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A Cost-Effectiveness Analysis Of Individual Learning Units In A Junior High School Basic Mathematics Program.

Nicholas Anthony LaPlaca
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A COST-EFFECTIVENESS ANALYSIS OF INDIVIDUAL
LEARNING UNITS IN A JUNIOR HIGH SCHOOL
BASIC MATHEMATICS PROGRAM

A Dissertation
Presented to
the Faculty of the Graduate School
University of the Pacific

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

by
Nicholas Anthony LaPlaca

May 1973

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A COST-EFFECTIVENESS ANALYSIS OF INDIVIDUAL LEARNING UNITS
IN A JUNIOR HIGH SCHOOL BASICS MATHEMATICS PROGRAM

Abstract of Dissertation

PURPOSE: The study was designed to: (1) determine the expenditures for an individual basic mathematics program in the junior high schools using Individual Learning Units, (2) determine the expenditures for a traditional, textbook-oriented approach to basic mathematics instruction, and (3) compare the achievement gains of the two programs. Null hypotheses related to cost-effectiveness stated that the operational cost per unit gain, and the sum of the developmental and operational cost per unit gain of the ILU program would be greater than the cost per unit gain of the traditional approach. Null hypotheses related to effectiveness stated that the ILU treatment would not have a statistically significant effect upon: (1) total mathematics scores, (2) arithmetical computations, (3) arithmetical concepts, and (4) arithmetical applications.

POPULATION: One hundred and eighteen eighth-grade basic mathematics students were chosen from two junior high schools in the Stockton Unified School District, Stockton, California. The schools offered a contrast for they differed markedly in racial and ethnic makeup, socio-economic level of residents, and school size. In order to ameliorate teacher-effectiveness variables, teachers were assigned an experimental and control group which were similar in mathematical ability and which met in consecutive periods. The instructors determined the treatment each group was to receive. Neither the teachers nor the students had worked with Individual Learning Units previously.

PROCEDURE: The preassembled groups were assigned to a Nonrandomized Control-group Pretest-Posttest Design. All groups were pre- and post-tested on the Comprehensive Test of Basis Skills, Form Q, Level III. The hypotheses relating to cost-effectiveness were analyzed by establishing a cost-effectiveness ratio and its subsequent factor for each program. The cost component for the cost-effectiveness ratio was represented by the price per pupil in the respective approach. The mean of the mathematics achievement gains for each group was considered as the effectiveness component. By dividing the months gained in achievement into the cost per pupil, a factor stating the cost per unit gain was derived. The hypotheses relating to effectiveness were analyzed through the use of four two-way analyses of variance with unequal cells. These analyses yielded the effects of the treatment, the achievement scores in the different schools, and the interaction between the treatment and the schools. The achievement gains and the cost of the programs were dependent variables; the treatment received and the different schools were the independent variables.

FINDINGS: The Individual Learning Unit program for individualizing basic mathematics instruction did not prove to be cost-effective. The operational cost-effectiveness factor for the experimental program was \$5.54 per unit gain in achievement, measured against \$3.36 per unit gain for the traditional. However, the treatment groups had significantly higher arithmetical application scores on the CTBS, and approached significance on the total mathematics scores. Significant interaction effects were recorded on the total mathematics scores, the arithmetical computations sub-test, and the arithmetical concepts sub-test. The investigator concluded that the proximity in cost, plus the superior achievement gains, make the ILU approach a viable, but perhaps costly, alternative to the traditional, textbook-oriented approach to basic mathematics instruction.

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CHAPTER I

INTRODUCTION

There is a growing demand from various sectors of our society that the public school system be held more accountable, both in terms of money expended and results achieved.¹ The American educational system has to date, however, been subjected to only a few tests of efficiency and effectiveness.² Less than one third of one percent of the billions of dollars budgeted yearly for education is spent on evaluating the quality of its performance.³ It is paradoxical, writes Lessinger, "that we, who are the most advanced nation in the world in technology and management, seem incapable of applying that know-how to education."⁴ Lovell, in developing both a design and appropriate models for evaluating instructional programs, found that the literature offered little methodological assistance to those who

¹Willis Tucker, "Accountability: Who Owes What to Whom?" The Education Digest, XXXVII (April, 1972), 34-36.

²Leon Lessinger, "It's Time for Accountability in Education," Nation's Business, LIX (August, 1971), 54.

³Ibid.

⁴Lessinger, "It's Time for Accountability," 55.

wish to conduct educational assessment.¹ Moon contends that even within the fields of instructional technology, with its philosophical synthesis of systems-learning theory, a void exists in the actual knowledge of evaluation.²

The application of cost-effectiveness analysis, a technique of management science, is a possible way of meeting the demand for accountability and for vastly increased efficiency within certain cost restraints. Such a method involves an effort to discover ways whereby desired objectives (quality output) may be reached with a minimum application of resources (cost or input).³ The Committee for Economic Development has examined the possible benefits of cost-effectiveness analysis and has concluded that the employment of this technique is one of the major imperatives for education today.⁴ Stowe similarly argues that the entire concept of accountability is undeniably a healthy

¹Ned Broward Lovell, "Cost Effectiveness Evaluation of Instructional Programs: A Developmental Design (K-12)," (unpublished Ph.D. dissertation, The Florida State University, 1971), pages 1-6.

²John P. Moon, "A Learning Effectiveness, Time Efficiency, and PPBS Cost/Effective Investigation of a Media Modes Paradigm for the Independent Learning Environment," (unpublished Ed.D. Dissertation, University of Southern California, 1971) pp. 30-31.

³Austin D. Swanson, "Cost-Effectiveness Measures in Education," The Encyclopedia of Education - Vol.2, (MacMillan Co. and the Free Press, 1971), p. 451.

⁴Research and Policy Committee of the Committee for Economic Development. Innovation in Education: New Directions for the American School, (December, 1968), p.13.

movement for education in general.¹

Cost-effectiveness analysis may be especially helpful in evaluating innovative programs. Individual Learning Units (ILUs), specially designed booklets to guide students through a highly structured program of learning materials, will be the focus of the analysis in this research.² The relative merit of the ILUs will be determined by comparing the cost and the effectiveness of this innovative program with a more traditional method of classroom instruction.

THE PROBLEM

Statement of the Problem

What is the relative cost-effectiveness of Individual Learning Units in an individualized junior high school basic mathematics program when compared with a more traditional method of instruction?

Rationale

The objective of this study is an analysis of the costs and student achievement of Individual Learning Units as a means of individualizing basic mathematics instruction in junior high school.

The learning package is not a totally new idea in education. The textbook and materials accompanying basic

¹H.R. Stowe, "Critical Issues in Instructional Development," Audiovisual Instruction, XVI (December, 1971), 8-10.

²John E. Arena, "An Instrument for Individualizing Instruction," Educational Leadership, XXVII (May, 1970), 64.

texts are examples of incomplete packaging concepts for individualizing instruction that have been standard for many years. Grobman reports that the major differences in today's packages are that they are more comprehensive, more frequent, more carefully prepared, more adapted to individual learning, involve more varied techniques and media, and are generally easier to order since they come as a single packet.¹

Arena, a project director using learning packages, explains that the basic function of this instrument is to guide the student through a tightly structured program of learning materials.² A brief rationale, performance objectives written in behavioral terms, and a means of evaluating student progress, usually in the form of pretests and posttests should be included in each package.³ The needs, abilities, and interests of the students are considered to help determine the necessary activities to reach a particular objective.

Among the major stumbling blocks to the use of packages in a school program are cost and demonstrated quality. Grimsley states that many bold claims are made to promote some programs and packages, but we must ask: (1) what criteria was used to base these claims of effectiveness?; (2)

¹Hulda Grobman, "Educational Packages-Panacea?" Educational Leadership, XXVII (May, 1970), 422.

²Arena, "An Instrument for Individualizing Instruction," p. 64-65.

³Ibid.

where and under what conditions was the program tested?, and (3) has there been feedback and have any modifications resulted?¹

Present accounting and management records in school systems generally do not make possible an accurate judgement of the effectiveness received for money spent. Business and industry employ a cost analysis system for three important reasons according to Wohlford. First, business can only continue to function if income is greater than expense, therefore, methods used in industrial cost accounting have been devised to account carefully for all expenses. Second, accurate assessment of cost at each stage is fundamental to the determination of the value of specific production procedures. Through the use of cost analysis processes the most efficient method can be determined for a particular job. Third, managerial decisions pertaining to the content and/or quality of the product are aided by cost accounting procedures. Tests are conducted to measure the product at each stage of development and costs are assigned at each stage.²

Applying this logic to the education of children is obviously not a simple transition, but much of what is done in business and industry is directly applicable to education. Cost-effectiveness analysis can be a useful tool in rational-

¹Edith E. Grimsley, "Before I Look Inside," Education-
all Leadership, XXVII (May, 1970), 422.

²Gerald H. Wohlford, "Cost Analysis in Education," The Education Forum, XXXIV (March, 1970), 340-341.

izing the decision making process. It should not be the sole determinant, but rather one additional tool to assist the program planner in comparing the resources mandated by an educational program to its effectiveness. This effectiveness is often measured in terms of pupil achievement.

The planner must first determine what resources are being used to produce specific educational objectives. Both "system" and "behavioral" objectives will be included. To look at costs from a systems point of view is to include only those costs that are involved in attaining a system's objectives. These costs will include facilities, personnel, training activities, equipment, resources and the like, not only at a specific point in time but throughout the life of the program. By projecting the expenditures over the expected life of the program a more realistic picture of the true dollar needs can be obtained.

Before the analysis of cost-effectiveness can begin, the problems of defining and measuring the effectiveness of an educational program must be dealt with.¹ In particular, a great deal of care must be used in the selection of instruments that will validly and reliably measure attainment of program objectives.

PURPOSE OF THE STUDY

A study to determine a school district's expenditures

¹Margaret B. Carpenter and Sue A. Haggart, "Cost-Effectiveness Analysis for Educational Planning," Educational Technology, X (October, 1970), 26-28.

for: (1) a program to help individualize basic mathematics instruction in the junior high schools using Individual Learning Units, and (2) a traditional, textbook-oriented approach to basic mathematics instruction served as the basis for this investigation. This study is also based on a comparison of achievement gains in the individualized package program with the traditional textbook programs. The cost-effectiveness of a particular program can only be presented as a set of measures and indicators. Once these are obtained, the curriculum planner must then weigh the relative importance of the various aspects of the program's effectiveness as they apply to his particular school.

HYPOTHESES

Major Hypothesis 1: A cost-effectiveness analysis of the use of Individual Learning Units in junior high school basic mathematics instruction will demonstrate that the operational cost per unit gain in achievement will be equal to or less than the operational cost per unit gain in a traditional textbook-oriented, lecture approach, with minimal usage of audio-visual equipment.

Sub-Hypothesis 1: A cost-effectiveness analysis of the use of Individual Learning Units in junior high school basic mathematics instruction will demonstrate that the sum of the developmental and operational cost per unit gain in achievement will be equal to or less than the cost per unit gain in a traditional approach.

Major Hypothesis 2: There will be significant differences in achievement gains, total mathematical scores, between junior high school students using Individual Learning Units and junior high students in a traditional program, as measured by the Comprehensive Test of Basic Skills, Level III.

Sub-Hypothesis 1: There will be significant differences in gain scores on the arithmetical computational skills sub-test of junior high school students using Individual Learning Units and junior high students in the traditional program.

Sub-Hypothesis 2: There will be significant differences in gain scores on the arithmetical concepts sub-test of junior high school students using Individual Learning Units and junior high students in the traditional program.

Sub-Hypothesis 3: There will be significant differences in gain scores on the arithmetical applications sub-test of junior high school students using Individual Learning Units and junior high students in the traditional program.

DESCRIPTION OF THE STUDY

This study investigated the relative cost-effectiveness of Individual Learning Units in a junior high school basic mathematics program as compared with a more traditional textbook-oriented, lecture approach with a minimal usage of audiovisual equipment. A ratio of dollars expended per pupil month gain in achievement was derived from the study and served as a basis for comparison of the two approaches.

For this study, only "direct costs" were considered. Direct costs are those expenditures incurred in providing educational opportunities, e.g., instructional and administrative salaries, supplies, textbooks, repairs, building maintenance, and equipment.

The direct costs suggested for analysis were classified as either "developmental" or "operating" costs. For purposes of cost-effectiveness analysis, developmental costs may be defined as those expenditures related to the planning and implementation of educational programs. Included in this cost category are: initial program planning, acquisition of equipment and materials (including textbooks), special training and orientation programs and any other cost related to the planning and implementation phase of a program. Operating costs include those items associated with the operation of a program, e.g., salaries, supplies, printed materials, duplicating materials, utilities, and employee benefits.¹

The major hypothesis and its sub-hypotheses relating to achievement were analyzed through the use of a two-way analysis of variance with unequal cells. The independent variable was the use of the Individual Learning Units in basic mathematics instruction; the dependent variables were the achievement gains noted in the Comprehensive Test of Basic

¹Ray Haywood Forbes, "A Technique for Analyzing the Costs of an Education Program Based on Behavioral Stated Instructional Objectives," (unpublished doctoral dissertation, University of Massachusetts, 1970), pp. 38-39.

Skills and the cost of the programs.¹ The overall gain and the subtest areas were analyzed individually.

ASSUMPTIONS AND LIMITATIONS

Assumptions

The assumptions upon which this research was based include the following:

1. A systematic examination and comparison of alternative programs is plausible.
2. The significant resources needed for developing and operating an innovative instructional program using I.L.U. s can be identified.
3. The period of time during which the study was conducted provided sufficient usage of the Individual Learning Units to compare them with the traditional mathematics program.
4. The scores on the CTBS standardized test used in this research were an accurate measure of academic achievement gains.
5. The data collected and the method in which it was analyzed may be of value in curriculum decisions.

Limitations

The following limitations are noted as being relevant to the study:

1. The research was limited to an in-depth examination

¹California Test Bureau. Comprehensive Test of Basic Skills (Monterey, California: Del Monte Research Park, 1968)

of two junior high schools in the Stockton Unified School District, Stockton, California.

2. The students were assigned to classes according to ability level in mathematics.
3. There are inherent limitations in the administration, nature, and scope of the testing instrument.
4. The effectiveness of the programs has been limited to the measurable gain in mathematics achievement. There has been no attempt to project the gain in terms of economic benefits or ultimate success of the students.
5. Although social and attitudinal variables are relative to success in mathematics, there has been no attempt to qualify these factors.
6. The basic cost estimates have been limited to the average per pupil cost of materials for each program, pro-rated on a consumption basis.
7. The research was limited by the writer's concern in only comparing the Individual Learning Units with the traditional mathematics program.

DEFINITIONS OF TERMS USED

Behavioral Objectives: a precise statement of a single meaningful unit of behavior that will satisfy an instructor that a student can perform a task that is a desired outcome of a course of instruction.¹

¹Paul Harmon, "Curriculum Cost-Effectiveness Evaluation," Audiovisual Instruction, XV (January, 1970), 24.

Cost-effectiveness: an analytical approach to solving problems of choice which require the definition of objectives, identification of alternative ways of achieving the objective, the identification of the alternative that yields the greatest effectiveness for any given cost, or . . . yields a required or chosen degree of effectiveness for the least cost. The term is usually used in situations in which the alternative outputs cannot be easily quantified in dollars.¹

Educational Systems: an arrangement of elements (such as teachers, classrooms, space, etc.) and processes (such as instruction and counseling) that combine to produce student learning.²

Individual Learning Units: a specially designed booklet to guide the student through a highly structured program of learning materials.³

Planning, Programming, Budgeting Systems (PPBS): this approach attacks the resource allocation dilemma through systems accounting-fiscal procedures. It is an attempt to integrate planning (establishing objectives and policies), programming (method(s) to accomplish the objectives), and budgeting (specifying allocations of resources in a given

¹Richard H.P. Kraft, Cost-Effectiveness Analysis of Vocational-Technical Education Programs, For the Department of Educational Administration, Educational Systems and Planning Center, The Florida State University (Tallahassee, Florida: Department of Education, 1969), p. 142.

²Carpenter and Haggart, "Cost-Effectiveness Analysis" p. 26.

³Arena, "An Instrument for Individualizing," p. 64.

time interval). It is aimed at helping management make better decisions on the allocation of resources among alternative ways to attain program objectives.¹

SUMMARY

The first chapter of this study presented an introduction to the investigation. The emphasis was on the heretofore failure to apply cost-effectiveness analysis, a proven technique in the business world, and its application to educational programs. Elucidating the direction and intent of the study were statements regarding the problem, hypotheses, rationale, description of the study, assumptions and limitations, and definitions of terms used.

Following chapters include a review of the literature, methodology of procedures, collection of data, analysis of data, conclusions and recommendations.

¹Sanford Temkin, A Cost-Effectiveness Evaluation Approach to Improving Resource Allocations for School Systems (a published doctoral dissertation on Business and Applied Economics, University of Pennsylvania, 1969; Research for Better Schools, Inc., 1970).

CHAPTER II

REVIEW OF RELATED LITERATURE

INTRODUCTION

For the purpose of this study, the investigator focused on three major areas in the review of related literature. The first section, Individualization of Instruction, began with a definition of the title phrase, then statements regarding the premise for individualizing instruction and various techniques used in individualizing mathematics programs followed. The second area dealt with the concept of learning packages and their role in individualized programs. An in-depth look has been taken of Learning Activity Packages (LAPs) after which the Individual Learning Units (ILUs) were modeled. The final major area covered was cost-effectiveness analysis. An investigation into the development of the concept and its relationship to PPBS was reported, with the limitations of this analysis and its applicability to educational instructional improvement. The areas concerning learning packages and cost-effectiveness analysis were reviewed in a historical manner because of the paucity of research studies concerning their usage in education.

INDIVIDUALIZATION OF INSTRUCTION

The literature which related to the individualization

of instruction is discussed below under three headings. These sections deal with the following: (1) individualized instruction: a definition, (2) the premise for individualized instruction, and (3) programs employing individualized instructional techniques.

Individualized Instruction: A Definition

The term "individualized instruction" is often used in a rather broad sense. An instructor might say that he has individualized his particular classroom, referring to a few minor changes in classroom procedures which enabled him to work with the students on more of a one-to-one relationship during the mathematics class. Another using the term might be referring to substantial changes from normal procedures. It is, therefore, important to precisely define this term. At the same time, when someone states that instruction is individualized, it is imperative to ask, "more individualized than what?"¹

The Bureau of Compensatory Education Program Development for the State of California has adopted a fairly comprehensive definition of the individualized instructional approach.² It is:

The assignment of appropriate learning tasks to children as determined by a comprehensive, diagnostic

¹Robert E. Campbell, Methods of Individualizing Learning (Supplementary Education Center - ESEA Title III, San Francisco Unified School District, San Francisco, California, 1970), p. 3.

²Vernon Broussard, "The Individualization of Instruction," paper presented to the 1971 Bakersfield Conference on Individualized Instruction, Bakersfield, California, December 16, 1971, pp. 1-2.

assessment of each child's strength and special educational needs Additionally, individualized instruction applies to the assignment and methods of achieving these assignments rather than learning in physical isolation They may learn through independent study, small group discussions, large group activities, or teacher-led activities, whichever is most appropriate. An important component, using this definition, is breaking down the instructional programs into sets of performance objectives that are coded into an orderly scope and sequence and can be assigned as learning tasks.¹

This definition, as well as others found in the literature, generally agree on five elements considered basic to individualized instruction: (1) purposeful pacing of learning for each individual, (2) alternative means to meet the learning needs of each student, (3) a wide assortment of self-evaluation processes with both the pupil and teacher having a clear understanding of desired and expected outcomes, (4) student participation in decision-making activities, and (5) purposive interaction among groups and individuals.² These five conditions are interrelated and interdependent. They are fundamental, but by no means required since individualization does not stipulate well-defined boundaries. Ultimately, the limits of a program are determined by the imaginative potential evolved from the individual teacher and the group of students.³

¹Ibid.

