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ABSTRACT

This study investigated the differences in students' attitude toward mathematics, achievement from pretest to posttest, and ability to transfer concepts to a novel problem-solving situation when taught by an individualized method of instruction and when taught by a traditional lecture method. A quasi-experimental design was utilized and the study was conducted for one semester with pretests and posttests in both achievement and attitude, and a posttest in problem-solving. Two courses utilizing two instructional approaches were used; 62 students were enrolled in Fundamentals of Algebra I, and 39 were enrolled in Intermediate Algebra at two urban community colleges. Two instructors were involved. All students were given lists of behavioral objectives during the first week of the semester and those who received instruction by the individualized approach were given additional literature describing individualized instruction. All students took pretests and posttests during the first week and last (fifteenth) week of the semester, respectively. During the fourteenth week, all students were given a problem solving task. Data were submitted to an analysis of covariance with pretest scores serving as the covariate. Results indicated no significant differences in attitude or achievement for the two groups. Students given individualized instruction scored higher on the problem solving task. (Author/SD)

Community College Students' Academic Achievement in Mathematics and Attitudinal Change as a Function of Instructional Methodology

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A MAJOR APPLIED RESEARCH PROJECT
PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
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ABSTRACT

This study has investigated the extent to which students enrolled in (1) Intermediate Algebra and (2) Fundamentals of Algebra I (a) achieved a more positive attitude toward mathematics, (b) exhibited greater achievement gains from pretest to posttest, and (c) demonstrated greater ability to transfer concepts to a novel problem-solving situation when taught by the Individualized Method of Instruction than when taught by the Traditional Lecture Method.

A quasi-experimental design was utilized and the study was conducted for one semester with pretests and posttests in both achievement and attitude, and a posttest in problem-solving. The two levels of courses utilizing two instructional approaches comprised 101 Ss: 62 were enrolled in Fundamentals of Algebra I, and 39 were enrolled in Intermediate Algebra. The study was conducted at two urban Community Colleges whose student population was similar in ethnicity, socio-economic backgrounds and educational experiences. Two instructors were involved.

All Ss received behavioral objectives during the first week of the semester and those who received instruction by the individualized approach were given additional literature describing Individualized Instruction; they studied for fifteen weeks and at their own pace. The Ss who were traditionally instructed by the lecture method also studied for fifteen weeks but progressed through the content at the instructors' pace. All Ss took pretests and posttests during the first week and last week of the semester, respectively. During the

fourteenth week, all Ss were assigned a problem-solving task which had to be completed within a week's duration. The problem-solving task was designed to evaluate Ss' abilities to use initiative, mathematical skills and skills that led to independent thinking that were not teacher-directed. A cumulative graph was kept by all Ss to record their progress.

Achievement and attitude testing were computer-scored, and problem-solving tasks were scored by each instructor with a maximum of 120 attainable points.

Based on the data collected from the study, a 2 X 2 ANCOVA was employed for each task encompassing achievement, attitude and problem-solving. In achievement and attitude the pretests were utilized as covariates, but in problem-solving (posttest only) the posttest achievement scores were used as a covariate in order to control for selection bias.

The following results were noted:

(1) There was no significant difference in achievement on the Diagnostic and Achievement test between the two groups. ($F = 0.07$; $df = 1/67$; $p < .01$).

(2) There was no significant difference in attitude changes as exhibited by Ss' scores on the attitude inventory. ($F = 0.41$; $df = 1/67$; $p < .01$).

(3) There was a significant difference in problem-solving, in favor of Individualized Instruction. ($F = 6.50$; $df = 1/63$; $p < .05$).

Secondary findings were:

(1) A significant B effect (course) in achievement. ($F = 29.37$; $df = 1/67$; $p < .01$).

(2) A significant B effect (course) in attitude. ($F = 15.83$;

df = 1/67; p < .01).

(3) An AB effect of 3.76 in attitude which approached significance at the .05 level (F - 4.00; df = 1/67; p < .05).

Findings of earlier studies were replicated by this study. However, several suggestions were made for further research and refinement among which were: further comprehensive and systematic research on other affective variables in academic achievement; and institutional implementation of varied teaching methodologies, evaluating the outcomes through on-going research.

