achieve feelings of pride and satisfaction in mastering the principles he is being taught. It strengthens the teacher's awareness of individual differences not only in ability, but also in past experience and personality. The options provided allow the teacher great flexibility in pacing to suit individual progress, or in using the carefully sequenced progression of instruction by objectives that constitutes the program.

The objectives of the Hoffman instructional material state what the student will be able to do after he has completed a study unit; what he is exposed to, but is not expected to have mastered; and what he has previously learned that is reinforced herein. Because these specific goals are made known at the outset, their achievement is made possible.

Before a unit of instruction is begun, the student can be assessed in terms of his current aptitude. The Mastery Tests can be used for this pre-study unit evaluation, as well as for their primary purpose of assessing the progress of the student after participation in the unit of instruction. The optional Math Mate independent activity booklet, which is designed to be compatible with the study unity, can also be used to determine the student's understanding of the lesson.

Even though the teacher's manual format is designed for instruction by objectives, the components of the system are complete within themselves and may be varied to meet the instructional methods preferred by the teacher. The Hoffman Math System can be adjusted to meet the needs of the student and the teaching methods of the instructor.