²Patrick A. O'Donnell, and Charles W. Lavaroni, "Elements of Individualized Instruction," The Education Digest, XLVI (September, 1970), 17-20.

³Ibid.

The Premise for Individualized Instruction

A knowledge of individual differences and how they may affect achievement in school is necessary before an individualized program in mathematics can be developed. Interest can be traced back to Aristotle and Plato; however, the first studies on the laws of individual variation were made by biologists who were primarily interested in natural causes of variability.¹

Stern, a German psychologist, published a comprehensive treatise on individual differences in 1900 and a more extensive third edition in 1921, summarizing the principal statistical and psychological studies published up to that time.² He described selected methods for observing and testing individual differences and statistical methods for analyzing the data.³

The twenty-fourth Yearbook of the National Society for the Study of Education, published in 1925, was titled Adapting the Schools to Individual Differences. The first two paragraphs of the introduction by Washburne read as follows:

The widespread use of intelligence tests and achievement tests during the past few years has made every

¹R.S. Ellis, "The 'Laws' of Relative Variability of Mental Traits," Psychology Journal, 1947, quoted in Vernon Broussard, "The Effect of an Individualized Instructional Approach on the Academic Achievement in Mathematics of Inner-City Children" (unpublished Ph.D. thesis, Michigan State University, 1971), p. 31.

²Vernon Broussard, "The Effect of an Individualized Instructional Approach on the Academic Achievement in Mathematics of Inner-City Children" (unpublished Ph.D. thesis, Michigan State University, 1971), p. 31.

³Ibid.

educator realize, forcefully, that children vary greatly as individuals and any one school grade contains children of an astonishingly wide variety of capacity and achievement. It has become palpably absurd to expect to achieve uniform results from uniform assignments made to a class of widely differing individuals. Throughout the educational world there has therefore awakened a desire to find some way of adapting schools to the differing individuals who attend them. This desire has resulted in a variety of experiments.¹

Within a typical school population with a narrow range in mental ability, marked differences in motor skills, interests, achievement, and personality traits exist. Studies of American children have consistently revealed a wide range of learning ability in both grade and age groups, according to Hildreth.² Thompson's studies of children in other countries revealed similar findings.³

Hildreth believes scientific determination of trait variability among the pupils is required in order to provide for the wide range of learning abilities. This can be accomplished through: (1) objective measurements of scholastic aptitude and mental ability, (2) diagnostic study of special verbal and numerical abilities or deficiencies, (3) the appraisal of personality, social, and emotional traits, temperament, and evaluation of interests, (4) measurement of

¹Carleton W. Washburne, ed., Adapting the Schools to Individual Differences, Twenty-Fourth Yearbook of the National Society for the Study of Education, Part II (Bloomington, Illinois: Public School Publishing Co., 1925), p. X.

²Gertrude H. Hildreth, "Guidance in the Lincoln School," Teacher's Collection Record, 42 (1940), 18.

³G.H. Thompson, "The Northumberland Mental Tests," The British Journal of Psychology, 1921.

health status and physical development, and (5) measurement of achievement.¹

The research that follows indicates the possibility that a given instructional approach may be best for a learner with one personality characteristic, but not for a learner with an opposite characteristic. Sutter found students high in anxiety achieved better working alone, while those low in anxiety scored higher when working with a partner.²

In a study by Doty and Doty, subjects high in sociability performed poorly on programmed instructional tasks. The authors stated that this form of instruction may be inappropriate for students with high social needs as these students seem to perform poorly under methods involving minimal interpersonal contact.³

Another characteristic, dominance, appears to influence performance of students working in a group environment. In a study by Altrocchi, dominant pairs were more productive in problem-solving tasks than submissive pairs.⁴ Snow found that subjects who could be characterized as active, assertive,

¹Hildreth, "Guidance in the Lincoln School," pp. 18-19.

²Emily G. Sutter, and Jackson B. Reid, "Learner Variables and Interpersonal Conditions in Computer-Assisted Instruction," Journal of Educational Psychology, LX (June, 1969), 155.

³Barbara Doty, and Larry A. Doty, "Programmed Instructional Effectiveness in Relation to Certain Student Characteristics," Journal of Educational Psychology, LV (December, 1964), 338.

⁴J. Altrocchi, "Dominance as a Factor in Interpersonal Choice and Perception," Journal of Educational Psychology, L (May, 1959), 308.

self-assured, and independent performed at a higher level under live classroom presentations while subjects possessing the opposite characteristics tended toward higher performance in a film-learning condition.¹

In a study of 1,865 third grade students, Passy found a positive relationship between a child's socio-economic background and his achievement in mathematics.² The data indicated a direct relationship between the increased level of education and skill of the working parent and a child's mathematics achievement. He recommended that an instructional program in mathematics should be one that will foster learning in all children without cultural bias.³

Gage points out that many of the contemporary arguments favoring individualizing instruction are extremely plausible:

Learners do differ in ways relevant to their ability to profit from different kinds of instruction, content, incentives, and the like. Almost by definition, instruction adapted to these individual differences should be more effective.⁴

Bishop agrees and contends that the concept of individualization of instruction has had greater impact upon the de-

¹Richard E. Snow, Joseph Tiffin, and Warren F. Seibert, "Individual Differences and Instructional Film Effects," Journal of Educational Psychology, LVI (December, 1965), 319.

²Robert A. Passy, "Socio-Economic Status and Mathematics Achievement," The Arithmetic Teacher, XI (November, 1964), 469-470.

³Ibid.

⁴Nate Gage, "Theoretical Formulations for Research on Teaching," Review of Educational Research, XXXVII (June, 1967), 358-370.

velopment of modern education programs and the implementation of instructional changes than any other concept.¹ He mentions for consideration the following propositions:

1. That learning takes place individually; therefore, curriculum and methodology should be organized around the individual child. The quest for ways to individualize learning is the most important innovating force influencing the development of present-day educational systems.
2. That students must come in contact with different levels of learning and have the opportunity to work together to discover the relationships of various disciplines as aspects of one world.
3. That for education to be internalized, students must learn that true education is a continuing process. This is the ubiquitous nature of true education and learning.
4. That the educational program must be dynamic and in a constant state of evaluation and change in order to survive. It must be adaptable, flexible, and capable of meeting the demands of a complex technological and changing culture.²

The preceding premises contain powerful implications for any instructional program desiring to provide the best possible education for its children.³

Programs Employing Individualized Instructional Techniques

The literature pertaining to this subtopic will be further examined, for purpose of analysis, into these areas: (1) early work in individualized techniques, (2) programs involved in individualizing instruction by changing the school's organizational pattern, (3) programs employing cur-

¹Lloyd K. Bishop, "Individualizing Educational Programs," Business Education Forum, XXV (May, 1971), 13.

²Ibid.

³Ibid.

riculum developments and innovations in mathematics instruction, and (4) recent improvements made possible by advances in educational technology.

Early Work in Individualized Techniques

Individualization of instruction within classes has a long history. Hildreth states:

. . . it is likely, that soon after class instruction became the fashion in American schools some resourceful teachers began to employ means for giving specific attention to individual pupils, especially those whose learning was unsatisfactory.¹

In 1888, Preston W. Search, superintendent of Pueblo, Colorado schools, developed a systematic plan of instruction to provide for individual differences among secondary school students. Apparently the plan was discontinued when local dissatisfaction led to the firing of the superintendent.²

According to Henderson, differentiated staffing first appeared in 1898, in a program that involved a master teacher and an assistant teacher who helped with large classes. Attempts to individualize instruction through homogeneous or ability grouping began about 1900.³ Washburne states that Burk pioneered in breaking the "lock-step" in education by developing individual instructional materials which led to

¹Hildreth, "Guidance in the Lincoln School," p. 23.

²George L. Henderson, "Individualized Instruction: Sweet in Theory, Sour in Practice," The Arithmetic Teacher, XIX (January, 1972), 18.

³Ibid.

the development of the Winnetka Plan in 1919.¹ This was a non-graded approach in which each student was given a separate course of study for each subject in the program, with provisions made for continuous-progress promotion.

Baker reports that the Dalton Plan was developed by Parkhurst at about the same time.² The principal features were: freedom for the individual child to work on his assignment; economy through budgeting of time; and discarding the fixed daily schedule. Differentiation of assignments was provided for different ability levels and the classroom was thought of as a workroom. By 1925, the Dalton Plan was in use in over 200 U. S. schools, but then gradually disappeared.³

Billet describes a third major individualized method known as the Morrison Plan. Here the sequence in units is provided for and guide sheets are used for lesson assignments. The classroom became a laboratory with pupils of varying ability having differentiated units and assignments. The Morrison Plan was most generally used in the teaching of science.⁴

¹Washburne, Adapting the Schools, pp. 77-82.

²H.J. Baker, "The Nature and Extent of Individual Mental Differences," The Journal of Educational Research, (March, 1932), 12.

³Ibid.

⁴R.O. Billet, "Provisions for Individual Differences, Marking, and Promotion," National Survey of Education Monograph, No. 13 (Washington, D.C.: Government Printing office, 1933).

Henderson contends that an indication of the popularity of individualized instruction during the twenties was provided in a 1925 bibliography that listed 487 books and articles about individualizing in specific American schools.¹

In the years following this period the literature included descriptions of a number of individualized procedures and devices less comprehensive in scope than the Winnetka, Dalton, and Morrison Plans. In a report released by the Division of Educational Research and Results, the Philadelphia Board of Public Education describes three devices for individualizing classroom work in junior and senior high school.² These included differentiated unit assignments, individual remedial exercises, and grouping pupils within the classrooms. Three types of differentiated assignments were noted: (1) the common assignments differing in rate, (2) maximum and minimum assignments differing as to achievement level expected, and (3) common group objectives with added assignments for each pupil. In the grouping process, committees were formed for special assignments and other groups were given needed remedial instruction. According to the authors, highly satisfactory results were achieved in this program.³

Lipson took into account the individual or unique

¹Henderson, "Individualized Instruction," p. 18.

²Broussard, "The Effect of an Individualized Instructional Approach," p. 38.

³Ibid.

characteristics of the student when discussing individualization in junior high school mathematics.¹ This first method he suggests is using a common assignment, but allowing for individual response. Regardless of the assignment, each student will bring to and take away something different. A second method is to state common objectives for all students, but provide individual paths to their completion. His third suggestion is to individualize the objectives for all students in the program, and allow different times for completion.²

Altering Organizational Patterns to Better Meet Individual Needs

New organizational patterns have been designed to create greater flexibility within schools and offer more alternatives to meet student needs for individualization.

Ability grouping, which is defined as classifying children into restricted range (homogeneous) classroom environments, has been used extensively as a means of providing for individual differences in response to increased public concern with academic achievement. The variety of reasons consistently offered by educators for the use of ability grouping are presented by Esposito.³ The rationale for ho-

¹Joseph Lipson, "Individualization of Instruction in Junior High Mathematics" (paper presented at the Regional Meeting of the National Council of Teachers of Mathematics, Montreal, Canada, November 6, 1970), pp. 1-3.

²Ibid.

³Dominick Esposito, "Ability Grouping - Good for Children or Not?" The National Center for Research and Information on Equal Educational Opportunity, Tipsheet No. 4, (May, 1971), pp. 1-3.

mogeneous ability grouping, not necessarily based on research findings, generally include the following: (1) individual differences are taken into account by allowing pupils to advance at their own rate while grouped with others of similar ability, and by offering methods and materials geared to their level, (2) the teacher has more time to provide individual attention, (3) the pupils are challenged to do their best within a realistic range of competition, (4) it is easier to teach to a narrower range, and (5) teachers in heterogeneous groups must teach to the average student.¹

The implication is that ability grouping is a means for providing for individual differences, but Esposito states that there is no clear-cut evidence indicating that this objective has been realized.² In fact, the 1968 NEA report states that despite the increasing popularity of ability grouping, there is a lack of empirical evidence to support its use in the schools.³ Furthermore, the NEA claims that homogeneous ability grouping results in the ethnic and socioeconomic separation of students, and that this grouping procedure should be abandoned and replaced with an educational opportunity.⁴

According to Trafton, flexible grouping seems to be a more effective organizational pattern than ability grouping,

¹Ibid.

²Esposito, "Ability Grouping," p. 2.

³Ibid.

⁴Ibid.

for it permits the partitioning of classes into small groups for short periods of time to work on specific content.¹

When the topic is completed, the students can be brought together until the need again arises to have smaller groups. This approach has been effectively implemented in skill areas where wide divergence in achievement often occurs.²

Nongraded programs are another example of new organizational patterns which meet student needs for individualization. These needs are accomplished through the systematic assignment and reassignment of the pupil to classes consistent with his performance level. Brown evaluated the nongraded program at Powell Elementary School (grades 1-6) in Philadelphia and indicated that individualization did occur and that the pupils performance in reading and arithmetic, as measured by the Iowa Test of Basic Skills, was significantly improved over the previous year.³ Also, nongraded pupils attained higher levels of independent study skills than most of their peers in graded schools.⁴

Team teaching presents new opportunities for teachers with different specialities and students with varied backgrounds to learn from one another. A team will usually consist of two to seven teachers, with one acting as team lead-

¹Paul R. Trafton, "Individualized Instruction: Developing Broadened Perspectives," The Arithmetic Teacher, XIX (January, 1972), 11.

²Ibid.

³Edward K. Brown, The Nongraded Program at the Powell Elementary School: Evaluative Phase II (Philadelphia Public Schools, Philadelphia, Pennsylvania, 1970), pp. 1-39.

⁴Ibid.

er. The strengths of the group must be analyzed and the syllabus planned accordingly, inviting guest instructors to fill gaps in their fund of knowledge. Student grouping may be parallel (all at the same level) or vertical (ability with enrichment in small groups). A team effort can also be administered in separate classes, with each teacher agreeing to organize instruction around a central theme. Regardless of the method employed, the principal advantages of team teaching are minimizing of preparation, saving of time, and unification of student experience.¹

Curriculum Developments and Innovations in Mathematics Instruction

Numerous developments have occurred in individualized instruction which focus primarily on curriculum and instructional materials and are based on a continuous progress concept.

Individually Prescribed Instruction (IPI), developed at the University of Pittsburgh, is a more specific term used to describe a form of programmed instruction that probably represents the most thoroughly developed and sophisticated form of individualization which is not dependent upon computers. The essential aspects of IPI are as follows:

1. Individualization of the rate at which students proceed through a carefully sequenced set of ob-

¹Robert J. Elkins, "Team Teaching and Individualized Instruction," (speech presented at the Conference of Modern Language, History, and Social Studies Teachers, Wetzlar, Germany, December 2, 1970), pp. 1-3.

- jectives for a given subject;
2. Mastery of subject matter content to enhance discovery or creativeness as one proceeds through a set of objectives;
 3. Some self-direction, self-evaluation, and self initiation to a limited degree on the part of the learners; and
 4. Individualized techniques and materials of instruction.¹

The IPI materials include tapes, worksheets, booklets, and records all aimed at self-instruction and equipped with built-in tests. These tests help the student determine: (1) whether he needs to study the material or if he has already mastered it, (2) if he actually understands each step, and (3) after completing a unit of study, has he indeed moved along in the direction of one of the curriculum objectives.²

Yetter sees IPI as one system that can meet the needs of our changing world because it has helped change the interest and attitudes of many in learning how to learn.³ He believes IPI is a step toward the superior classroom because it includes materials that can be used independently, allowing each child to learn at his own pace and realize success. Additionally, the teacher is provided tools for assessment,

¹John O. Bolvin, "Individually Prescribed Instruction," Educational Screen and Audiovisual Guide, XLVII (April, 1968), 14-15.

²"Oakleaf School," Grade Teacher, LXXXV (May-June, 1968), 81-84.

³Clyde C. Yetter, "Do Schools Need IPI? Yes!" Educational Leadership, XXIX (March, 1972), 491.

mastery measurement, and specified management techniques.¹

Meade and Griffin in their final report of an IPI mathematics program as an instructional approach in grades 1-6, concluded that no significant differences occurred between the control and experimental groups in achievement, but that a positive difference was found in teachers' and pupils' attitudes. The classes in this study had been matched by mean I.Q., previous mathematics achievement, and socio-economic status.²

Tillman lists the shortcomings of IPI as: (1) the overly strong emphasis on sequence, (2) the validity placed on diagnostic tests, and (3) the establishment of 85 percent correct responses as a major criteria for determining success.³ He has found much research, experience, and expert opinion to refute heavy reliance on any of these as "near absolutes." Fehrle has similar doubts which include: (1) the financial burden incurred by those adopting the program, (2) the lack of student interaction, (3) the need for more color, depth, variety, and open-ended thinking situations, and (4) the training or retraining of teachers.⁴ Fehrle

¹Ibid.

²William F. Meade, and Lawrence M. Griffin, A Comparative Study of Student Achievement and Other Selected Student Characteristics in a Program of Traditional Instruction in Mathematics in Grades 1-6 (Horseheads Central School District, Horseheads, New York, 1969), pp. 140-155.

³Rodney Tillman, "Do Schools Need IPI? No!" Educational Leadership, XXIX (March, 1972), 495.

⁴Carl C. Fehrle, "A Look at IPI," Educational Leadership, XXVII (February, 1971), 481-484.

further states that even though the program is still in the experimental stage, its idea appears sound and the results may be rewarding.¹

Sinks analyzed the effects of changing the educational environment drastically to achieve an individually prescribed curriculum for each of the students in his experimental group.² These subjects were given an individually prescribed curriculum in mathematics, science, language arts, and social studies and were compared with the control group using the traditional textbook approach, class-group method in all subjects. Results suggest that the experimental treatment accounted for the gains in achievement scores on the Sequential Test of Educational Progress in all four subject areas and for the desirable changes in the student's attitude, behavior, and learning strategy.³

The multi-text approach is another strategy being used to individualize mathematics instruction. Teachers in Broward County, Florida, developed the Scientific Approach to Mathematics Instruction (SAMI) which is a series of testing booklets covering skills required by students at

¹Ibid.

²Thomas Alonzo Sinks, "How Individualized Instruction in Junior High School Science, Mathematics, Language Arts, and Social Studies Affect Student Achievement" (unpublished Ph.D. dissertation, University of Illinois, 1968), pp. 109-129.

³Ibid.

different grade levels.¹ The teachers also studied several different grade level textbooks and matched material from corresponding texts. Students are assigned a pretest which is corrected by an aide who submits the results to the teacher. The teacher's role is that of diagnostician and after viewing the test results, will assign several texts for the student's use. A thorough record of each child's progress is kept and from these records students are assigned to groups for formal teaching lessons. Numerous other schools have developed very similar individualized programs in mathematics.²

The Learning Activity Package (LAP) is a curriculum package on a given topic with clearly defined objectives, carefully developed sequences, and evaluations to determine if the objectives have been met. The LAPs have been used to provide appropriate curriculum materials in numerous school districts that have adopted ideas such as team teaching, continuous progress, non-gradedness, and flexible scheduling. The learning package concept will be covered in-depth later in this chapter.³

Project PLAN (Program for Learning in Accordance with Needs), developed by the Westinghouse Corporation in

¹Florence T. Pieronek, A Survey of Individualized Reading and Mathematics Programs (Calgary Separate School Board, Alberta, Canada, 1969), p. 38.

²Ibid.