It is of great importance to educators and especially to mathematics instructors that students who have suffered the fear of failure syndrome be assisted to recover and develop new positive attitudes. Students can be helped by humanizing mathematics without sacrificing excellence. Individualized Instruction may help the achievement of these goals.

CHAPTER I

INTRODUCTION

Context of the Problem

Several research reports (Englert, 1972; Neidt and Hedlund, 1967; Dreger and Aiken, Jr., 1961; Whipkey, 1969) have been written to establish the interrelationship of mathematics achievement and mathematics attitude. Most recently many educators have been deeply concerned about meeting the students' individual needs through individualized instruction; some dissertations (Frase, 1971; Taylor, 1971; Jeffrey, 1972) reflect this concern. Jeffrey (1972) investigated preferences and attitude toward one of two modes of mathematics instruction, Frase (1971) observed the time utilized by two groups to complete the same number of units with two different styles of instructional experiences, and Taylor (1971) tried to obtain statistical evidence that might be partially used to determine the effectiveness of independent study as used in teaching Algebra. In addition, Aiken (1963) researched personality correlates of attitude toward mathematics, and Cattell (1945) performed a study on personality traits associated with mathematical abilities. Despite these concerns and research articles, little attention has been given to discover the effects of teaching methodology on students' attitudes toward mathematics. Within this construct Hayes (1972) has researched the effects of two methods of presenting homework upon attitude, achievement and perceptions of study habits in a college mathematics course; Connolly and Sepe (1973) worked on an analysis of student attitudes toward divergent modes of instruction, the implications of which were geared toward individualized instruction; and the Department of Educational Research of Miami-Dade Junior College, Florida (1971) investigated learning systems and student achievement as a test of a model in a large, urban community college.

In all levels of instruction, teachers of mathematics have been confronted with students' attitudes toward this subject and its relationship to performance. Gough (1954) used the term "mathemaphobia" to describe students' reaction to mathematics, Tuloch (1957) referred to it as "emotional blocks" and Johnson (1957) emphasized the need for "conditioning" a positive attitude toward mathematics through reward. The fact is, educators have become increasingly aware of the difficulties which students experience in mathematics, many of whom have committed themselves not to merely accept rationalizations from students, but to seek out new methods of presenting the subject matter which might affect attitudes and give cause to greater achievement. Many students actually experience great emotional stress and actually shy away from this discipline; this phenomenon has caused several authors (Poffenberger and Norton, 1959; Aiken, 1963; Hamza, 1952) to investigate the factors that produce this symptom. This educator is especially interested in alleviating these fears and fostering a positive attitude by "humanizing" mathematics -- a humanism exemplified by the methodology of instruction utilized in the teacher-learning process.

The definition of learning as changed behavior, if accepted, allows appropriate consideration to be given to the possibilities of changing attitudes in conjunction with the acquiring of knowledge. An instructor may well affect change by providing a classroom climate in which students grapple with past problems which were the cause of negative experiences in mathematics, verbalize them and set forth new goals in which they would strive for complete recovery from "mathemaphobia" (pronounced fears in the presence of mathematics) and "emotional blocks" (dislike of, and hostility toward mathematics); the end results, hopefully would be greater academic success in the understanding of mathematics, a more positive attitude toward the subject matter, and the ability to transfer concepts learned to problem-solving situations.

Statement of the Problem

The purpose of this study was to ascertain the extent to which students enrolled in (1) Intermediate Algebra and (2) Fundamentals of Algebra I (a) achieved a more positive attitude toward mathematics, (b) showed greater achievement gains from pretest to posttest, and (c) demonstrated greater ability to transfer concepts when taught by the Individualized Method of Instruction than when taught by the Traditional Lecture Method.

Review of the Literature

For the past fifteen years, 1959-1974, there has been an increased number of published articles relative to performance in mathematics, the effects of attitudes on performance and methods of instruction, the expressed theme of which was greater mathematics achievement and how personality and environmental factors affect attitude toward mathematics. Most recently, educators have been devoting their energies to instructional outcomes, instructional preferences, behavioral objectives, and above all meeting individual needs of students through a variegated array of programs. Current evidence to support this contention is reviewed below.