³Sally M. Cardarelli, "The LAP - A Feasible Vehicle of Individualization," Educational Technology, XII (March, 1972), 23.

conjunction with the American Institute for Research, utilizes similar packages called "Teaching Learning Units" (TLUs). The program is computer-managed, in that the computer processes and stores student progress data for the purpose of making prescriptions. Pretests and objectives are used to establish the needs of the students. Lessons are generally assignments from currently available commercial materials which have been related to the objectives and sequence of Project PLAN. PLAN is working toward accountability by stating its objectives and demonstrating it can achieve them.¹

An individualized program using student "contracts" has been developed at Hopkins, a Minnesota High School, and it is enabling students to progress through geometry or algebra at their own rate.² The students are given contracts which they are to complete within an allotted time of usually one week. The Hopkins School has also been involved in an innovative testing system called Comprehensive Achievement Monitoring. This system uses computer analysis of periodic tests in mathematics to inform the teacher of which concepts and problems are causing difficulty with the students and which ideas are coming-across well.³

¹Robert A. Weisgerber, "PLAN Is a Project Halfway There," Educational Screen and Audiovisual Guide XLVIII (July, 1969), 12-13.

²Lipson, "Individualization in Junior High," pp. 4-5.

³Ibid.

Educational Technology

This third category for individualizing instruction is perhaps best exemplified with the recent technological developments in education. Salisbury believes that computer-assisted instruction (CAI) has been the most significant instructional application of computers and has been defined as:

A man-machine interaction in which the teaching function is accomplished by a computer system without intervention by a human instructor. Both training material and instructional logic are stored in the computer memory.¹

The three basic modes of computer-assisted instruction include: (1) drill and practice, (2) tutorial, and (3) dialogue.² The least complex is the drill and practice mode. Here the computer is used to control, guide, and monitor by repetition a specific task or group of tasks. The purpose is to develop a predetermined level of proficiency in a given skill. This mode has been used considerably in elementary school mathematics instruction. The tutorial mode is more complex in that more material is presented and a higher level of student response is called for. It is generally used for original rather than supplemental instruction, and an entire course may be taught in this mode alone. Dialogue is the third and most complex manner of instruction. The student actually engages in a conversation with the computer, rather than being presented textual material and then being

¹Alan B. Salisbury, "An Overview of CAI," Educational Technology, XI (October, 1971), 48.

²Ibid.

questioned to determine his comprehension, as in the tutorial process. Depending upon whether the initiative to ask the questions rests with the pupil or the computer, the dialogue mode can be further classified as Computer Inquiry or Student Inquiry.¹

Bundy, in reviewing the literature pertaining to CAI, drew the following conclusions: (1) pupils seem to learn at least as well with CAI as with conventional classroom instruction, (2) CAI can provide learning and retention at least equivalent to conventional techniques, (3) the computer program can include a wide variety of audiovisual aids in the learning program, (4) students are generally interested in and favor the CAI form of instruction, and (5) the computer provides an excellent opportunity for an experimental research lab to study learning and perhaps ultimately to build a theory of instruction.² Bundy concludes by stating that CAI's potential has yet to be fulfilled, largely because it is still too expensive.³

Computer-Managed Instruction (CMI) is an information system in the sense that it keeps a record of and provides information about students. CMI also increases the potential of meeting individual needs because of the wide range of programs that are possible. The curriculum is learner-oriented,

¹Salisbury, "Overview of CAI," pp. 48-50.

²Robert F. Bundy, "Computer-Assisted Instruction - Where Are We?" Phi Delta Kappan, XLIX (April, 1968), 425.

³Ibid.

adaptive, self-directive, and makes use of stimulus control and contingency management.¹ A typical program consists of modules of instruction or teacher-learner units, feedback, and usage of student variables in prescribing instruction. The student receives his suggestions, works at his own rate, and upon completion of the unit, will be tested in the testing center. A remote terminal connects each school with a central computer.²

Nichols states that during the 1950's the production of programmed materials reached staggering proportions.³ Those who were involved in the writing of these materials proceeded on the assumption that a student should learn at his chosen rate, and they followed Skinner's concept of reinforcement - each response immediately followed by the judgement as to whether it is right or wrong.⁴

Deterline, President of General Progress Teaching, Palo Alto, California, defines programmed instruction as:

Interactive instruction involving an individualized interaction between student and instructional input, whether student paced or group paced, made up of a sequence of steps, each consisting of instructional input followed by some form of student response, followed in turn by some form of evaluation of the

¹John A. Finch, "Computer-Managed Instruction: An Annotated Bibliography," Audiovisual Instruction, XVII (March, 1972), 72.

²William W. Cooley, "Data Processing and Computing," Encyclopedia of Educational Research (Toronto: Collier - MacMillan Limited, 1969), pp. 289-90.

³Eugene D. Nichols, "Is Individualization the Answer," Educational Technology, XII (March, 1972), 53.

⁴Ibid.

response. This is a process, not a medium or a thing.¹

A typical program consists of sequentially arranged pieces of information called frames. Most frames require a student response that is checked immediately against the correct response.²

Lindvall and Bolvin, in summarizing the advantages of educational programming, state that studies indicate that programs: (1) permit progress at individual rates, (2) can teach effectively, (3) can be used in various ways, and (4) can hold the attention of the pupils. They further state that programmed instruction is most effective if the entire school or a series of grades is programmed.³

The main problems mentioned by Lindvall and Bolvin are: (1) that not all available programs are effective, (2) many needed programs have yet to be developed, (3) greater flexibility and organization in the curriculum is needed than is found in most school situations, and (4) that too many schools adopt the materials without adopting the philosophy.⁴ Another distinct disadvantage lies in the cost factor. Bright estimates the cost of preparing materials,

¹William A. Deterline, "Programmed Instruction as a Process," Educational Screen and Audiovisual Guide, XLVI (June, 1967), 18.

²Nichols, "Is Individualization the Answer," p.53.

³C.M. Lindvall, and John O. Bolvin, "Programmed Instruction in the Schools: an Application of Programming Principles," quoted in Phil C. Lange, ed. Programmed Instruction (Chicago: University of Chicago Press, 1967).

⁴Ibid.

regardless of the media utilized, to be an investment of approximately two hundred professional man hours, to prepare the materials that an average student will go through in one hour.¹

Electronic calculators have also been viewed as an innovative technical means of improving mathematics instruction. Keough and Burke conducted an experimental study in two high schools in New York to determine the feasibility of using calculators.² They were also concerned with developing curriculum-related materials, and whether the usage of the calculator could be applied to the teaching of areas related to mathematics. The Sequential Test of Education Progress was used as a pretest and posttest measure of math achievement. When a new unit of instruction was initiated the students in the experimental group used electronic calculators to solve problems related to homework assignments and classroom work. From the posttest, a T-test indicated a significant difference between the groups at the .01 level. The authors concluded that the results indicate that electronic calculators can facilitate mathematics instruction in eleventh and twelfth grade classes.³

With the use of technological developments such as

¹"According to Dr. Bright," Educational Screen and Audiovisual Guide, XLVI (June, 1967), 14-16.

²John J. Keough, and Gerard W. Burke, Utilizing an Electronic Calculator to Facilitate Instruction in Mathematics in the Eleventh and Twelfth Grades (Suffolk County Regional Center, ESEA Title III, Patchogue, New York, (1969), pp. 1-60.

³Ibid.

computers, calculators, and programmed instruction, math labs have been initiated to enable a student to learn mathematics by discovering concepts on his own with only discreet guidance from the instructor. The emphasis is placed upon individualized learning through the discovery approach. The basic objective in using the discovery method is to present mathematics in a manner that will make sense to the student. He is learning math through his reactions and responses to the experiences. Meaning becomes apparent to the student only through the individual's experience, interest, and imagination as an active participant.¹ A teacher will seldom tell the solution to a problem or how to find it, but instead will use strategic suggestions and questions to stimulate the youngster to work out the problem himself.²

The math lab also places emphasis on children handling physical materials, and on their devising methods to solve problems. This approach stems from Piagetian principles of education. Some labs make use of special materials, such as Cuisenaire rods and Diene's MAB blocks, whereas others use environmental materials such as pebbles, bottle caps, tongue depressors, and pieces of spaghetti. Often children are assigned specific tasks, while at other times they may be asked to help design their own projects.³ Kessler believes

¹Herman Boeckmann, "The Discovery Approach Strategy for Mathematics Teachers," School Science and Mathematics, LXII (January, 1971), 4.

²Bernard M. Kessler, "Individualizing Mathematics Learning Through the Math Lab," Educational Technology, XII (March, 1972), 30.

³Kessler, "Individualizing Mathematics," pp. 30-32.

that "the power of the math lab approach lies in its ability to free the creative energies of children, teachers, administrators and the community towards a more effective school system."¹

Summary

In the preceding section, various strategies leading to the individualization of instruction and its application to the general school curriculum, as well as specific mathematics instruction, were discussed. Five elements basic to individualized instruction were included to provide a definition for the term as it applies to this study.

The premise for individualized instruction was stated using the opinions of writers as well as the results of research conducted on the effect of individual differences on academic achievement. Characteristics mentioned included: personality traits, scholastic aptitude, mental ability, motor skills, interests, and socio-economic background. A review of the literature indicates that a correlation does exist between individual differences and a child's ability to profit from his education.

Programs employing individualized techniques were also reviewed. Examples were cited from the late nineteenth century to the current innovations brought about by educational technology. Techniques that alter organizational patterns were described and a number of examples of curriculum development in mathematics were reviewed.

¹Ibid.

LEARNING PACKAGES

The review of the literature pertaining to learning packages is discussed under three major headings. The sections will deal with the following: (1) a discussion of learning packages, (2) the role of learning packages in individualized programs, and (3) Learning Activity Packages (LAPs).

An Introduction to Learning Packages

In order to provide a thorough discussion of the concept of learning packages, it is necessary to divide the topic into three subtopics which include: (1) a background of learning packages, (2) major characteristics of a learning package, and (3) some general implications regarding their use.

A Background of Learning Packages

The advent of learning packages did not appear on the educational scene as abruptly as many of the other new instructional practices that emerged during the 1960's. Incomplete packaged materials accompanying basic textbooks, such as end-of-chapter reviews, supplementary readings, teacher resource guides, and the all-too-familiar workbooks have been standard for many years. Contemporary packages are more comprehensive, involve a systems concept, include more varied techniques and media, and can be developed independently or purchased commercially with content ranging through most of the subject areas sequentially arranged for

school use.¹

The more common formats in package designs have been organized under UPI, LAP, UNIPAC, and Westinghouse Learning Corporation's, TLUs.² These programs have generally arranged the curriculum sequentially in small components with clearly stated performance objectives that allow an individual to progress at his own rate. Typically, these packages are a self-contained set of teaching-learning materials structured for independent and individual usage, and designed to teach a single concept in a continuous-progress school program.³

Major Characteristics of Learning Packages

Just as there are varied differences in the defining of individualized instruction, so any discussion of instructional packages encounters semantic difficulties. In classifying a learning package, six specific characteristics are usually readily discernible:

1. Role of the instructor
2. Concept focus
3. Behaviorally-stated objectives
4. Multiple activities and methods
5. Diversified learning materials and activities

¹Hulda Grobman, "Educational Packages - Panacea?" Educational Leadership, XXVII (May, 1970), 781.

²William Georgiades, "Introduction: The Advent of Learning Packages," Journal of Secondary Education, XLVI (May, 1971), 199.

³Ibid.

6. Evaluation¹

It is the intent of this section to describe each major characteristic and explain its function.

The role of the instructor has been changed significantly from the time he was mainly a dispenser of knowledge. He becomes a diagnostician of learning in helping each individual child find success. The student moves into a more active role in the learning process as many individual decisions are left for him to make. Teachers also have more time to provide enrichment activities and for effective planning to aid the students in their learning problems. The professional expertise of the teacher can provide local adaptations for the most positive learning conditions possible.²

Within a course of study there are broad generalizations, referred to as "units", and within these units there are more discrete "clusters" of concepts which make up the structure of the units. The focus of a package is determined by the selection of a single concept from the structure. The concept chosen for a given package will dictate the package's place in the total curriculum. The expected level of performance of the learners must be matched with the choice of concept focus. It is this match which sets the package apart from textbooks or a curriculum guide that

¹R. Herbert Ringis, "What is 'A Instructional Package?'" Journal of Secondary Education, XLVI (May, 1971), 201.

²Glenys G. Unruh, "Can I Be Replaced by a Package?" Educational Leadership, XXVII (May, 1970), 765.

is used during an entire semester or school year.¹

Clearly stated instructional objectives should convey the concept in a form recognizable to the learner so he will know the quality of performance expected of him. The self-directive nature of the package requires that the objectives be clearly stated and understood by the learner. If this is achieved, the objectives will provide guidance for the learning experiences contained in the package.²

Varying types of multimedia learning materials are included, based on the belief that there is no one best way for any learner to learn. This multiplicity of activities to accomplish objectives compels the learner into decision-making, provides for different styles of learning, and attempts to relieve the "sameness" of the educational process. The student may elect to be involved in: (1) experimentation, (2) observation, (3) group work, (4) independent study, (5) role playing, (6) simulation, (7) field trips, (8) model building, (9) research, (10) construction, or (11) use of varied materials and media.³

A variety of materials and media should be provided with the activities listed in addition to the multiple methodologies. To accomplish an objective the learner can choose from among films, records, tapes, filmstrips, diagrams, videotape recordings, models, and charts. He may

¹ Ringis, "What Is 'A Instructional Package?'" p. 202.

² Ibid.

³ Ringis, "What is 'A Instructional Package?'" p. 204.

wish to use a single resource or a combination of them to achieve his objectives and concept formation. This diversity is also provided to allow for variations in the individual styles of learning.¹

The evaluation instruments within packages allow for individual assessment throughout and usually include: (1) pretest, (2) selftest, and (3) posttest. The pretest serves in assessing readiness, determining the level of prerequisite abilities, and providing a basis for deciding where, and with what part of the package the learner will begin. Short selftests give reinforcement of improvement and provide check-points as the learner proceeds toward the objectives. With a posttest, the learner and the teacher assess the student's progress and decide whether or not he has gained sufficiently to exit the package. If the performance specified in the objectives is not attained, additional learning experience from the same package, or from another package may be prescribed. Most importantly, the posttest provides closure for the learner; he may experience a sense of personal accomplishment.²

General Implications

Included among the general implications of the use of curriculum packages in educational innovation and change are a number of possible problems. In the initial years of pro-

¹Ibid.

²Ringis, "What is 'A Instructional Package?'" p. 204.

gram development, quality control is often lacking. Generally the packages contain a disproportionately higher use of low-level cognitive objectives with little emphasis on transfer, synthesis, or problem-solving skills. In addition, there are claims that the package is too dehumanizing, and too narrow, and that it cannot measure attitude.¹

The process of revision should be an integral part of packaging and could solve many of these ills and lead to vastly improved instruction. To make revision successful, creative instructors with programming skill and a willingness to include attitudinal responses are necessary. More generally, a higher order of educational objectives are needed to encourage divergent rather than convergent student responses, and ultimately to improve problem-solving skills and attitudes toward learning.²

Grimsley asserts that poor classroom implementation can hamper the effectiveness of even the best designed package.³ Teacher training is vital to the success of any new program and the producers must make provisions for this training as part of the package. Attention must also be given to involving the district's curriculum workers in the introduction of the new program and in teacher training, for

¹Rita E. Johnson, "Self-Instructional Packages: Good or Bad?" Junior College Journal, XLVI (August/September 1971), 19-20.

²Ibid.

³Edith E. Grimsley, "Before I Look Inside," Education-
al Leadership, XXVII (May, 1970), 773-774.

the program can be threatened by the withdrawal of contract consultant services.¹

Budget restrictions and rising expenses make the cost of a packaged program a major hurdle for most districts. In the majority of programs, a high initial cost is incurred. One may argue that the package is a better instructional system and a more economical choice based on demonstrated quality, but the product must be offered at a reasonable cost before widespread adoption and use can take place. Empirical data concerning initial and replacement costs, as well as pupil achievement, can be helpful to a district considering a learning package approach to the curriculum.²

The degree of structure built into the package is a prime consideration for any school district. Just how much structure is desirable and how flexible should the package be?³

Some structure is necessary for optimal learning, for if there is no predetermined sequence, no part of the material can assume prior skills, techniques, and abilities and no part can pyramid learning on prerequisite skills. Also, different teachers need different amounts and kinds of structure to feel confident in teaching any subject matter.

¹Ibid.

²O.L. Davis, and Paul W. Kirby, "The Package: A New Way of Life," Educational Leadership, XXVII (May, 1970), 771.

³Grobman, "Educational Packages," p. 781.

Unless the package includes: (1) extensive explanations regarding the philosophy of the materials, (2) suggested approaches, (3) alternatives, (4) possible difficulties, and (5) a carefully annotated bibliography to help stimulate creative teaching, their potential will not be realized.¹

Flexibility should be provided within the framework of the course and the package by offering a variety of learning experiences for achieving the objectives. There should be alternatives involving a variety of media, approaches, and subject coverage, so that all parts of the materials are illustrative of some general skills of concern to the curriculum, but need not focus on a given series of facts.²

The Role of the Learning Package in Individualized Programs

Ubben states that the learning package is more than just another approach to individualized instruction.³ Instead, it offers a design for an individualized management system that is planned and paced on a one-to-one basis for each child according to his individual needs. Learning packages can be sequenced into a continuum of skills and used for continuous progress learning, or a few select packages can be identified to help the child with remedial work, should his diagnosis determine the need. This prescribing

¹Grobman, "Educational Packages," pp. 781-782.

²Ibid.

³Gerlad C. Ubben, "The Role of the Learning Package In an Individualized Instructional Package," Journal of Secondary Education, XLVI (May, 1971), 206.

of learning experiences on an individual basis, after appropriate diagnosis of needs, is but one change in the recasting of the teacher's role. Others include the role of instructional manager, managing the learning process, and evaluating the results. To accomplish this, a system such as a learning package is needed, for it makes possible the pre-planning of an infinite number of lessons to achieve an infinite number of behaviors.¹

A well designed package system makes available multiple packages or objectives covering a range of skills and concepts, as well as multiple resources within each package that allows for a number of options on how the package may be administered. Edling's table illustrates the options available when answering who is to decide which objectives are chosen and what resources are to be used in achieving those objectives.²

		OBJECTIVES	
		Teacher Selected	Student Selected
RESOURCES	Teacher Selected	A	C
	Student Selected	B	D

¹Ibid.

²Jack V. Edling, Individualized Instruction: A Manual for Administrators (Corvallis, Oregon: Continuing Education Publications, 1970), quoted in Gerald C. Ubben, "The Role of the Learning Package In an Individualized Instructional Package," Journal of Secondary Education, XLVI (May, 1971), 207.

Option A. The teacher prescribes both the package to be studied and the resources to be utilized within that package.

Option B. The teacher prescribes a particular learning package, but the student is allowed freedom in choosing those resources that appeal to him. Here the student needs to complete only enough resources for him to meet the behavioral performance called for in the objectives.

Option C. The student is allowed to choose from the numerous packages within the package system. The teacher assigns the resources to be used after the child has made his selection.

Option D. The student has the freedom to select his own package and to choose his resources within that package.¹

Practical classroom application may entail the use of all four options at some time, depending on the nature of the package, the adequacy of the resources, and the ability of the particular child to work independently. However, the more a child is involved in making his own educational decisions, the more likely he is to be totally committed to them.²

Learning Activity Packages

Arena asserts that many educators who have recognized

¹Ibid.

²Ubben, "The Role of the Learning Package," p. 208.

the need for a systems approach to individualized instruction have previously hesitated to undertake the task because of uncertainty surrounding an effective instrument for implementation. Within the last few years, Learning Activity Packages (LAPs), conceived and developed at Nova High School in Ft. Lauderdale, Florida, have shown their effectiveness and are increasingly being employed by educators throughout the nation to individualize the instructional program.¹

Basically, the LAP is a specially designed booklet on a given topic, containing objectives directly related to this topic, varied activities to meet these objectives, and evaluations to determine the students success in meeting the objectives. Flexibility is evidenced by the fact that each teacher, and each school district that initiates a LAP program sets up a format devised to meet their specific needs.²

The components of the LAP include the following:

1. Rationale
2. Behavioral or performance objectives
3. Pretest and its analysis
4. Basic references
5. Program for learning
6. Self-evaluation test and its analysis
7. Posttest³

¹John E. Arena, "An Instrument for Individualizing Instruction," Educational Leadership, XXVII (May, 1970), 784.

²Sally M. Cardarelli, "The LAP - A Feasible Vehicle of Individualization," Educational Technology, XII (March, 1972), 24.

³Arena, "An Instrument for Individualizing," pp. 784-785.

The rationale is a short introduction to the unit which attempts to explain why the content of the LAP is important, and which makes evident the continuity between LAPs and the need to progress from one to the next in an orderly sequence.¹

Following the rationale are a list of behavioral objectives for the entire unit. The objectives should provide the student with a clear verbal picture of what he is expected to accomplish. Early use of the LAPs should come with a simple performance statement and proceed to precise behavioral objectives as the child gains experience in using the package.²

Upon completion of the pretest, the teacher and student meet to decide on a suitable program of instruction. Ideally, it will be a multi-media, multi-modal, multi-level approach to fulfill the objectives of the LAP. The teacher should be available for consultation whenever the student requires it.³

The posttest is taken when the student feels he has completed the program of instruction, to determine if he has mastered the objectives or has to review certain ones. Here, evaluation should assume its full role by evaluating teacher and program effectiveness, as well as student progress. This test-revision cycle applies not only to the student, but

¹Ibid.

²Cardarelli, "The LAP," p. 25.

³Ibid.

also to the teacher and the tools used in meeting the student's instructional needs.¹

Cardarelli summarizes the philosophy of the LAP program in the following manner:

1. Each student is viewed as an individual who has a right to receive a program of instruction geared to his needs, his capabilities, and his interests.
2. The role of the teacher is that of diagnostician, motivator, prescriber, and facilitator of learning.
3. The role of the student is that of an independent person capable of making his own decisions and accepting responsibility for his own education.
4. The atmosphere of a LAP program must reflect an open structure where creativity, initiative, exploration, and meaningful interaction with others can flourish.

In short, the LAP philosophy is aimed at producing the creative, spontaneous, and innovative person of tomorrow who will cope with and contribute to the society of the future.²

Summary

In the above section, an in-depth, descriptive review of the literature pertaining to Learning Packages was conducted.

The major characteristics and general implications of the use of Learning Packages were discussed with four of the writers giving cautionary statements regarding their usage. They included the following: (1) quality control may be lacking, (2) packages may be too dehumanizing, (3) a higher order of educational objectives is needed, (4) poor class-

¹Cardarelli, "The LAP," p. 26.

²Cardarelli, "The LAP," p. 27.

room implementation may hinder the program, (5) the cost may be prohibitory, and (6) the degree of structure necessary may be too demanding.

The role of the learning package in an individualized program was investigated and found to be rather flexible, dependent upon the amount of structure desired, the nature of the package, the adequacy of resources, and the ability of the student to work independently.

Learning Activity Packages, their components, and resulting philosophy were discussed, for the Individual Learning Units (ILUs) used in this study were modeled after the LAP concept.

COST-EFFECTIVENESS ANALYSIS

The literature on cost-effectiveness analysis will be covered in this section under the following headings: (1) an introduction to cost-effectiveness analysis, (2) a background on cost-effectiveness analysis, with subheadings on definitions and the development of cost-effectiveness analysis concepts, (3) relationship to Planning, Programming, Budgeting Systems (PPBS), (4) the function of cost in cost-effectiveness analysis, (5) the function of effectiveness, (6) limitations of cost-effectiveness analysis, and (7) cost-effectiveness and educational instructional improvement.

Introduction to Cost-Effectiveness Analysis

According to Enthoven:

Ultimately all policies are made and all systems are chosen on the basis of judgements. There is no other

way and there never will be. The question is whether those judgements have to be made in the fog of inadequate and inaccurate data, unclear and undefined issues, and a welter of conflicting personal opinions, or whether they can be made on the basis of adequate, reliable information, relevant experience, and clearly drawn issues.¹

Burkett asserts that education can no longer afford a random approach to the selection of educational programs; it is imperative that more effective systems to achieve clearly delineated objectives for specified populations be identified.² Cost-effectiveness analysis may offer the objective evaluation needed today.³

Cost-effectiveness analysis is a technique which can be used by educators in their decision-making process. It provides a conceptual framework for analyzing the costs, effectiveness, and other related variables of one or more programs, program components, or program alternatives. When properly implemented cost-effectiveness analysis supplies the decision-makers with data related to the: (1) cost of achieving program objectives, (2) overall effectiveness of a program in achieving its objectives, and (3) program effectiveness with subgroups of students.⁴

¹A.C. Enthoven, "Choosing Strategies and Selecting Weapon Systems," United States Naval Institute Proceedings, 90, Whole No. 731 (Washington, D.C., 1964), p. 151.

²Beverley Zielie Burkett, "A Benefit-Cost Analysis of Programmed Instruction for the Initial Teaching of Reading" (unpublished Ph.D. dissertation, The Catholic University of America, 1970), p. 6.

³Ibid.

⁴Ray Haywood Forbes, "A Technique for Analyzing the Costs of the Educational Program Based on Behavioral Stated Instructional Objectives" (unpublished doctoral dissertation, University of Massachusetts, 1970), p. 29.

This information is most valuable in planning new programs and in determining if existing programs should be modified, expanded, continued, or deleted. Cost-effectiveness analysis will not make decisions; this remains the responsibility of the educator. Cost-effectiveness simply provides the data which will aid the decision-maker to make better and more realistic decisions.¹

Background of Cost-Effectiveness Analysis

The review of the literature pertaining to the background of cost-effectiveness analysis will involve the following two subheadings: (1) definitions of the concepts included in this analysis, and (2) the development of cost-effectiveness analysis concepts.

Definitions of the Concepts

Confusion may result from the similar nature of the terms cost-benefit, cost-effectiveness, and cost-utility, because each term refers to an effort to make comparisons systematically, in quantitative terms, by using a logical series of steps.² It is appropriate to clarify these concepts to possibly eliminate further uncertainty.

Cost-Benefit Analysis (Benefit-Cost Analysis).---An analytical approach to solving problems of choice

¹M.B. Carpenter, and S.A. Haggart, "Cost-Effectiveness Analysis for Educational Planning," Educational Technology, X (October, 1970), 26.

²Francis A. Cary, "Development of an Instructional Cost-Effectiveness Analysis Model for Use in School Districts" (unpublished doctoral dissertation, State University of New York at Buffalo, 1972), p. 42.

which requires the definition of objectives and identification of the alternative that yields the greatest benefits for any given cost, or . . . yields a required or chosen amount of benefits for the least cost. The term usually applies to situations in which the alternative outputs can be quantified in dollars. A chief characteristic of cost-benefit analysis is that its aim is to calculate the present value of benefits and costs, subject to specified constraints.¹

Cost-Effectiveness Analysis.--An analytical approach to solving problems of choice which requires the definition of objectives, identification of alternative ways of achieving the objective, the identification of the alternative that yields the greatest effectiveness for any given cost, or . . . yields a required or chosen degree of effectiveness for the least cost. The term is usually used in situations in which the alternative outputs cannot be easily quantified in dollars.²

Cost-Utility Analysis.--Long range goals and objectives are fulfilled by "utility" criteria involving the returns to society. This area would include data of a quantitative (such as life-time earnings or life-time crime rates) and qualitative data (such as meeting society's needs for leisure activities). The utility concept would be of value to the social scientist and the economist.³

According to Lovell, cost-benefit analysis should be applied when the alternative output can be quantified monetarily and cost-effectiveness when the outputs cannot be easily quantified in dollar units. This basic distinction seems to indicate that cost-effectiveness has more potential

¹Richard H.P. Kraft, Cost-Effectiveness Analysis of Vocational-Technical Education Programs, for the Department of Educational Administration, Educational Systems and Planning Center, The Florida State University (Tallahassee, Florida: Department of Education, 1969), p. 142.

²Ibid.

³Cary, "Development of a Cost-Effectiveness Model," pp. 42-43.

for evaluating instructional programs than cost-benefit analysis.¹

An evaluator using cost-benefit analysis must decide what benefits to include and how they should be valued. Dorfman states that the real issue is whether or not one can estimate the social value of benefits accurately enough to justify the effort involved.² Unfortunately, the social value or the monetary benefits of many instructional programs still cannot be determined.

Cost-effectiveness studies assess much more specific activities within an educational framework than do cost-benefit studies. According to the Educational Improvement Center:

Cost-effectiveness is used to compare two or more approaches to the same goal. To conduct a cost-effectiveness comparison, the units of effect must be the same . . . economics also allows us to compare the economic desirability of programs with different goals, through cost-benefit analysis. In cost-benefit, all the different units of effect must be converted to the same units of value or utility.³

Kershaw and McKean see cost-effectiveness analysis as an orderly method of assisting decision-makers to select a

¹Ned B. Lovell, "Cost-Effectiveness Evaluation of Instructional Programs: A Developmental Design (K-12)" (unpublished Ph.D. dissertations, The Florida State University, 1971), p. 10.

²Robert Dorfman, ed., Measuring Benefits of Government Investments (Washington, D.C.: The Brookings Institution, Studies of Government Finance, 1965), p. 8.

³"Cost-Benefit Analysis," Educational Improvement Center-South Jersey Region, p. 3.

preferred course of action from a set of alternatives.¹

They believe the purposes of this analysis are: (1) to discover new alternatives, (2) to improve on the existing alternatives, (3) to provide a means for incremental costs considerations, and (4) a rational alternative to the use of expert opinion, committee decision, or pure intuition in choosing instructional strategies.²

The term cost-utility analysis is still preferred by some writers. The basic differences between this term, cost-benefit and cost-effectiveness are usually matters of degree, context, emphasis, and personal preference.³

From the preceding distinctions made between the three terms, it seems that cost-effectiveness will be generally more useful to educational decision-making than cost-benefit or cost-utility. With this in mind, the design applied to this study was categorized as cost-effectiveness analysis. The study was concerned with: (1) specific activities within an institution, (2) a comparison of two or more approaches to the same goal, (3) measuring of all the alternatives by the same units of effect, and (4) the analysis of alternative outputs that cannot be easily quantified in dollar units.⁴

¹J.A. Kershaw, and R.N. McKean, System Analysis and Education, Memorandum RM-2473-FF. (Santa Monica, California: The RAND Corp., 1959), p. 2.

²Ibid.

³Kraft, Vocational-Technical Education Programs, p. 8.

⁴Lovell, "Cost-Effectiveness Evaluation," p. 12.

Development of Cost-Effectiveness Analysis Concepts

A Congressional Subcommittee on Government Operations states that the concept of cost-effectiveness analysis is a very old discipline for:

Long-range planning, budgeting, and seeking the least costly way to achieve objectives all date back to the days when man first began to think ahead and realize that his resources were insufficient to permit him to do everything he wanted to do.¹

Basically, cost-effectiveness analysis is nothing more than engineering economics and has been a concern from the very beginning of the engineering arts, according to Feldstein.² He further states that the roots of cost-effectiveness can be traced back to the seventeenth century, but it apparently was given its initial impetus as a formal economic discipline by Wellington, in his treatise in 1887.³

Fish of Stanford, in 1923, was probably the first to write a book devoted exclusively to the concept of engineering economy.⁴ During the 1930's and early 1940's, Grant

¹U.S. Congress, Senate, Committee on Government Operations, Subcommittee on National Security and International Operations, Planning-Programming-Budgeting, Initial Memorandum, 91st Cong., 1st Sess. (1967), (Washington, D.C.: GPO), p. 2.

²Martin S. Feldstein, "Economic Analysis, Operational Research, and the National Health Service," Oxford Economic Papers, XV (March, 1963), 19-31.

³A.M. Wellington, The Economic Theory of Railway Location (New York: Wiley, 1887), quoted in J. Morley English, ed. Cost-effectiveness: The Economic Evaluation of Engineered Systems (New York: John Wiley & Sons, Inc., 1968), p. 2.

⁴J.C.L. Fish, Engineering Economics (New York: McGraw-Hill, 1923), quoted in English, Cost-Effectiveness, p. 2.

brought about an awareness of the need for economic evaluation of engineering projects.¹ His work led to the acceptance by the business world of some of the approaches to economic evaluation employed by engineers.

At about the same time, Agg introduced cost-benefit analysis into evaluation of public works.² This concept focused attention on evaluating the projects individually, rather than comparing alternatives for accomplishing a given objective. The major change in this approach was the comparison of the benefit stream converted into dollar values with the equivalent dollar cost stream.³

Following World War II, operation researchers provided a greatly expanded viewpoint of economic evaluation in government. Governmental agencies began evaluating projects where costs were easily ascertained and outputs easily priced. Projects dealing with irrigation, water supply, lumber operations, and electric power were some of those first evaluated. Furthermore, the cost implications of alternative methods to achieve a given result were being considered by the engineers. Water resources and transportation studies provided the greatest impact of both concepts and assisted experts in the application of economic analysis

¹E.L. Grant, Principles of Engineering Economy (New York: Ronald, 1930), quoted in English, Cost-Effectiveness, p. 2.

²English, Cost-Effectiveness, p. 2.

³Ibid.

to policy questions.¹ For example, McKean² and Eckstein³ published books in 1958 evaluating cost-benefit analysis as employed by federal water resource agencies.

Greater impetus was given to the growing interest in cost-effectiveness analysis during the early 1960's by Robert McNamara, Secretary of Defense, and by Charles Hitch, Assistant Secretary of Defense. The application of this analysis was especially important in defense-oriented research and in defense contracting. This usage has led to the application of cost-benefit and cost-effectiveness studies in a large variety of governmental agencies and programs.⁴

One of the earliest studies in American education relative to costs and outputs was the Cooke study of 1910. Cooke studied in-depth the business practices of eight colleges and universities and recommended: (1) that the principles of management should be adopted by college officials, (2) that college procedures be standardized, (3) that officials seek to increase the utilization of personnel, grants, and grounds, and use them in an efficient manner, and (4) that colleges and universities increase cooperation and coordination between themselves.⁵

¹Lovell, "Cost-Effectiveness Evaluation," p. 34.

²Roland N. McKean, Efficiency in Government Through Systems Analysis (New York: John Wiley & Sons, Inc., 1958).

³Otto Eckstein, Water Resource Development (Cambridge, Massachusetts: Harvard Univ. Press, 1958).

⁴Lovell, "Cost-Effectiveness Evaluation," p. 35.

⁵Morris Llewellyn Cooke, Academic and Industrial Efficiency, Report to the Carnegie Foundation for the Advancement of Teaching, Bulletin No. 5 (New York City, 1910).

Currently, the expanding pressures of educational accountability, along with higher over-all costs, have emphasized the need for expanded use of analysis techniques.

Burkhead agrees with this and has enumerated some of the reasons for the higher cost of education. These are:

1. A long-run trend to devote more of the nation's resources to education;
2. Increasing number of school-age children;
3. Longer periods of school attendance for most students;
4. Larger portion of population now attending post-secondary institutions;
5. Growth of graduate and professional schools;
6. Expansion of in-service and adult education;
7. Compensatory education.¹

Hagen believes that economic analysis can be modified and thus be applicable to educational practice. He states:

Obviously expenditure choices in industry can be measured much more precisely by dollar return-on-investment analysis than in government. For example, the Department of Defense program, though quite complex . . . is less complex than those of school systems. The latter, in addition to having complex, varied programs, must account for, segregate, and distribute their multiple tax incomes and supporting programs according to local tax, county support, state aid, and federal grants. However, the basic objective of measuring expenditure utility is fundamentally the same in each

¹Jesse Burkhead, Input and Output in Large-City High Schools (Syracuse, New York: Syracuse University Press, 1967), p. 1.

area.¹

With increasing demands, educational institutions at all levels are being forced to achieve educational objectives and to administer their resources in the most efficient manner possible. To meet these needs, educators are turning, for the first time, to the practices, tools, and theories of scientific management which have been used primarily in industry and government.²

While many of the specific objectives and activities of education, industry, and government are dissimilar, they do have many basic similarities. For this reason educational planners and economists allege that economic analysis can aid educational decision-making and resource allocation, just as it successfully aided governmental, industrial, and military managers.³

Relationship to Planning, Programming,
Budgeting Systems (PPBS)

Accountability for performance has become a major concern of educators. Planning, Programming, Budgeting Systems (PPBS) and resultant cost-effectiveness analysis has been one

¹J.W. Hagen, "A Three Dimensional Program Budget Format for Public Schools" (unpublished doctoral dissertation, University of California at Los Angeles, 1968), pp. 70-71.

²John E. Swanson, et. al., Financial Analysis of Current Operation of Colleges and Universities (Ann Arbor: Michigan Institute of Public Administration, University of Michigan, 1966), p. 4.

³Lovell, "Cost-Effectiveness Evaluation," pp. 29-30.

of the major foci of this accountability thrust.¹

PPBS received its principal impetus from the Department of Defense studies conducted under Secretary McNamara. This approach attacks the resource allocation dilemma through system's accounting-fiscal procedures. It is an attempt to integrate planning (establishing objectives and policies), programming (method(s) to accomplish the objectives), and budgeting (specifying allocations of resources in a given time interval).²

Hartley states that PPBS is intended to provide the kinds of information and data analysis which give administrators a more complete basis for rational choice.³ He further states that this system is designed to foster economic efficiency and offers advantages over traditional practices. It provides: (1) program-oriented data, (2) analysis of feasible alternative programs and objectives, (3) long-range planning and evaluative criteria, (4) improved utilization of teacher competency, (5) structural flexibility and total

¹John P. Moon, "A Learning Effectiveness, Time Efficiency, and PPBS Cost-Effectiveness Investigation of a Media Modes Paradigm for the Independent Learning Environment" (unpublished doctoral dissertation, University of Southern California, 1971), p. 32.

²Sanford Temkin, A Cost-Effectiveness Evaluation Approach to Improving Resource Allocations for School Systems (a published dissertation in Business and Applied Economics, University of Pennsylvania, 1969; Research for Better Schools, Inc., 1970).

³Harry J. Hartley, "PPBS-Current Research and Programmatic Implications for Collective Negotiations," (paper presented to the 1968 annual meeting of the American Educational Research Association, Chicago, Illinois, February 8, 1968), p. 1.

group planning, and (6) reporting of school programs in the school budget document.¹

Temkin believes that in addition to the specification of goals, programs, and program objectives, an accounting system which can relate costs to program activities is essential.² School districts must depart from the line-item accounting system so prevalent today, and also include accrual procedures to tie expenditures to time in a more realistic manner.³

Moon notes from his research of planning and budgeting procedures that most school budgets are input rather than output oriented.⁴ He points out that this has led to line-item structured budgets which are rather dramatically opposed to PPBS procedural characteristics. The traditional budget provides, at best, only a fragmented view of the school program and its various subprograms.⁵

Cost-effectiveness and cost-benefit analysis have been popularized as analytical tools used by program planners in the PPBS process. Such analysis is used primarily to compare benefits (output) with the costs (resources or inputs) in order to evaluate and possibly generate alternative courses of

¹Ibid.

²Temkin, "A Cost-Effectiveness Evaluation Approach," pp. 2-3.

³Ibid.

⁴Moon, "Investigation of a Media Modes Paradigm," p. 35.

⁵Ibid.

action.¹

According to Mushkin, cost-effectiveness is an integral part of PPBS theory.² "The basic notion underlying the core of the PPB System is analysis of the relative cost and the relative effectiveness of program options."³ Program budgeting is suggested as a vehicle for cost-effectiveness, for it provides basic and necessary information in a manner that will facilitate the consideration of alternatives.