A. Teaching Styles and Instructional Programs.

Chapman (1966, p. 34) asked: "Are Junior Colleges superior teaching colleges? Is the teaching in Junior Colleges as good as, or better than that of other institutions of higher learning?" He alluded to Sidney Hook's statement in which it was mentioned that it is an open scandal that the worst teaching in the American system of education takes place at the college level, and continued that he did not know whether Hook was including junior colleges in his denunciation; one thing that was certain in Chapman's mind was that there should be no room for complacency at the junior colleges. Rather, he suggested educators improve the teaching by "resharpening the tools of instruction" so that improved learning can take place; by "tools" he meant the total college environment -- all personnel, facilities, student services, curriculum, and instruction that were utilized to reach the obligations of the college. He added that

> Whether we like it or not, technology has invaded the classroom. It will in all probability, have a greater and greater effect upon us, the way we do things . . . students can progress at individual rates . . . material will be presented in a variety of ways which are designed to intensify learning.

The influence of Keller's work has been particularly important in establishing the Individualized Methods of Instruction. Keller, a psychologist, and dissatisfied with the conventional approaches to teaching, devised a new style in which he applied his behavioral approach to college teaching. He implemented the concept of mastery learning and developed a systematic behavioral model known as the Personalized System of Instruction (PSI) or the Keller Plan. One of Keller's (1968, p. 80) hand-outs read as follows:

> This is a course through which you may move, from start to finish, at your own pace. You will not be held back by other students or forced to go ahead until you are ready. At best, you may meet all the course requirements in less than one semester; at worst, you may not complete the job within that time. How fast you go is up to you. . . .

A brief synopsis of this (Keller) Plan would be: It divides the material into small, clearly-defined objectives, permits each student to proceed at his own pace, requires mastery of one unit before proceeding to the next, furnishes immediate positive reinforcement and provides for the personal-social interactions that we know are important to motivation. Research evaluations (The EPIE Report, April, 1974) have also shown that retention of content is as good as or better than that which occurred in the conventional classroom. Some of the studies also tested students from nineteen weeks to nine months afterward, to obtain contrasts in retention. Here all studies favored PSI, and the contrast was greater than that shown immediately after the course ended. When differences at the end of the course ranged from 6 per cent to 20 per cent, with a mean of 10.8 per cent, differences in later retention ranged from 10 per cent to 22 per cent with a mean of 17 per cent.

Several other programs have been invented since the PSI Plan. The Educational Products Information Exchange Institute (EPIE, January, 1974) looked at three similar programs, namely, Program for Learning in Accordance with Needs (PLAN), Individually Guided Education (IGE), and Individually Prescribed Instruction (IPI); PLAN is an instructional system that facilitates Individualized Instruction; IGE among other components focuses on the individual learner, develops measurement tools and evaluation procedures; and IPI is an instructional system which is designed to individualize the teaching of subject content. IPI, one of the older and more widely known instructional systems, has been closely identified with an elementary mathematics program (EPIE, 1974).

Connolly and Sepe (1973, p. 31) tried to identify those characteristics of Individual and Traditional Instruction preferred by community college students. From the choice of the two methods of instruction, 50 per cent of 377 students chose Individualized Instruction and of eight characteristics describing the two teaching methodologies, seven of the statements were favored over the traditional counterparts; the one characteristic not preferred was "learner control" as opposed to "external control". These two characteristics were described as follows:

> Would you prefer a course in which (check one)
>
> Learner Control ☐ the student will be responsible for his own learning and progress and for meeting the stated course objectives,
>
> or a course in which
>
> External Control ☐ the student will have to meet certain requirements set by the instructor to maintain satisfactory progress in the course.

The students were told in advance that the particular course in which they were planning to register would be taught in these two different styles, and that they were free to select the one they preferred. Since these two concepts -- "learner control" and "external control" -- were well-defined, the authors were of the opinion that there appeared to be some unwillingness on the part of the students to accept responsibility for learning. They also attributed much of the failure of individualization to this factor and recommended that students be taught a "new" way, as individuals. They must modify a learning style that has focused primarily upon the teacher to one that will depend primarily upon the students.