Padro believes that even though cost-effectiveness is the objective behind the implementation of PPBS, it is the least developed component.⁴ Educational planners have established program budgets, written praise-worthy objectives, developed long-range planning, and implemented highly-sophisticated computerized fiscal systems. Therefore, while many of the PPBS preliminaries have been achieved, the major task, cost-effectiveness, remains.⁵

The Function of Cost in Cost-Effectiveness Analysis

In cost-effectiveness analysis the decision-maker must have criteria for assessing the desirability of an alternative. Generally, the maximization of the present value of

¹Lovell, "Cost-Effectiveness Evaluation," p. 32.

²Selma Mushkin. Proceedings, Southwest Florida Conference, Program-Planning-Budgeting System (Charlotte County, Florida: March 12-14, 1969), p. 2.

³Ibid.

⁴Susan Padro, "Computer Simulation for Allocating Educational Resources Based on Student Activity Modules" (unpublished doctoral dissertation, The Florida State University, Tallahassee, 1971), p. 19.

⁵Ibid.

all benefits, less that of all costs, is a suitable criterion, according to Cary.¹

Webster states, cost is "the amount paid or given for anything . . . hence whatever, as labor, self denial . . . etc., is requisite to secure a benefit."² The important point is that cost is one element of value (or benefit) foregone in order to secure a greater benefit.³

Enthoven emphasizes the point that cost includes money, performance, time, consumption of scarce resources, and the use of available human skills.

Economics is the science of the allocation of limited resources; the study of both how our economic system actually allocates limited resources and how it might be done more efficiently. Thus, economics is not really concerned just with money. It is concerned with limited resources of all kinds. Economists give particular attention to money simply because it is the common denominator our society used to measure the relative value of material things.⁴

McCullough identifies two different methods in using cost estimates for selecting alternatives; the fixed budget approach and the specified-effectiveness approach.⁵ In a fixed budget approach the criterion for choices is maximum

¹Cary, "Development of a Cost-Effectiveness Model," p. 45.

²Webster's Seventh New Collegiate Dictionary (7th ed. 1965).

³English, Cost-Effectiveness, p. 4.

⁴R.S. McNamara, C.I. Hitch, and A. Enthoven, A Modern Design for Defense Decision (Washington, D.C.: Industrial College of the Armed Forces, 1966).

⁵J.D. McCullough, "Estimating Systems Cost," in T.A. Goldman, ed., Cost-Effectiveness Analysis (New York: Praeger, 1967) p. 72.

effectiveness. This entails the examining of different ways of attaining objectives within a specified budget amount. The decision-maker is searching for the maximum level of effectiveness for a fixed level of financial support.¹

Cost is the criterion of choice in the specified-effectiveness approach. A predetermined level of effectiveness is chosen after which the alternatives that require the smallest quantity of resources are examined.²

The costs used for analysis in a cost-effectiveness study should be direct measurable societal costs, according to Forbes.³ Measurable societal costs are classified as either direct or indirect. Direct costs are those items which are listed in the school system's budget as incurred by providing educational opportunities. Included under this category would be such items as salaries, supplies, textbooks, building construction and maintenance, repairs, utilities, and employee benefits.⁴

Forbes states that indirect costs are those expenses that do not appear on budget requests, but are considered to be related to the operation of the school system. These costs may be relevant for cost-benefit analysis, but need not be considered in cost-effectiveness analysis.⁵

¹Ibid.

²Ibid.

³Forbes, "A Technique for Analyzing the Costs," p. 38.

⁴Ibid.

⁵Ibid.

The directly measurable societal costs suggested for analysis in a cost-effectiveness study may be classified as either capital or operating costs. Capital costs are defined as those expenditures related to the developmental planning and implementation of educational programs. This cost category includes: initial program planning, construction, renovation, acquisition of non-expendable materials and equipment, orientation programs and other training, and any additional costs related to the planning and implementation phase of the program.¹

Operating costs are those items associated with the operation of a program. Included in this cost category are salaries, supplies, utilities, employee benefits, debt service, custodial services, and any other costs directly related to program operation.²

Kraft has concluded from his studies of educational cost-effectiveness analysis that most analysis of this type has concentrated upon quantitative criteria and an emphasis on cost data has resulted. Meaningful measures of other program aspects are in dire need of development.³

Carpenter and Haggart agree and warn against this fascination with numbers:

Analysis does not necessarily mean number juggling.

¹Forbes, "A Technique for Analyzing the Costs," pp. 38-39.

²Ibid.

³Kraft, Vocational-Technical Education Programs, p. 28.

A great deal can be gained from just a systematic approach to defining the problem and seeking possible solutions. Numbers, of course, do help. We all know that. We also know that some numbers are better than other numbers. The trick is to know as well as possible the meaning of the numbers: What do they tell you? Where do they come from? On what are they based? The point that should be emphasized is that numbers alone do not make a better analysis; the important fact is the context in which they are used and how they are used. The process of trying to make explicit some of the qualitative considerations inherent in defining the problem and in seeking possible solutions probably contributes more to making a better analysis.¹

The Function of Effectiveness in Cost-Effectiveness Analysis

Effectiveness, in contrast to cost, connotes the benefits or desirable effects gained by the incurring of a cost. Therefore, costs are always trade-offs for anticipated higher benefits. Effectiveness also implies some evaluation of performance or degree of output of the benefit-producing system.²

Carpenter and Haggart see the determination of effectiveness of an alternative as an important aspect of the analytical process.³ Effectiveness, they feel, is actually a set of measures or indicators describing the learning brought about by a program. In this way we can tell what to expect from each alternative.

¹M.B. Carpenter, and S.A. Haggart, Analysis of Educational Programs Within a Program Budgeting System. Memorandum P-4195 (Santa Monica, California: The RAND Corp., 1969) p. 5.

²English, Cost-Effectiveness, p. 4.

³Carpenter and Haggart, "Cost-Effectiveness Analysis," p. 28.

Before the cost-effectiveness of alternatives can be assessed, the problems of defining and measuring the effectiveness of instructional programs must be considered. The specification of instruments to measure the degree of attainment of program goals, validly and reliably, is often a basic problem. Too often the instruments are difficult to obtain or develop, and even if one is available, extreme care must be exercised to see they are administered in a consistent fashion and that the scoring mode is appropriate for the program goals.¹

Quade feels that the measures of effectiveness in educational cost-effectiveness analysis are, at best, only approximations.² Furthermore, the degree of confidence in the accuracy of effectiveness estimates is lower than it is with cost estimates. With this in mind and the fact that the learning process is so complex and contains many intangibles, a full set of measures and indicators must be obtained from the analysis of effectiveness.³

Carpenter and Haggart advocate the use of multiple measures and indicators. They assert:

If it is accepted that a single number for the dollar cost of a program conceals most of the information needed for decision-making, it should be even clearer that no single measure of program effectiveness will

¹Ibid.

²E.S. Quade, Some comments on cost-effectiveness. A panel presentation on "Cost-Effectiveness" at the Fourth U.S. Army Operations Research Symposium, Relstons Arsenal, Huntsville, Alabama, 31 March 1965. (Santa Monica, California: The RAND Corp., 1965) p. 12.

³Ibid.

tell the whole story about the worth of the program because any program promotes several different kinds of change in the student. Because these changes are different in kind, no unit exists by means of which the changes attributable to a particular program can be made commensurate. Thus, the effectiveness of a program can only be presented as a set of measures and indicators. In order to choose among alternative programs, the planner must then judge the relative importance of the various aspects of program effectiveness as they apply to particular schools.¹

Analysis must be structured, yet there must be great latitude allowed in the types of measurement instruments used and the modes for supporting data. It may often become necessary to develop new methods of qualitative measurement before one can assess the effectiveness of innovative instructional programs.²

Several guidelines for evaluating effectiveness have been developed by the State of Hawaii's Department of Education and should be carefully examined by any educator contemplating cost-effectiveness evaluation.

1. Qualitative evaluation should be made at the program rather than the activity level since it is the success of the program which the analyst desires to evaluate.
2. Qualitative evaluation of program effectiveness should always be closely related to the reasons for which a program exists.
3. No single qualitative measure should be relied on to

¹Carpenter and Haggart, "Cost-Effectiveness Analysis," p. 29.

²Hawaii, Budget Guide (Honolulu: Office of Business Administration, Department of Education, 1966), pp. 35-36.

the exclusion of other measures.

4. Sufficient time should be allowed after program actions are taken to obtain results.
5. The answer to a particular question does not indicate what course of action (e.g., increasing the appropriation) should be taken with respect to a program.¹

Reliance on expert judgement is indispensable to all analysis, especially those cases that contain too many intangibles, lack necessary planning factors, or cannot be represented by mathematical equations because of poor interrelationships. Quade believes that one of the real virtues of cost-effectiveness analysis is that it provides a framework for a more systematic and direct use of expert judgement.²

Limitations of Cost-Effectiveness Analysis

The necessity for caution in carrying-out cost-effectiveness evaluations is highlighted by the fact that the worth of an evaluation has been found to be closely correlated with the experience, ingenuity, and insight of the analyst in avoiding potential pitfalls which could negate or bias his conclusions. An awareness of these limitations by the analyst will improve the validity and worth of his cost-

¹Ibid.

²E.S. Quade, "Cost-Effectiveness: Some Trends in Analysis," in J. Morley English, ed., Cost-Effectiveness: The Economic Evaluation of Engineered Systems (New York: John Wiley & Sons, Inc., 1968), Chapter 11, p. 246.

effectiveness evaluations.¹

The educational process contains some unique characteristics which tend to make educational analysis more difficult than many of the problems encountered by the military and business worlds.

1. The long gestation period of education outputs and the length of the necessarily sequential learning processes.
2. Our limited knowledge of the learning process which might hamper attempts to attribute a particular result to the actual activity which produced it.
3. The mutiplicity of objectives in education which complicates the task of assigning a particular activity to the final educational purpose which it serves.
4. The difficulty of factoring out the effects of non-school experiences on the process and product of learning.²

Quade states that every systems analysis has its limitations or defects.³ Each analysis of choice falls short of

¹A.D. Kazanowski, "Cost-Effectiveness Fallacies and Misconceptions Revisited," in J. Morley English, ed., Cost-Effectiveness: The Economic Evaluation of Engineered Systems (New York: John Wiley & Sons, Inc., 1968), Chapter 8, p. 164.

²Selma J. Mushkin and James R. Cleveland, "Planning for Educational Development in Planning-Programming-Budgeting System," in Interdependence in School Finance: The City, The State, The Nation, Proceedings 11th National Conference of School Finance (Dallas, Texas: NEA Committee on Educational Finance, 1968), p. 90.

³E.S. Quade, "Introduction and Overview," in Thomas A. Goldman, ed., Cost-Effectiveness Analysis: New Approaches in Decision-making (New York: Praeger, 1967), p. 7.

scientific research because its objective is primarily to recommend policy, not to understand or predict. He emphasizes: (1) that analysis can never treat all the relevant considerations, even if there were no limitations on time and money, (2) the measures of effectiveness are inevitably approximate because of vaguely defined objectives, and (3) methods to adequately predict future possibilities are lacking.¹

One of the more formidable problems of cost-effectiveness analysis, according to Kazanowski, involves the effectiveness criteria selection.² As one narrows the scope of the problem, the number of significant criteria is also reduced. He believes it is virtually impossible to reduce the total evaluation to a sole criterion which is to be used as the basis for the evaluation.

Kazanowski also refutes those who would describe cost-effectiveness as a technique for selecting the one alternative which yields the maximum effectiveness at minimum cost.³ In reality, such an alternative does not exist, for the maximum is infinitely large and the minimum cost must be zero. Hitch and McKean state, "Seek the policy which has that outcome, and you will not find it."⁴

¹Ibid.

²Kazanowski, "Cost-Effectiveness Fallacies," p. 152.

³Ibid., p. 160.

⁴C.J. Hitch and R.H. McKean, The Economics of Defense in the Nuclear Age (Cambridge, Massachusetts: Harvard Univ. Press, 1961), p. 125.

Hartley identified nine limitations of systems analysis as it applies to educational programs and related activities.¹ Included in this group are: (1) intangibility of educational goals, (2) undermanagement of schools for rigorous analysis, (3) high turnover rate of superintendents, (4) shortcomings of analysis dealing with attitudinal issues, (5) prohibitive cost of staff involvement, (6) adversarial relationships in most negotiations, (7) opposition to innovation by educators, (8) teacher ineffectiveness, and (9) intrinsic ambivalence in technology.²

Giroux argues that educational instructional systems are ill-suited to the classical application of cost-effectiveness. He says:

The operational structure of an educational system, however, is necessarily ill-suited to a classical application of cost-effectiveness design. The application of a cost-effectiveness tool pre-supposes control over the operation of a program. As has usually been the case, control, such as defined in a classical control/experimental research design, is seldom evident in school operations. In most school situations, however, such control is not present. Students are subject to innovative practices on the basis of need without concern for research findings, thus eliminating the selection of a control group (e.g., all underprivileged children will benefit from a federal project). Teacher's assignments are often made on the basis of scheduling needs, not on the desire to test a hypothesis. Control of inputs (books, supplies, etc.) are often dependent on an operation outside of the school setting, such as a central administrative

¹H.J. Hartley, "Planning and Politics," The School Administrator, (April, 1971), 8-9.

²Ibid.

office.¹

Because of the many uncontrolled variables present in any instructional situation, the responsible evaluator must be hesitant to generalize from findings. Therefore, instructional cost-effectiveness designs and models should not assume that a tightly controlled situation exists.²

Hartley is still optimistic about the use of cost-effectiveness analysis in schools, regardless of the limitations, fallacies, and misuses of analytical procedures. He affirms:

It is difficult to find fault with the systems viewpoint of modern planners, who agree in principle that it is preferable to examine problems or data in a whole context. There are exciting opportunities, accompanied by risks and dangers, in the application of modern decisional technologies to education. The new systems analysis mode of thinking is already exerting influence on political structure and style. PPBS-type arguments and justifications are being widely used by the new breed of "technipols" in political debates about education. These leaders employ rational argumentation to enhance their intuitive judgements.³

If the misuse of analysis in education is to be prevented, caution must be exerted in dealing with the unique characteristics of education. In summary, the words of Mushkin, "Education is probably one of the most complicated outputs in the whole of the battery of things that society provides," should be remembered.⁴

¹Roger Giroux, et. al., Cost-Effectiveness Study (Division of Planning and Long-Range Development, Milwaukee Public Schools, Milwaukee, Wisconsin, 1971), p. 4.

²Lovell, "Cost-Effectiveness Evaluation," p. 64.

³Hartley, "Planning and Politics," p. 10.

⁴Mushkin, "Planning for Educational Development," p. 6.

Cost-Effectiveness Analysis in Education

Cost-effectiveness analysis is suitable for decision-making where the outputs of the system are not priced at the market while the inputs are subject to market pricing.

Clearly, many decisions in education fall into this realm.¹

Schools, like other productive enterprises, have three general properties which, taken together, define a "production process." First, educational objectives can be defined as the output of the process; second, there are students, teachers, administrators, buildings, supplies, and other materials and personnel which provide inputs into the educational process; and third, there exist various techniques of combining the inputs to produce the aforementioned educational objectives.²

Forbes states that activities designed to achieve positive reactions and cooperative participation by staff members should be included in all plans for implementing a cost-effectiveness study.³ The anxieties of school personnel, who see cost-effectiveness as a threat to their positions, should be alleviated when the analytical procedures are presented as an aid for more realistic decision-making. Also, the value of this analysis as a planning tool must be made clear. Above all, staff members that are expected to partic-

¹Quade, "Introduction and Overview," p. 8.

²Henry M. Levin, Cost-Effectiveness Evaluation of Instructional Technology: The Problems (Washington D.C.: Academy for Educational Development, Inc., 1970), pp. 3-4.

³Forbes, "A Technique for Analyzing the Costs," p. 93.

ipate in the implementation of the study should be given the opportunity to participate in the planning activities.¹

Lovell has pointed out that in an educational setting, cost-effectiveness analysis can function at varying degrees of sophistication.² The analysis may vary from the fairly simple, which merely assembles existing data in a meaningful way, to the highly technical and mathematical studies. At least initially, the schools should prefer the less rigorous analysis; for the technical, in-depth studies require a great deal of time and money, as well as highly trained staff. The basic steps will be the same regardless of the degree of sophistication pursued.³

Kenezenich provides a more thorough explanation of both the less rigorous and the in-depth analysis methods:

Two levels of analysis can be distinguished by the depth, time or rigor spent in pursuing various dimensions. Less rigorous analysis is likely to be, at least initially, more prevalent in education. A decision based on analysis of alternatives for the allocation of resources moves ahead by identifying and documenting the following: The real objectives of the program, major feasible alternatives, best available estimate of the total program cost for each year considered for each alternative, major assumptions and uncertainties associated with the alternatives, and impact of proposed programs on government agencies or on private organizations. In-depth analysis, . . . goes further and approaches what are called cost-benefit or cost-utility studies. Some writers confine in-depth analysis to those situations where key factors can be quantified and mathematical models can be generated. Significant nonquantifiable program elements are not ignored but

¹Ibid.

²Lovell, "Cost-Effectiveness Evaluation," p. 58.

³Ibid.

are granted less weighting. In-depth analysis often takes many weeks to effect even in the well staffed organization. Sufficient lead time must be available. The amount of time and money required suggests that in-depth analysis cannot be used indiscriminately. Priorities must be established to select those programs with the highest likely payoff.¹

The current study was intended to more resemble a less rigorous analysis and the investigator has sought to identify and document most of the characteristics emphasized by Kenezevich.

Summary

The opinions of writers dealing with cost-effectiveness analysis were reviewed in the above section. After the concept was introduced, a background was provided by defining the terms and tracing the development of this analysis in general economic theory and in education.

In cost-effectiveness analysis, the decision-maker assesses the desirability of an alternative through the criteria of cost and effectiveness. The function of each criterion is described by the writings of numerous authors.

The fact that cost-effectiveness analysis is not a panacea for all educational budgeting ills, is brought out in a section on limitations. Regardless of its shortcomings, the majority of authors cited feel that this type of analysis is suitable for many of the problems confronting educational decision-makers today.

¹Stephen A. Kenezevich, ed., Administrative Technology and the School Executive (Washington, D.C.: American Association of School Administrators, 1969), p. 79.

SUMMARY

The second chapter of this study has reviewed the related research and literature in three specific areas: (1) individualization of instruction, (2) learning packages, and (3) cost-effectiveness analysis.

The investigator concluded from his review of the literature and research regarding individualization of instruction, that a correlation does exist between individual differences and academic achievement. Furthermore, a technique that provides for these differences can enhance the possibilities that a child will profit from mathematics instruction.

Although four of the writers have cautioned against the use of learning packages in some programs, the majority of authors believe these problems can be overcome, and that the learning package concept can bolster the effectiveness of any mathematics program. They also stressed that the following points must be considered: (1) the nature of the package, (2) the adequacy of the resources, and (3) the ability of the child to work independently. None of the researchers used cost-effectiveness analysis to compare the output of the packages with other alternatives.

Writers have almost universally agreed that it is imperative that more effective systems be identified to aid in educational decision-making than the random, intuition-based, "seat-of-the-pants" approach that has been the rule for many years.

Cost-effectiveness analysis has been brought to the forefront as a technique for analyzing the costs, effectiveness, and other related variables of one or more programs, program components, or program alternatives. Modern planners see it as an exciting opportunity, accompanied by risks and possible short-comings, to apply updated decisional technology to education.

The investigator concluded from his review of the related literature and research that an experimental study, using cost-effectiveness analysis to evaluate the learning package concept as an alternative to the traditional basic mathematics program, would make a useful contribution toward showing the effects of such procedures in education by: (1) measuring the input (costs) of each alternative, and (2) by evaluating the output (effectiveness) derived from each approach.

The research design and the procedure used in the present study are presented in Chapter 3.

CHAPTER III

THE DESIGN AND PROCEDURE OF THE STUDY

The design and procedure of the study, briefly outlined in Chapter I, will be presented here in a detailed format under sections dealing with the following: (1) the setting of the study, (2) identification of the population, (3) the research design and testing instrument, (4) the experimental and control group procedures, (5) cost analysis procedures, (6) hypotheses, (7) statistical procedures, and (8) summary.

SETTING OF THE STUDY

The setting for the study was in the Stockton Unified School District, Stockton, California. Stockton is the center of a metropolitan area with a population of over 150,000 and is located near the geographical center of the state, seventy-five miles east of San Francisco.

This study proposal was initially presented to James Shannon, Director of Research, Stockton Unified School District. After securing the school district's support, the Associate Superintendent of Business Administration, Gordon Chamberlin was contacted to arrange for necessary funding, and two junior high school principals were contacted to gain approval to conduct the study in their schools.

To determine the junior high schools within the district

whose students would be included in the study, the investigator considered those which had: (1) some background in employing individualized techniques, (2) radically different racial compositions, (3) dissimilar median income of residents in the schools' respective attendance areas, and (4) total enrollment variance to possibly include the largest and smallest schools. Because an experimental and a control group would be established in each school, these considerations were necessary to help provide a broader representativeness to the study.

IDENTIFICATION OF THE POPULATION

From the student populations of the five junior high schools, the investigator delimited a more specific group to participate in the study. Delimiting criteria included: (1) schools, (2) population, (3) grade level, and (4) sample selection.

Selection of Schools

The investigator chose two schools from the original five that most closely met the criteria stated above. School A was the district's largest with an enrollment of 1,803 students. School B ranked as the smallest with 1,096 students.¹

Population

Subjects for this investigation were all the students

¹"Racial and Ethnic Report," (Stockton, California: Stockton Unified School District, October 21, 1972), n.p.

regularly enrolled in basic or remedial mathematics at the eighth grade level in the two selected junior high schools. The schools offered a contrast for they differed markedly in socioeconomic and ethnic makeup.

School A had an ethnic distribution of 39.7% with Spanish surname, 30.9% Black, 13.0% Filipino and other minorities, 9.5% White other than Spanish, 6.8% Oriental, and .1% American Indian out of a total of 1,096 students. Also 63.4% of the students were classified as being low income children with 42.3% receiving Aid to Families with Dependent Children.¹

School B had an ethnic distribution of 9.9% with Spanish surname, 2.7% Black, 3.0% Filipino and other minorities, 79.5% White other than Spanish, 4.7% Oriental, and .2% American Indian out of a total enrollment of 1,803. Only 15.1% of the students were classified as being low income children, with 10.1% receiving Aid to Families with Dependent Children.²

Attendance Areas

The two junior high schools selected were located in contrasting areas of the district. School A was situated in a relatively low socioeconomic area, while School B was largely a high socioeconomic area. They have a combined enrollment from seventh through ninth grade of 2,899, which represents approximately 40% of the total district junior high school population of 7,184 students attending the five

¹Ibid.

²Ibid.

district junior high schools.¹

Median Income

Other demographic data concerning the two schools included median income of residents living within the schools' attendance areas. Median income in School A was \$7,155 per year, as compared to \$12,909 in School B.²

Selection of Grade Level

The investigator chose eighth grade as the level of students who were to participate in the study. This selection was made because more students at this level were working in basic mathematics than in ninth grade classes, and all of the seventh graders at School A were involved in a learning center-math lab approach to mathematics. This concept would have been impossible to replicate at School B because of financial limitations. The eighth grade level was also selected because students at this age, according to Piaget and Inhelder, tend to approach problems more systematically, and less on a random, trial-and-error basis. This is an important consideration in an individualized program, such as Individual Learning Units, because of the self-directive nature of the package.³

¹Ibid.

²"1970 Census Information," (Stockton, California: Stockton Unified School District, 1970), n.p.

³Jean Piaget and B. Inhelder, The Growth of Logical Thinking From Childhood to Adolescence. (New York: Basic Books, 1958), pp. 67-68.

Sample Selection

In both School A and School B the students were pre-assigned to classes by the school counselors on the basis of recommendations by the previous year's instructors, and according to the results of a test of achievement, the Comprehensive Test of Basic Skills, Form Q, Level III, and an aptitude test, the Lorge-Thorndike Intelligence Test, Level III. ~~Those classes most similar in ability were chosen as the experimental and control groups in each school; the instructors determined the treatment each group was to receive.~~

The classes were scheduled in consecutive periods to help rule out many of the factors associated with time-of-day differences between the groups, such as fatigue, hunger, and tardiness. Two teachers were selected from those meeting the above scheduling requirements. Each instructor was assigned an experimental and a control group to help nullify the teacher-effectiveness variables. Neither the teachers, nor the students, had worked with Individual Learning Units previously.

THE RESEARCH DESIGN AND TESTING INSTRUMENT

One hundred and eighteen eighth grade students were preassigned to the basic mathematics classes on the basis of recommendations by the previous year's instructors, and according to test results. The Comprehensive Test of Basic Skills, which measures achievement, and the Lorge-Thorndike Intelligence Test, which measures aptitude, were both administered to the students late in their sixth grade year and

were considered by the counselors in class placement. The preassembled groups were used for the experimental and control subjects to limit upsetting the class scheduling in both schools.

The investigator chose the Nonrandomized Control-group Pretest-Posttest Design, which is especially recommended for experimental studies using intact classes that are as similar as availability permits.¹ Campbell points out that:

In this popular design, the frequent effort to 'correct' for the lack of perfect equivalence by matching on pretest scores is absolutely wrong . . . as it introduces a regression artifact. Instead, one should live with any initial pretest differences, using analysis of covariance, gain scores, or graphic presentation.²

Kerlinger states that the main strength of a well-planned and well-executed before-after, experimental-control group design where the subjects are equated is that if something affects the experimental subjects between the pretest and the posttest measure, this something should also affect the control group subjects. Similarly, Kerlinger points out, the effect of testing should be controlled. "For if the testing should affect the members of the experimental group, it should similarly affect the members of the control group."³

The Nonrandomized Control-group Pretest-Posttest Design

¹Deobold B. Van Dalen, Understanding Educational Research, (New York: McGraw Hill Book Company, 1966), p. 276.

²Donald T. Campbell, "Quasi-Experimental Design," (Evanston, Illinois: Northwestern University, n.d.), quoted in Fred N. Kerlinger, Foundations of Behavioral Research, (New York: Holt, Rinehart and Winston, Inc., 1964), p. 310.

³Kerlinger, Foundations of Behavioral Research, p. 310.

consists of experimental and control groups to which members are preassigned. The experimental group receives pretesting, the experimental treatment, and posttesting. The control group receives both the pretesting and posttesting, but no experimental treatment. The design is diagrammed below:

	Pretest	Treatment	Posttest
Experimental Group	T_{1E}	X	T_{2E}
Control Group	T_{1C}		T_{2C}

Figure 1

Nonrandomized Control-group Pretest-Posttest Design. T_{1E} and T_{2E} = Pretest and Posttest Scores of Experimental Groups; T_{1C} and T_{2C} = Pretest and Posttest Scores of Control Groups; x = Experimental Variable.

Testing Instrument

The testing instrument used in the study to measure mathematics achievement was the Comprehensive Test of Basic Skills, Form Q, Level III. The CTBS is published in four overlapping levels with similar content at each level. Level III is appropriate for grades six, seven, and eight. There are alternate forms of Level III, Q and R.¹

EXPERIMENTAL AND CONTROL GROUP PROCEDURES

The experimental and control group procedures used in this study are discussed below under the following headings: (1) pretesting procedures, (2) the Individual Learning Unit

¹Comprehensive Test of Basic Skills, Bulletin on Technical Data, No. 2, (September, 1960), 39-42.

based program, (3) the traditional basic mathematics program, and (4) posttesting procedures.

Pretesting Procedures

During the week of October 2, 1972, the pretesting instrument was administered by the classroom instructors to both the experimental and control groups. The students received the pretesting in their normal classroom groups. The arithmetic computation subtest of the Comprehensive Test of Basic Skills was given on the second school day of the week. On the third day, both the arithmetic concepts and the arithmetic application subtests were administered. Students who had been absent were tested on the fourth and fifth days.

Individual Learning Unit Based Program

The Individual Learning Units (ILUs) used in this study were modeled after the Learning Activity Packages. Mathematics curriculum specialists and classroom teachers from the Stockton, California, Unified School District, were involved in an ESEA Title I program during 1969, and as an early step in program development, visited schools employing an Individualized Diagnostic-Prescriptive approach to learning. They were given sample LAPs and techniques and strategies used by classroom teachers in individualized instruction for all areas of the curriculum. During the summer a team of administrators, math specialists, and math teachers developed learning packages to correspond with their materials, and to further implement this approach they developed and designed a learning

center and a math lab. The ILU technique has been in use for the last four years in the elementary and junior high school basic mathematics program.¹

The Individual Learning Unit concept is an individualized-diagnostic-prescriptive ungraded approach to meeting the needs of participants in mathematics. It is pupil centered and begins with a comprehensive diagnostic evaluation of each pupil's strengths and educational needs through the use of a written placement test. With an educational diagnosis such as this, the teacher can better provide those learning experiences which will result in the greatest possible academic success.

The mathematics curriculum is composed of: (1) a sequential continuum stated in terms of what the student is expected to complete at each stage, (2) comprehensive diagnostic tests to determine what instruction is to take place, (3) lessons, such as work page assignments and teacher directed activities, and (4) posttesting to test the effectiveness of the instruction. The techniques and strategies employed in the program make it possible for each participant to start at a different point on the instructional continuum and progress at his own rate. Additionally, the objectives, stated in behavioral terms, are categorized by topic and sequence according to degree of difficulty and

¹Vernon Broussard and Gordon Chamberlin, A Model Demonstration Program In Reading and Mathematics, a proposal (Stockton, California: Stockton Unified School District, Department of Compensatory Education, 1969).

prerequisite conditions necessary.

The teacher is responsible for the student's assignments. If the pupil needs a new task, his immediate past work will be examined. If no additional work is needed, the teacher merely decides if sufficient progress is being made or whether more personal attention is required. The student's work is evaluated daily and new assignments are made on the basis of past performance. A diagnostic profile is kept for each child to make possible the continuous assessment of mathematics progress. If a student needs help on a new assignment or completed work scored during the period, the teacher attempts to attend to his needs at once. Often the student may score his own work from answer keys and are to exercise judgement as to when the instructor's attention is needed.

In School A, students utilized the "math lab" to view filmstrips and listen to tapes pertaining to their objectives. School B has a section of the library that was used for similar purposes. These same viewing and listening stations could be established in a classroom situation, but both schools favored a centralized location for maximum usage.

The participants work on their individual assignments for approximately three or four of the five school days. One or two days per week, the entire class will work as a group. The purpose of this group work is to (1) discuss topics of general interest to the entire class, (2) develop communication between students of different abilities and at different

levels of work, and (3) cover broad areas of the curriculum in a discussion-lecture situation. In other words, the group workday gives the participants perspective on where they have been and where they are going, as well as a sense of relation between mathematics and their world of outside interests.

The Traditional Basic Mathematics Approach

In School A, the control group used the eighth grade textbook, Basic Modern Mathematics: Second Course,¹ as its main source of instruction. The text was adopted by the State of California in 1970 for use in basic mathematics programs. Supplemental worksheets were provided and an occasional filmstrip relating to the day's particular assignment was shown. All homework was handed in during the first few minutes of class and corrected by the instructor later in the day. Unit exams and scores on the homework were the criteria upon which the report card grades were based.

School B's control group utilized the eighth grade text, Mathematics: Structure and Skills - Second Course,² also adopted in 1970 by the State of California. The Learning to Compute Workbook³ was used as a supplemental source. Homework assigned the previous day was corrected by the class

¹Richard Denholm, and V. Dale Blank, Basic Modern Mathematics: Second Course (Chicago: Science Research Associates, 1968).

²Robert E. Eicholz, and Thares O'Daffer, Mathematics: Structure and Skills - Second Course (Palo Alto, California: Addison-Wesley, Inc., 1965).

³Wilmer Jones, John Clark, and Mary Potter, Learning to Compute (New York: Harcourt, Brace and World, 1967).

as a group, and then work on the next day's assignment commenced. As in School A, end-of-unit exams and homework were used as grading criteria, and only minimal usage was made of audiovisual aids.

The control methods used in both schools were basically the standard approach to mathematics instruction employed throughout the district. The teachers involved in the study used these methods in all their classes before the Individual Learning Unit concept was developed.

Posttesting Procedures

During the week of February 26 to March 2, 1973 the posttesting was administered by the instructors to both the experimental and control groups. The posttesting was conducted in exactly the same manner as the pretesting and was completed on March 2, 1973.

COST ANALYSIS PROCEDURES

The cost analysis procedures used in the study are discussed below under the following headings: (1) cost variables, (2) developmental costs, and (3) operating costs.

Cost Variables

The variable per pupil cost (the expenditure for books and materials), was used to compute the program costs for the students involved in this study. A survey of cost items related to the basic mathematics program helped the investigator determine that the expenditures for developing the materials,

along with the cost of the books, filmstrips, tapes, and supplies were the relevant variables to be considered.

Total professional time spent in preparation and instruction, space, utility costs, shared audiovisual equipment, supportive services, and maintenance of the two programs were found to be comparable and no differential was computed for these factors. Student time is another cost variable that was recognized but not included in this study.

The self-pacing aspect of the Individual Learning Units can directly affect the benefits to be gained within a given time span. The student time variable between programs, as a result of self-pacing, are hidden costs that should be recognized, but are difficult to quantify as a factor for a cost-effectiveness analysis. The economical expenditure of saved student time is an unsupported assumption and to stay within the parameters of specifiable data, only variable budget cost items have been involved.¹

Developmental Costs

The developmental costs included those expenditures related to the planning and implementation of educational programs. For the Individual Learning Units this included initial program planning, acquisition of materials, and other costs related to this phase of the program.

More specifically, the ILUs were developed under the supervision of a math specialist and written by a team including two classroom teachers and the specialist. The

¹Burkett, "A Benefit-Cost Analysis," pp. 40-41

teachers were released from classroom duties for six weeks during the school year to write the packages. Thus the cost of retaining substitutes has been included with the percentage of the specialist's time devoted to the developmental stage. This same team spent an additional six weeks during the summer in writing the units and this cost was included. The duplicating materials necessary to print the units and the percentage of the secretarial time devoted to typing and collating the ILUs were also included.

To provide a more accurate per pupil cost, the developmental costs were divided by the number of students who were to use the units, then further divided by the prorated eight years of use. The ILUs were prorated on an eight year basis because they have been in use for four years and are expected to last at least four more.

Operating Costs

The school district's purchasing department provided cost data regarding the textbooks and materials used in the basic mathematics programs. Since the majority of items were relatively recent purchases the costs were taken from the 1972 book and supply list of the Stockton Unified School District. All of the articles were prorated on a time consumption basis determined by inventory records and past experiences of the local district.

Tables are used in Chapter 4 to illustrate the per pupil cost for materials for each of the programs. The data on the costs and effectiveness were based on information readily available in any school district. The quantification of the effectiveness, in direct relation to the program's

objectives, is derived from standardized tests similar to those administered in most public schools. Every effort was made to utilize a cost-effectiveness model that could be easily replicated by educational decision-makers.

In the analysis that follows in the next chapter the total cost factors are reported and analyzed.

HYPOTHESES

The hypotheses, stated in null form, for the study include:

Major Hypothesis 1. A cost-effectiveness analysis of the use of Individual Learning Units in junior high school basic mathematics instruction will demonstrate that the operational cost per unit gain in achievement will be greater than the operational cost per unit gain in a traditional textbook-oriented, lecture approach, with minimal usage of audio-visual equipment.

Sub-Hypothesis 1. A cost-effectiveness analysis of the use of Individual Learning Units in junior high school basic mathematics instruction will demonstrate that the sum of the developmental and operational cost per unit gain in achievement will be greater than the cost per unit gain in a traditional approach.

Major Hypothesis 2. There will be no significant differences in achievement gains, total mathematics score, between junior high school students using Individual Learning Units and junior high students in the traditional program, as measured by the Comprehensive Test of Basic Skills.

Sub-Hypothesis 1. There will be no significant differences in gain scores on the arithmetical computational skills sub-test of junior high school students using Individual Learning Units and junior high students in the traditional program.

Sub-Hypothesis 2. There will be no significant differences in gain scores on the arithmetical concepts sub-test of junior high school students using Individual Learning Units and junior high students in the traditional program.

Sub-Hypothesis 3. There will be no significant difference in gain scores on the arithmetical applications sub-test of junior high students using Individual Learning Units and junior high school students in the traditional program.

STATISTICAL PROCEDURES

The major hypothesis and its sub-hypothesis relating to cost-effectiveness were analyzed by establishing a cost-effectiveness ratio and its subsequent factor for each program. The cost figure represented the price per pupil in the respective approaches. The mean achievement gains for each of the groups was considered as the effectiveness component for the cost-effectiveness ratio. By dividing the months gained in achievement into the cost per pupil, a factor stating the cost per unit gain was derived. In this manner, a truer picture is developed, for higher costs can be offset by increased achievement gains.

The major hypothesis and its sub-hypotheses relating

to achievement were analyzed through the use of a two-way analysis of variance with unequal cells. The independent variables were the use of the Individual Learning Units in basic mathematics instruction and the different schools; the dependent variable was the achievement gains noted on the CTBS. The overall gain and the subtest areas were analyzed individually.

The test scores mentioned above were typed into a Burroughs 3500 terminal located at the University of the Pacific. The computer analyzed the data for the dependent variable in all areas of the CTBS. Data was reported from the computer analysis in the following manner: (1) means of the experimental and control groups, and (2) the two-way analysis of variance.

Data components for the analysis of variance include: (1) the school variability, (2) the treatment variability, (3) the interaction effect, (4) the within cells sum of squares and mean squares, and (5) the F values. The .05 level of significance was required for the rejection of the null hypotheses.

SUMMARY

The third chapter of this report reviewed: (1) the setting of the study, (2) identification of the population, (3) the research design and testing instrument, (4) the experimental and control group procedures, (5) cost procedures, (6) hypotheses, and (7) statistical procedures.

The settings of the study were in a lower socio-economic area, and a relatively higher socioeconomic section of the

Stockton Unified School District, Stockton, California. Two junior high schools were chosen from a total of five in the area on the basis of specified criteria. The schools offered a contrast for they differed markedly in enrollment, racial composition, and in median income of residents living in each school's attendance area.

Through further delimitation of the population, 118 eighth-grade basic mathematics students were selected for the study. These subjects were preassigned by school counselors to a Nonrandomized Control-group Pretest-Posttest Design. The design was extended to include an experimental and control group in each school. The testing instrument used in the study was the Comprehensive Test of Basic Skills, Form Q, Level III.

The procedure for the experimental and control groups was described in detail, including: (1) pretesting procedures, (2) the Individual Learning Unit based program, (3) the traditional basic mathematics program, and (4) posttesting procedures.

The cost procedures used in the study were discussed under the following headings: (1) cost variables, (2) developmental costs, and (3) operating costs.

Six hypotheses, stated in null form, were presented for acceptance or rejection, and those based solely on student achievement were set at the .05 level of significance. Statistical procedures to test the null hypotheses included a cost-effectiveness analysis and a two-way analysis of variance. The costs of the individual programs and the subjects'

posttest scores were used as the dependent variables.

Chapter 4 of this report will present an analysis of the statistical data drawn from the experimental study.

CHAPTER IV

ANALYSIS OF THE DATA

INTRODUCTION

As proposed in the initial chapter, the prime considerations in this cost-effectiveness analysis study were to: (1) determine a school district's expenditures for an individualized basic mathematics program in the junior high schools using Individual Learning Units, (2) determine the expenditures for a traditional, textbook-oriented approach to basic mathematics instruction, and (3) compare the achievement gains of the programs.