What did the students who have been exposed to both types of instruction say? Jioia (1973) in a sociology course taught by the Individualized Method of Instruction found that the students in comparing traditional approach with individualized approach favored the individualized course; the rationale was that they could work at their own pace and receive immediate gratification (quick test results) for their work. They pointed out, however, because of the nature of sociology, they missed classroom discussions and they felt isolated from their peers although they had more interaction with their instructor.

Roueche and Herrscher (1970) have acclaimed that learning is not an accident, but rather the result of strategically planned teaching methods. They advised that prospective teachers be trained in instructional methodology to meet the needs created by recent technological developments for educational innovations; consequently, this method should be a contributory factor to more effective teaching. They also advocated Individualized Instruction, and agreed with Bloom's (1968) research on student learning where he concluded that 95 per cent of students can learn a subject up to a high level of mastery -- the grade of A being an index of mastery. Roueche and Herrscher (1970, p. 26) further state that

> it is obvious that traditional methods of teaching do not succeed with individuals who are not traditional students. It becomes equally obvious that if the two-year college is ever to achieve its lofty ideals, the institutions will be compelled to experiment -- to try new programs and new methods, discarding those which do not succeed and refining those which are successful.

Koyanagi (1970) in his quest to determine the relative merits of two methodologies in improving problem-solving abilities, designed a study for a seventh grade science class. A relevant, but secondary purpose was to determine if relationships existed between students' problem-solving ability and their ability in critical thinking, reading, and non-verbal I.Q. Three groups were studied. Two randomly-selected groups comprised each of Groups 1 and 2; and Group 3 consisted of students from another school. Group 1 received instructions in which a problem was defined, the variables of the problem discussed, the direct procedure to solve the problem carefully outlined; then the students were allowed to work in pairs. Group 2 also received instructions in which a problem was defined and the variables discussed, but they were required to design and make their own procedure to solve the problem; they too were allowed to work in pairs. Group 3 received no formal science instruction during that school year and worked individually on the problems. The duration of instruction to all groups was fifteen 40-minute periods. The results of the study indicated that problem-solving abilities of lower I.Q. students who received instruction utilizing a teacher-planned procedure or an individually-ascertained procedure could be improved more significantly (significant at the .05 and .10 levels, respectively) than those students who received no instruction. Analyses of the data showed no significant gains for the remainder of the students in both treatment and control groups within the instructional time-limit allotted. There was also significant positive correlations between students' problem-solving abilities and their abilities in critical thinking, reading and non-verbal I.Q.

In summary, the literature discussed in this section reinforces the need for innovation in education, with special emphasis on the type of instruction afforded the community college student. There was supportive evidence that individualization of instruction to meet individual students' needs has blossomed into several variations throughout the country since Keller's departure from the conventional instructional approach. In the quest for teaching styles to meet students' needs, identifiable concerns were: (1) student input in selection of teaching methodology; (2) teaching style effectiveness from one program to another; (3) uniqueness of community college students because of the wide range of intellectual abilities -- students should be less subjected to traditional college lecture method of teaching; and (4) problem-solving ability of lower I.Q. students to perform with instructional assistance, working in small groups, and without instruction working individually. It was established that students with lower I.Q.'s could improve their problem-solving skills if given some initial instructional assistance and were allowed to work in a pair-group situation; it appeared that the higher ability students did not necessarily require teacher assistance since their problem-solving skills were not improved. This notable difference as a result of teaching styles is very pertinent since its implications are directly applicable to the community college student population.

B. Attitudes

Aiken and Dreger (1961) researched the relation of mathematics attitudes to achievement measures, the relation of mathematics attitudes to personality measures and the relation of mathematics attitudes to experiences with mathematics. They found that attitude as a predictor of achievement was borne out for females but not for males: leadership for males was significantly correlated with mathematics attitude whereas females with good "adjustment to reality" had more positive feelings toward mathematics than those with poorer adjustment; math attitudes were found to be related to remembered impressions of teachers, the females more clearly so than the male attitudes.