The cost-effectiveness analysis model employed in this study was a mathematical evaluation of the costs of the programs in direct relation to the achievement gains in mathematics. Cost analysis procedures included those variables related to the development of the ILUs and those incurred in operating the programs. These were labeled developmental and operating costs, respectively.

One hundred and eighteen subjects were preassigned to eighth grade basic mathematics classes and the classes were then assigned to a Nonrandomized Control-group Pretest-Posttest Design. The number of students and the treatments of groups participating in the study are presented in Table 1.

TABLE 1
 NUMBER OF STUDENTS AND TREATMENT OF
 GROUPS PARTICIPATING IN THE STUDY

Groups	Treatments			
	Pretest	Experimental	Posttest	Complete Pre- and Posttest Measures
Experimental 1	35	35	35	30
Control 1	33	--	21	14
Experimental 2	27	27	24	21
Control 2	23	--	23	20
Totals	118	62	103	85

A set of null hypotheses relating to cost and effectiveness of the programs is presented in this chapter. Those related to cost are stated and followed by a table showing how the total costs are derived and whether the null hypothesis is to be accepted or rejected. The hypotheses relating to the effectiveness measures of the program are stated, followed by mean scores. An analysis of variance table, indicating the degree of statistical significance found, is included, followed by a discussion of the acceptance or rejection of each null hypothesis.

The data presented in Table 1 indicate that between the time of selecting the sample and the collection of complete pre-and posttest measures, the original sample was reduced by approximately one-fourth. This reduction was consistent

in experimental and control groups 2, but control group 1 was less than one-half the size of experimental group 1. The sample results were not affected by the subject mortality, because gain scores were used to measure achievement.

ANALYSES OF COSTS

The per pupil costs for materials for each of the programs was compiled from the following tables which indicate the specific materials used and their relative costs. The figures constitute the variable for the total cost factor. The per pupil costs were computed on the basis of an average class size of thirty-five pupils.

ILU Program-Operational Costs

The initial outlay for the ILU materials for a class of thirty-five students was \$815.34. Thus, the cost was \$125.06, prorated on a five year basis. Computed on a per pupil basis, the cost was \$3.573, as shown by data presented in Table 2.

TABLE 2

ILU PROGRAM MATERIALS COST

Item	Unit Cost	Number	Outlay	Years Pro-rated	Cost
Basic Modern Mathematics-Bk. 1	\$6.00	5	\$30.00	5 yrs.	\$6.00
Teachers Edition	6.00	1	6.00	5 yrs.	1.20
Basic Modern Mathematics-Bk. 2	6.00	5	30.00	5 yrs.	6.00
Teachers Edition	6.00	1	6.00	5 yrs.	1.20

TABLE 2 CONT.

Item	Unit Cost	Number	Outlay	Years Pro-rated	Cost
Exploring Modern Mathematics-Bk. 1	\$4.17	5	\$20.85	5 yrs.	\$4.17
Teachers Edition	4.17	1	4.17	5 yrs.	.83
First Course in Fundamentals	5.92	5	29.60	5 yrs.	5.92
Teachers Guide	.33	1	.33	5 yrs.	.07
First Program in Mathematics	7.95	5	39.75	5 yrs.	7.95
Teachers Edition	7.95	1	7.95	5 yrs.	1.59
Growth in Arithmetic-Bk. 7	2.70	5	13.50	5 yrs.	2.70
Teachers Edition	2.70	1	2.70	5 yrs.	.54
Growth in Arithmetic-Bk. 8	2.70	5	13.50	5 yrs.	2.70
Teachers Edition	2.70	1	2.70	5 yrs.	.54
Individualizing Mathematics					
Whole Numbers	2.52	3	7.56	5 yrs.	1.51
Fractions	2.52	3	7.56	5 yrs.	1.51
Teachers Strategy Book	1.02	1	1.02	5 yrs.	.20
Kaleidoscope of Skills (5, 6, 7)	6.15/set	9	55.35	5 yrs.	11.07
Teachers Manual	.35/	3	1.05	5 yrs.	.21
Mathematics: Structure & Skills Bk. 1	4.49	5	22.45	5 yrs.	4.49
Teachers Edition	4.71	1	4.71	5 yrs.	.94
Mathematics: Structure & Skills Bk. 2	4.49	5	22.45	5 yrs.	4.49
Teachers Edition	4.71	1	4.71	5 yrs.	.94
Workbooks (Bk. 1 and Bk. 2)	1.17	6	7.02	5 yrs.	1.40
Modern General Mathematics	4.11	5	20.55	5 yrs.	4.11
Teachers Edition	5.48	1	5.48	5 yrs.	1.10

TABLE 2 CONT.

Item	Unit Cost	Number	Outlay	Years Pro-rated	Cost
Modern Math for Achievement Bk. 3	.99	5	4.95	5 yrs.	.99
Teachers Guide	.99	1	.99	5 yrs.	.20
Modern School Mathematics Bk. 7	4.00	5	20.00	5 yrs.	4.00
Teachers Edition	4.00	1	4.00	5 yrs.	.80
Refresher Arithmetic	6.20	5	49.60	5 yrs.	6.20
Answer Book	.21	3	.63	5 yrs.	.13
School Mathematics Bk. 1	4.11	5	20.55	5 yrs.	4.11
Teachers Edition	4.86	1	4.86	5 yrs.	.97
Intermediate Math Program Tapes and Worksheets	8.45	2	16.90	10 yrs.	1.69
SRA Drill Tapes	7.95	7	55.65	10 yrs.	5.56
Wollensak Teaching Tapes	7.95	14	111.30	10 yrs.	11.13
Arithmetic Practice Program Filmstrips and Worksheets	10.00	6	60.00	10 yrs.	6.00
Teachers Manual	3.95	1	3.95	10 yrs.	.40
EDL-Arithmetic Skills Program	4.60	20	92.00	10 yrs.	9.20
Teachers Manual	1.00/ level	3	3.00	10 yrs.	.30
Total			\$815.34		\$125.06

Traditional Program-Operational Costs

The initial outlay for the traditional basic mathematics program in School A, for a class of thirty-five, was

\$216.00. Prorated on a five year basis, the cost was \$43.20. Computed on a per pupil basis, the cost was \$1.234. These data are presented in Table 3.

TABLE 3
TRADITIONAL PROGRAM MATERIALS COST
SCHOOL A

Item	Unit Cost	Amount	Outlay	Pro-rated	Cost
Basic Modern Mathematics Bk. 2	\$6.00	35	\$210.00	5 yrs.	\$42.00
Teachers Edition	6.00	1	6.00	5 yrs.	1.20
Total			\$216.00		\$43.20

The initial outlay for the traditional basic mathematics program in School B, for a class of thirty-five, was \$49.29. Computed on a per pupil basis, the cost was \$1.408. These data are presented in Table 4.

TABLE 4
TRADITIONAL PROGRAM MATERIALS COST
SCHOOL B

Item	Unit Cost	Number	Outlay	Years Pro-rated	Cost
Learning to Compute Wk. Bk. 1	\$1.20	35	\$42.00	5 yrs.	\$8.40
Teachers Guide	.30	1	.30	5 yrs.	.06
Learning to Compute Wk. Bk. 2	1.20	35	42.00	5 yrs.	8.40
Teachers Guide	.30	1	.30	5 yrs.	.06
Mathematics: Structure and Skills Bk. 2	4.49	35	157.15	5 yrs.	31.43
Teachers Edition	4.71	1	4.71	5 yrs.	.94
Total			\$246.46		\$49.29

ILU Program-Developmental Costs

The initial outlay for the development of the Individual Learning Units totaled \$25,312.38. Prorated, the cost was \$3,164.06. Approximately 400 students a year are using the ILUs, which led to a projected total of 3,200 for the eight years of the program. Computed on a per pupil basis, the cost was \$.988. These data are presented in Table 5.

TABLE 5

ILU DEVELOPMENTAL COSTS

Item	Outlay	Prorated	Cost
Paper	\$ 178.13	8 yrs.	\$ 22.27
Covers	420.00	8 yrs.	52.50
Masters	89.25	8 yrs.	11.16
Printing and Collating	420.00	8 yrs.	52.50
Secretarial time	1,785.00	8 yrs.	223.13
Writing	9,820.00	8 yrs.	1,227.50
Editing	12,600.00	8 yrs.	1,575.00
Total	\$25,312.38		\$3,164.06

COST-EFFECTIVENESS ANALYSIS

Two hypotheses were stated in Chapter 3 regarding the cost-effectiveness analysis of the use of Individual Learning Units and a traditional approach to mathematics instruction.

These were:

H₁. A cost-effectiveness analysis of the use of

Individual Learning Units in junior high school basic mathematics instruction will demonstrate that the operational cost per unit gain in achievement will be greater than the operational cost per unit gain in a traditional, textbook-oriented, lecture approach, with minimal usage of audiovisual equipment.

H₂. A cost-effectiveness analysis of the use of Individual Learning Units in junior high school basic mathematics instruction will demonstrate that the sum of the developmental and operational cost per unit gain in achievement will be greater than the cost per unit gain in a traditional approach.

Table 6 presents summary data relative to the analysis model used to test H₁. The price per pupil was used as the cost factor and the mean of the mathematics achievement gain scores for each of the programs was considered as the effectiveness factor. The gain scores in achievement are analyzed more extensively in Tables 8-11. The cost of the traditional program was derived from the average cost of the control groups in Tables 3 and 4. The cost-effectiveness factors were derived by dividing the denominator of the ratio into the numerator. When these figures were computed, the traditional program was found to cost \$.3564 per unit gain in achievement, as compared to \$.5423 for the ILU program. The data reported in table 6 failed to support rejection of H₁.

TABLE 6

COST-EFFECTIVENESS ANALYSIS
OF OPERATIONAL COSTS

Program	Cost	Effectiveness	Ratio	Cost- Effectiveness Factor
Traditional	\$1.321	3.7057	$\frac{1.321}{3.7057}$	\$.3564
ILU	3.573	6.588	$\frac{3.573}{6.588}$.5423

Table 7 presents data relative to the cost-effectiveness analysis of the two programs, including developmental costs. The cost to develop and edit the learning units was added to the operational cost used in Table 6. The cost of the traditional program went unchanged, as no developmental costs were incurred. The results of this analysis increased the price per pupil and resulting cost-effectiveness factor of the ILU program to \$.6923, while the factor for the traditional program remained at \$.3564. Since the sum of the developmental and operational cost per unit gain in achievement was greater in the ILU approach, the null hypothesis must be accepted.

ANALYSES OF EFFECTIVENESS

The mean of the mathematics gain scores for each of the groups was considered in analyzing the effectiveness of the respective approaches. The figures in the following tables constitute the variable for the effectiveness factor.

TABLE 7

COST-EFFECTIVENESS ANALYSIS OF
OPERATIONAL AND DEVELOPMENTAL COSTS

Program	Cost	Effectiveness	Ratio	Cost- Effectiveness Factor
Traditional	\$1.321	3.7057	$\frac{1.321}{3.7057}$	\$.3564
ILU	4.561	6.588	$\frac{4.561}{6.588}$.6923

In Chapter 3, the major hypothesis dealing with achievement gains, total mathematics score, was stated in null form.

H₃. There will be no significant differences in achievement gains, total mathematics score, between junior high school students using Individual Learning Units and junior high students in the traditional program, as measured by the Comprehensive Test of Basic Skills, Level III.

A highly significant interaction effect was indicated by the data in Table 8 between the differing schools and treatment applied. Neither the individual schools nor the treatment the groups received reached the $P < .05$ level of significance.

Since data in Table 8 show that $P > .05$, the null hypothesis was accepted. The groups receiving the experimental treatment were not significantly higher in mathematics achievement than the control groups. The interaction effect, however, was significant at the $P < .01$ level.

TABLE 8

ANALYSIS OF VARIANCE RESULTS FOR POSTTESTING
IN MATHEMATICS ACHIEVEMENT - TOTAL
MATHEMATICS SCORES

Source	Sum of Squares	DF	Mean Squares	F Values
Schools	1.7272	1	1.7274	0.5741
Treatment	9.6988	1	9.6988	3.2236
Interaction	29.9365	1	29.9365	9.9500*
Within Cells	243.7035	81	3.0087	

* $p < .01$

A significant interaction effect was also obtained in the computational skills section of the posttest measure. This section measures computational skills in the four fundamental operations: addition, subtraction, multiplication, and division.¹ Neither the individual schools nor the treatment the groups received reached the $P < .05$ level of significance. These data are presented in Table 9.

H₄. There will be no significant difference in gain scores on the arithmetical computational skills of junior high school students using Individual Learning Units and junior high students in the traditional program.

Since the data in Table 9 show that $P > .05$, the null hypothesis was accepted. The groups receiving the experimental treatment were not significantly higher in

¹Comprehensive Test of Basic Skills, Examiner's Manual (Monterey, California: McGraw-Hill, 1968), p. 25.

TABLE 9

ANALYSIS OF VARIANCE RESULTS FOR POSTTESTING
IN MATHEMATICS ACHIEVEMENT-COMPUTATIONAL
SKILLS SUB-TEST

Source	Sum of Squares	DF	Mean Squares	F Values
Schools	1.4716	1	1.4716	1.0774
Treatment	1.2022	1	1.2022	0.8801
Interaction	6.3636	1	6.3636	4.6589*
Within Cells	110.6372	81	1.3659	

* $p < .05$

arithmetical computational skills achievement than the control groups. The interaction effect was significant at the $P < .05$ level.

The groups receiving the experimental treatment approached, but did not reach statistical significance on the arithmetical concepts section of the CTBS. This section measures the ability of the student to: (1) recognize the appropriate technique and concept, (2) convert concepts expressed in one form to another form, (3) comprehend numerical concepts, and (4) organize all facts.¹ A significant interaction between the treatment received and an individual school was obtained, as shown by the data in Table 10.

H₅. There will be no significant differences in gain scores on the arithmetical concepts sub-test of junior high school students using Individual

¹Ibid.

Learning Units and junior high students in the traditional program.

TABLE 10

ANALYSIS OF VARIANCE RESULTS FOR POSTTESTING
IN MATHEMATICS ACHIEVEMENT-ARITHMETICAL
CONCEPTS SUB-TEST

Source	Sum of Squares	DF	Mean Squares	F Values
Schools	0.0377	1	0.0377	0.0592
Treatment	0.2079	1	0.2079	0.3270
Interaction	3.7240	1	3.7240	5.8579*
Within Cells	51.4931	81	0.6357	

* $p < .05$

This sub-test emphasizes problem-solving, and involves the ability to: (1) comprehend the problem statement, (2) select the appropriate method for solving, (3) organize all facts, and (4) solve for the answer.¹

Since data in Table 10 show that $P > .05$, the null hypothesis was accepted. The groups receiving the experimental treatment were not significantly higher in achievement on the arithmetical concepts sub-test than the control groups. There was an interaction effect, significant at the $P < .05$ level.

The sixth null hypothesis stated in Chapter 3 was relative to the sub-test, arithmetic applications. The ILU treatment groups scored significantly higher at the $P < .05$

¹Ibid.

level than the traditionally instructed groups.

H₆. There will be no significant difference in gain scores on the arithmetical applications sub-test of junior high students using Individual Learning Units and junior high school students in the traditional program.

Since the data in Table 11 show that $P < .05$, the null hypothesis was rejected. The groups receiving the experimental treatment were significantly higher in achievement on the arithmetic applications sub-test than the control groups.

TABLE 11

ANALYSIS OF VARIANCE RESULTS FOR POSTTESTING
IN MATHEMATICS ACHIEVEMENT-ARITHMETIC
APPLICATIONS SUB-TEST

Source	Sum of Squares	DF	Mean Squares	F Values
Schools	0.0872	1	0.0872	0.1794
Treatment	2.4395	1	2.4395	5.0220*
Interaction	1.0385	1	1.0385	2.1377
Within Cells	39.3477	81	0.4858	

$p < .05$

In three of the four hypotheses pertaining to mathematics achievement, a significant interaction effect was observed. This was due to the marked differences in performance of the groups. In School A, the ILU treatment was more effective, while the traditional approach proved more

effective in School B. Group mean gains for each effectiveness measure are found in Tables 12-15. Significant interaction effects were recorded for the total mathematics scores, the arithmetical computations, and arithmetical concepts sub-tests.

gain scores summed
 TABLE 12
 GROUP MEANS FOR POSTTESTING IN MATHEMATICS
 ACHIEVEMENT-TOTAL MATHEMATICS SCORES

		TREATMENT		
		EXPERIMENTAL	CONTROL	SCHOOL MEAN
Schools	<u>A</u>	8.300	-0.286	5.568
	S's	30	14	44
	<u>B</u>	4.143	6.500	5.2938
	S's	21	20	41
Group Mean		6.588	3.7057	
		Actual Mean 5.435		

SUMMARY

Of the six research hypotheses formulated for this investigation and presented in Chapter 1, only the last was confirmed. Eighth grade students using the Individual Learning Units did demonstrate greater mathematical achievement in arithmetic applications after five months of the program than similar eighth grade pupils who were instructed in the traditional manner for the same period of time.

TABLE 13

GROUP MEANS FOR POSTTESTING IN MATHEMATICS
ACHIEVEMENT-ARITHMETICAL COMPUTATIONS

		TREATMENT		
		EXPERIMENTAL	CONTROL	SCHOOL MEAN
Schools	<u>A</u>	3.833	0.214	2.6815
	S's	30	14	44
	<u>B</u>	2.524	3.950	3.2196
	S's	21	20	41
Group Mean		3.294	2.4117	
Actual Mean 2.941				

TABLE 14

GROUP MEANS FOR POSTTESTING IN MATHEMATICS
ACHIEVEMENT-ARITHMETICAL CONCEPTS

		TREATMENT		
		EXPERIMENTAL	CONTROL	SCHOOL MEAN
Schools	<u>A</u>	2.600	0.214	1.8408
	S's	30	14	44
	<u>B</u>	0.476	1.950	1.195
	S's	21	20	41
Group Mean		1.7254		
Actual Mean 1.529				

TABLE 15
 GROUP MEANS FOR POSTTESTING IN MATHEMATICS
 ACHIEVEMENT-ARITHMETICAL APPLICATIONS

		TREATMENT		
		EXPERIMENTAL	CONTROL	SCHOOL MEAN
	<u>A</u>	1.867	-0.714	1.0457
Schools	S's	30	14	44
	<u>B</u>	1.143	0.600	0.8781
	S's	21	20	41
	Group Mean	1.5689	0.0589	
		Actual Mean 0.965		

There were some apparent differences in the effect of the ILU treatment on students who participated in the experimental groups. While the total gain scores were almost double those noted for the control groups, they were not significant enough to offset the higher cost of the ILU program for the cost-effectiveness ratio. These findings were based upon advertence of the collected data.

Interpretations of the findings reported in this chapter are presented in Chapter 5 of this study. In addition, a summary of the study, conclusions, and recommendations for further research are included.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

INTRODUCTION

This study investigated the relative cost-effectiveness of Individual Learning Units in a junior high school basic mathematics program as compared with a traditional, textbook-oriented, lecture approach. A factor of dollars expended per pupil month gain in achievement was derived from the study and served as the basis for comparison of the two approaches.

Presented in this chapter are: (1) a summary of the study, (2) limitations of the study, (3) conclusions relating to the hypotheses, (4) implications of the study, and (5) recommendations for further research.

SUMMARY OF THE STUDY

The study is summarized under three major headings: (1) the setting and selection of participants, (2) the procedure, and (3) analysis of the data.

The Setting and Selection of Participants

The setting for the study was in two contrasting socioeconomic areas of the Stockton Unified School District in Stockton, California. Two of the five junior high

schools in the district were selected to participate. The schools chosen differed markedly in: (1) median income level of residents in the school's attendance areas, (2) racial and ethnic composition, and (3) total enrollment. An experimental and control group were established in each of the two schools.

Subjects in the two schools were delimited to eighth grade students enrolled in basic mathematics instruction.

Students were assigned to classes by the previous year's instructors according to the results of the Comprehensive Test of Basic Skills, Level III and Lorge-Thorndike Intelligence Test, Level III. Those classes most similar in ability, as indicated by these two tests, were chosen as the experimental and control groups in each school. Two teachers were chosen who met with classes of similar ability in consecutive periods. An experimental and a control group were assigned to each instructor to nullify the teacher-effectiveness variables.

The Procedure of the Study

The 118 selected subjects were assigned in groups to a Nonrandomized Control-group Pretest-Posttest Design. The design included the experimental groups receiving pretesting, the experimental Individual Learning Unit treatment, and posttesting. The control groups received the pretesting and posttesting, but were not exposed to the ILUs. The testing instrument used to measure mathematics achievement was the Comprehensive Test of Basic Skills, Form Q, Level III.

The variable of per pupil cost was used to compute the program costs for the students involved in the study. The expenditures for developing the materials and operating the programs were included in the survey of cost items.

Analysis of the Data

Following the posttesting, the data were submitted to four separate two-way analyses of variance with unequal cells. The .05 level of significance was used to determine whether the null hypotheses pertaining to effectiveness were to be accepted or rejected. The cost data were combined with the posttest scores to establish a cost-effectiveness ratio and its subsequent factor for each program. The factor was derived by dividing the months gained in achievement into the cost per pupil. A simple comparison of the factors determined whether the null hypotheses relating to the cost-effectiveness analysis were accepted or rejected.

LIMITATIONS

The findings of this study and generalizations and conclusions derived therefrom should be viewed with the following limitations in mind:

1. That the subjects were exposed to the different treatment for a period of approximately five school months.
2. That the teachers and students involved had no previous experience in working with Individual Learning Units.
3. That the cost of this particular experimental program may be more expensive than a similar, commercially prepared

program or other alternatives to individualized instruction.

4. That this study relates only to students attending junior high schools similar to those described in the Stockton Unified School District.

5. That although social and attitudinal variables are relative to success in mathematics, there has been no attempt to qualify these factors.

6. That the basic cost estimates of each program have been limited to the average per pupil cost of materials, prorated on a time consumption basis.

CONCLUSIONS RELATING TO THE HYPOTHESES

The primary objective of this study was to investigate the cost-effectiveness of Individual Learning Units in a junior high school basic mathematics program as compared to a traditional, textbook-oriented program.

Hypotheses Relating to Cost

H₁. A cost-effectiveness analysis of the use of Individual Learning Units in junior high school basic mathematics instruction will demonstrate that the operational cost per unit gain in achievement will be greater than the operational cost per unit gain in a traditional, textbook-oriented, lecture approach, with minimal usage of audiovisual equipment.

H₂. A cost-effectiveness analysis of the use of Individual Learning Units in junior high school

basic mathematics instruction will demonstrate that the sum of the developmental and operational cost per unit gain in achievement will be greater than the cost per unit gain in a traditional approach.

The findings of this study did not support the hypothesis that the operational cost per unit gain of the ILU program would be less than the cost per unit gain in the traditional. Nor did the finding support the hypothesis that the sum of developmental and operational cost per unit gain of the ILU program would be less than the operational cost per unit gain in the traditional. In both instances, the cost per unit gain in the traditional program was less than the experimental.

However, the cost per unit gain in the ILU program may not be impractical when compared with the traditional program. The operational cost-effectiveness factor for the ILUs was \$.54, measured against \$.36 for the traditional program. The sum of the developmental and operational cost per unit gain for the ILUs was \$.69, measured against \$.36 for the traditional program which incurred no developmental costs.

Therefore, if a school district were to consider the ILU technique as an alternative to the traditional approach to mathematics, the decision would not be cost-effective. However, the stated proximity in cost, plus the greater achievement gains, make it a viable option.

Hypotheses Relating to Effectiveness

H₃. There will be no significant differences in

achievement gains, total mathematics score, between junior high school students using Individual Learning Units and junior high students in the traditional program, as measured by the Comprehensive Test of Basic Skills, Form Q, Level III.

The findings of this study failed to support the hypothesis that groups receiving the ILU treatment would have significantly higher achievement gains on the total mathematics score than the control groups. Nevertheless, those involved in the ILU program had scores approaching the level of significance. A highly significant interaction effect was also indicated with the ILU treatment in School A and the traditional approach in School B proving to be most effective.

H₄. There will be no significant differences in gain scores on the arithmetical computational skills sub-test of junior high school students using Individual Learning Units and junior high students in the traditional program.

The hypothesis that the experimental groups' scores on the arithmetical computational skills sub-test would be significantly higher than control groups' scores failed to be supported. Again, however, a significant interaction effect was indicated with the ILU treatment in School A and the traditional approach in School B proving to be most effective.

H₅. There will be no significant difference in gain scores on the arithmetical concepts sub-test of junior high school students using Individual Learning Units and junior high students in the traditional program.

The findings also failed to support the hypothesis that the experimental groups' gain scores on the arithmetical concepts sub-test would be significantly higher than control groups' scores. Again, a significant interaction effect was indicated with the ILU treatment in School A and the traditional approach in School B proving to be most effective.

H₆. There will be no significant differences in gain scores on the arithmetical applications sub-test of junior high students using Individual Learning Units and junior high school students in the traditional program.

The final hypothesis that the experimental groups' gain scores on the arithmetic applications sub-test would be significantly higher than control groups' scores was supported. This section of the test measured problem-solving ability of the subjects.

IMPLICATIONS OF THE STUDY

Considering the limitations previously stated, as well as the significant differences in achievement on the applications sub-test, and the significant interaction effects registered, the investigator viewed the results with some encouragement. The fact that the experimental groups averaged 6.6 months gain in achievement, as compared to 3.7 for the control groups, indicated that the Individual Learning Unit technique may be a viable means of individualizing mathematics instruction. While the cost of developing a learning package program may appear prohibitive in some circumstances, a commercially prepared program, or one acquired from another district may reduce the total cost factor.

The significant achievement gains of the experimental

groups on the arithmetic applications sub-test indicate that the ILU technique can help students apply problem solving to the physical world. The School Mathematics Study Group, a National Science Foundation sponsored research committee of math scholars, asserts that arithmetic applications is especially relevant because it involves the translating of problems of the world around us into number relationships. They believe this translation is one of the reasons why we study arithmetic today.¹

The significant interaction effects recorded on the total mathematics score and two of the CTBS sub-tests must be considered. The achievement gains of the treatment group in School A were superior to the control group, while the control group in School B outperformed the experimental group in all areas except arithmetic applications. The subject populations of the two schools differed drastically. School A's enrollment consisted of approximately 95% racial and ethnic minority, while School B had approximately 80% of its students classified as Caucasian. Individual student gains within each ethnic group were not a concern of this study, but the data indicates that an intra-group study of this nature may be beneficial in an extension of this investigation.

If implementation of this cost-effectiveness model is to be successful in similar studies, adequate time must be allocated to school personnel. Cary asserts that educators could be benefited by merely adopting the mode of thinking associated with instructional cost-effectiveness analysis.²

¹School Mathematics Study Group, Studies in Mathematics, IX (Palo Alto, California: Leland Stanford Junior University, 1963), p. 419.

²Cary, "Development of an Instructional Cost-Effectiveness Model," 186.

Educators who mentally go through the steps underlying an instructional cost-effectiveness model . . . will probably come up with "better" and more rational decisions than they do now when dealing with curriculum. Gradually, a complete scheme could be implemented.¹

RECOMMENDATIONS FOR FURTHER STUDY

The findings at the conclusion of the Individual Learning Unit treatment gave evidence that this method could be helpful in assisting an individualized program in junior high school basic mathematics instruction, but at an increased cost. Since it must not be concluded from a single study that ILUs are the final solution to individualizing, the investigator recommends that further study be made in the following areas:

1. A longitudinal study of this nature should be designed to predict how lasting the effects of the experimental treatment would be.

2. A longitudinal study of this nature should be designed to predict whether or not additional teacher and student experience with the ILU technique leads to greater achievement gains.

3. An intra-group study concerned with individual student gains within each racial and ethnic group may be a beneficial extension of this study.

4. One area of valuable research would be to develop new individualized program alternatives, such as ILUs, based on

¹Ibid.

educational activities and objectives, and to compare them with traditional programs.

5. An extension or replication of this study be conducted with a broader range of schools.

6. A cost-effectiveness analysis comparing the Individual Learning Units with other learning packages similar in nature could prove helpful in evaluating possible program alternatives. It would be particularly desirable to determine which of the learning packages resulted in a more favorable ratio of cost per unit gain in achievement.

7. Educational decision-makers should take the lead in adopting and enlarging cost-effectiveness analysis concepts for use in the evaluation of instructional programs.

8. Finally, it is recommended that current efforts be continued and intensified in the development of individualized instructional techniques in mathematics to hopefully allow each student to achieve on a level commensurate with his abilities.

SUMMARY

In this chapter, the investigator has summarized the cost-effectiveness analysis of Individual Learning Units and reviewed his findings. While the ILU program did not prove to be cost-effective, it did demonstrate its effectiveness through achievement gain scores on: (1) arithmetical computations, (2) arithmetical concepts, and (3) arithmetic applications, with the last falling within the significant range. Significant interaction effects were recorded for the total mathematics scores, and each sub-test except applications.

Since the results of a single study should not be used to alter the educational policies of a school system, the investigator urged other educators to adopt and enlarge the cost-effectiveness analysis concepts discussed here to provide a basis for the evaluation of instructional alternatives to the traditional approach to mathematics.

APPENDIX

RAW DATA COLLECTED IN THE
EXPERIMENTAL STUDY

TABLE 16

Grade Equivalent Test Scores of Students
in the Experimental Group, School
A - CTBS, Form Q, Level III

No.	Pre Comp.	Post Comp.	Pre Conc.	Post Conc.	Pre Appl.	Post Appl.	Pre Total	Post Total
1	5.5	6.6	7.2	6.6	5.4	8.5	5.9	7.0
2	7.8	9.0	7.2	8.1	7.0	5.9	7.5	8.1
3	5.1	6.3	7.2	8.5	5.9	7.5	5.8	7.2
4	4.0	4.0	8.1	6.6	4.1	2.4	4.9	4.4
5	5.0	6.8	5.5	6.2	4.1	6.6	4.9	6.6
6	5.7	5.0	4.5	5.5	6.2	4.5	5.4	5.0
7	5.8	5.7	8.1	8.5	7.5	7.5	6.8	6.8
8	5.7	6.8	5.5	5.5	4.1	5.9	5.3	6.3
9	6.4	6.4	5.5	5.2	4.1	4.1	5.7	5.6
10	7.0	8.3	7.8	9.7	8.0	7.5	7.5	8.6
11	8.0	8.7	6.2	7.5	4.5	7.0	6.7	8.0
12	7.2	7.8	7.2	8.8	5.9	8.0	6.9	8.1
13	6.6	7.0	4.9	6.9	7.0	5.9	6.3	6.7
14	6.6	8.0	8.8	9.0	3.0	9.0	6.5	8.5
15	6.8	8.5	5.5	7.2	5.4	6.2	6.2	7.7
16	4.7	5.1	3.0	4.5	4.5	4.5	4.1	4.7
17	5.8	8.5	6.6	7.2	5.9	6.2	6.0	7.7
18	5.8	6.3	6.2	8.1	5.9	8.0	5.9	7.2
19	6.6	7.0	5.9	8.1	4.1	6.6	5.9	7.3
20	6.0	6.8	5.5	6.9	8.0	8.0	6.3	7.1
21	8.8	9.1	7.5	8.1	8.0	7.0	8.3	8.5
22	5.5	7.2	7.8	8.8	5.4	7.0	6.1	7.7
23	5.3	6.6	8.1	9.0	6.2	8.0	6.3	7.7
24	4.7	5.7	4.5	4.5	5.4	4.1	4.7	5.0
25	6.3	5.1	7.8	7.8	6.2	7.0	6.7	6.3
26	5.7	5.8	5.5	7.8	7.0	7.5	5.9	6.7
27	6.4	7.0	6.6	6.2	6.6	6.6	6.5	6.7
28	6.3	6.3	5.2	6.6	6.2	5.9	6.0	6.3
29	5.3	5.0	3.3	5.2	4.1	5.0	4.4	5.0
30	3.1	3.6	3.0	3.0	2.4	4.5	2.7	3.4

Key: No. = Student

178.1 201.9
1092.43 1410.13

23.8

Comp.* = Arithmetic Computation, Comprehensive Test of Basic Skills, Form Q, Level III.

Conc.* = Arithmetic Concepts, Comprehensive Test of Basic Skills, Form Q, Level III.

Appl.* = Arithmetic Applications, Comprehensive Test of Basic Skills, Form Q, Level III.

Total* = Total Score, Comprehensive Test of Basic Skills, Form Q, Level III.

*Pre = Pretest; Post = Posttest

TABLE 17

Grade Equivalent Test Scores of Students
in the Control Group, School A -
CTBS, Form Q, Level III

No.	Pre Comp.	Post Comp.	Pre Conc.	Post Conc.	Pre Appl.	Post Appl.	Pre Total	Post Total
1	5.1	6.1	3.0	2.6	4.5	2.4	4.3	4.4
2	2.3	4.0	3.7	3.3	4.5	2.4	2.9	3.3
3	5.8	6.3	3.0	3.7	4.1	4.1	4.6	5.2
4	5.3	5.1	4.5	2.0	5.0	4.1	5.0	3.5
5	3.1	3.8	2.0	3.0	2.4	2.4	2.3	3.1
6	5.1	4.3	3.6	3.3	4.1	4.1	4.1	3.8
7	3.0	3.0	3.3	5.2	6.2	4.1	3.7	3.7
8	2.7	3.6	4.5	4.1	4.1	2.4	3.3	3.3
9	2.0	5.0	3.7	5.9	3.0	2.4	2.3	4.6
10	5.0	3.6	4.5	4.1	2.0	4.1	4.1	3.7
11	5.3	3.8	6.2	6.2	5.4	6.6	5.5	5.2
12	6.0	3.8	4.5	4.5	2.4	2.0	4.9	3.4
13	3.6	3.8	2.6	2.3	2.0	3.5	2.7	3.1
14	5.0	3.4	2.3	2.0	3.0	3.0	3.5	2.6

Key: No. = Student

53.2 52.9 -0.3
215.64 207.99

Comp.* = Arithmetic Computation, Comprehensive Test of Basic Skills, Form Q, Level III.

Conc.* = Arithmetic Concepts, Comprehensive Test of Basic Skills, Form Q, Level III.

Appl.* = Arithmetic Applications, Comprehensive Test of Basic Skills, Form Q, Level III.

Total* = Total Score, Comprehensive Test of Basic Skills, Form Q, Level III.

*Pre = Pretest; Post = Posttest

TABLE 18

Grade Equivalent Test Scores of Students
in the Experimental Group, School
B, - CTBS, Form Q, Level III

No.	Pre Comp.	Post Comp.	Pre Conc.	Post Conc.	Pre Appl.	Post Appl.	Pre Total	Post Total
1	4.3	5.3	7.8	5.9	4.5	5.4	5.3	5.4
2	4.7	5.7	3.0	4.1	4.1	4.1	3.9	4.9
3	4.3	5.1	5.9	5.2	6.2	5.4	5.2	5.2
4	2.7	4.5	3.7	3.7	4.5	5.4	3.2	4.4
5	5.0	5.1	5.2	5.9	4.1	5.9	4.7	5.4
6	3.8	6.4	3.3	5.9	3.5	4.1	3.4	5.8
7	5.0	5.3	5.2	5.2	3.0	3.5	4.5	4.9
8	5.7	6.0	5.2	8.1	7.0	8.0	5.8	7.0
9	5.3	5.5	4.9	5.5	5.0	5.9	5.1	5.5
10	6.0	7.0	6.9	6.6	5.9	7.5	6.2	7.0
11	5.3	5.0	7.8	7.8	7.0	5.9	6.4	5.9
12	3.8	4.7	4.1	4.1	3.5	4.5	3.7	4.4
13	5.8	4.7	6.2	6.2	6.2	5.4	6.0	6.3
14	4.7	5.5	5.2	6.2	4.1	5.0	4.6	5.5
15	4.3	4.3	3.3	3.7	2.4	2.4	3.4	3.5
16	6.8	8.7	5.9	5.5	5.0	5.9	6.2	7.2
17	4.7	5.8	5.9	4.1	4.5	4.1	5.0	5.0
18	6.0	5.5	4.9	6.2	3.5	5.4	5.2	5.6
19	3.4	4.0	4.9	4.9	4.5	3.5	3.9	4.1
20	5.7	5.8	4.5	3.7	3.5	5.0	4.9	5.1
21	5.7	5.5	6.6	7.8	6.6	7.5	6.1	6.5

Key: No. = Student

102.7 114.6 11.9
522.85 649.26

Comp.* = Arithmetic Computation, Comprehensive Test of Basic Skills, Form Q, Level III.

Conc.* = Arithmetic Concepts, Comprehensive Test of Basic Skills, Form Q, Level III.

Appl.* = Arithmetic Applications, Comprehensive Test of Basic Skills, Form Q, Level III.

Total* = Total Score, Comprehensive Test of Basic Skills, Form Q, Level III.

*Pre = Pretest; Post = Posttest

TABLE 19

Grade Equivalent Test Scores of Students
in the Control Group, School B, -
CTBS, Form Q, Level III

No.	Pre Comp.	Post Comp.	Pre Conc.	Post Conc.	Pre Appl.	Post Appl.	Pre Total	Post Total
1	4.3	5.5	4.9	5.9	3.5	4.5	4.2	5.3
2	4.5	4.5	3.3	3.7	3.5	3.5	3.8	3.9
3	5.0	6.1	5.5	6.9	5.0	5.0	5.1	6.1
4	5.8	4.7	6.6	6.6	6.2	5.4	6.1	5.3
5	4.0	5.5	5.9	4.1	4.1	4.5	4.5	4.9
6	5.1	7.0	7.8	7.5	6.2	8.0	6.1	7.4
7	3.6	3.1	3.0	5.2	5.4	3.5	3.7	3.7
8	5.3	5.5	6.9	6.9	5.4	5.4	5.7	5.8
9	4.3	4.7	3.7	5.5	4.5	4.1	4.1	4.7
10	5.0	7.2	4.1	6.6	6.2	7.5	5.0	7.1
11	5.1	5.7	3.7	5.5	3.5	5.4	4.3	5.5
12	2.7	5.0	9.0	8.1	5.4	2.0	5.3	5.3
13	6.0	6.0	5.2	6.2	6.6	7.0	5.9	6.3
14	3.6	3.1	3.0	3.0	2.4	4.5	2.9	3.2
15	4.3	4.5	3.7	5.2	4.1	5.0	3.9	4.7
16	3.0	5.0	4.1	6.6	5.0	6.6	3.5	5.7
17	5.0	6.0	7.5	5.2	6.2	6.2	5.9	5.8
18	6.3	7.0	5.5	7.5	6.2	6.6	6.1	7.1
19	4.3	5.7	6.2	7.5	4.5	5.9	4.9	6.2

Key: No. = Student

91 104
454.04 592.54

13

Comp.* = Arithmetic Computation, Comprehensive Test of Basic Skills, Form Q, Level III.

Conc.* = Arithmetic Concepts, Comprehensive Test of Basic Skills, Form Q, Level III.

Appl.* = Arithmetic Applications, Comprehensive Test of Basic Skills, Form Q, Level III.

Total* = Total Score, Comprehensive Test of Basic Skills, Form Q, Level III.

*Pre = Pretest; Post = Posttest

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