Neidt and Hedlund (1967) made reference to the number of studies reflecting relationship of attitudes toward school or toward a specific subject matter and achievement. Their study designed to investigate the relationship between change in student attitudes toward a class in which they were participating and final achievement in class, with ability held constant, resulted in consistently decreasing mean attitude scores in all three of the classes tested -- Science, English, and German. (Attitude results were not tested statistically). In two of the classes, it was found that attitudes were significantly related to final course grades rather than early in the period of instruction, and that student attitudes toward a particular learning experience became more closely related to achievement in the learning experience as the period of instruction progressed.

Whipkey (1969), utilizing the Dutton Attitude Scale and the Hurd Number System Test, also found a small but important relationship between mathematical attitude and mathematical achievement. He was convinced that a mathematical attitude does have a relationship with an associated behavioral disposition which is the determinant or consequence of attitude.

Aiken (1963) investigated 160 female college sophomores for personality correlates of attitudes toward mathematics. He chose all females since his previous study (1961) indicated that non-intellectual factors were more influential in determining the attitudes of females toward mathematics than those of males. The results suggested that women with more favorable attitudes toward mathematics (high scorers on attitude scale) tend to be more socially and intellectually mature, more self-controlled, and placed more value on theoretical matters than those with less favorable attitudes (low scorers on attitude scale). He concluded that attitudes toward mathematics were significantly related to general personality variables.

Another of Aiken's studies (1970) reviewed several research projects that were conducted over a period of ten years with the subjects ranging from elementary school to college level. He discovered that on the college level, low correlations between mathematics attitude and achievement existed. However, there was found to exist a significant relation between selection of a mathematics course versus no mathematics, and attitude.

Poffenberger and Norton (1959, p. 172) in an attempt to find out why high school and college students had such seemingly lack of interest in mathematics pursued extensive research, first with a pilot study -- Student Attitudes Toward Mathematics -- followed by another study namely, The Formation of Attitudes Toward Arithmetic and Mathematics. The studies revealed that "students do not care as much for mathematics as they do for other subjects . . . (and) there is a tendency in our culture to believe that men like and do better in mathematics than women." Other results from the study were certain factors that significantly differentiated the two groups under study into those subjects who indicated a "positive" attitude and those who indicated a "negative" attitude. These factors were (1) the attitudes of the fathers toward mathematics and the expectation of both parents of mathematical achievement on the part of the children; (2) a teacher effect, where students with positive attitudes showed a greater liking for a teacher than those with negative attitudes -- those with negative attitudes being more critical of their teachers and even if they liked the teacher disliked the subject; and (3) the present lack of interest in mathematics which was largely a cultural phenomenon pervading not only the educational system of the country but also the family as an institution that conditions the attitudes of children.

In a longitudinal study over a six-year period (1960-66) Antonnen (1969, p. 467) investigated the relationships between mathematics attitude and mathematics achievement from the late elementary to the late secondary school level. The 607 subjects were tested in the spring of 1960 with a mathematics attitude instrument and were retested in the spring of 1966.

> Using a .05 level of significance, the results showed a significant positive correlation between the elementary attitude scores and the secondary attitude scores. In addition, significant positive correlations existed between all measures of attitude and achievement.

In summary, of the several studies performed to research the relationship between mathematical attitude and mathematical achievement, there has been increasing evidence substantiating the existence of a high positive correlation between these two variables; poor or negative attitude resulted in low achievement, while a positive attitude often resulted in high achievement. Personality variables have also been correlated with attitudes toward mathematics and there has been exhibited a fear of this subject at all levels of education. The attitudes exhibited in elementary school have been seen to persist through high school and into college, where students demonstrate their attitudinal behavior by enrolling or not enrolling in mathematics courses. Family members and teachers of mathematics have contributed to the development of attitudes toward mathematics as well, but a humanistic approach to teaching mathematics currently in use throughout the country may affect more positive and less negative attitudes toward this subject.

C. Achievement and Transfer of Concepts.

Sheppard and MacDermot (1960) described a design and evaluation of a programmed-teaching procedure applied to a large undergraduate course in the psychology of learning. The design of the experimental teaching procedure was patterned after the approach taken by Keller

(1968) and the performance of these students was compared with the performance of students covering the same subject matter in a conventional manner. The results showed the experimental teaching procedure to be superior to conventional instruction procedures as measured by student achievement and student satisfaction. The authors concluded by agreeing to Michael and Corey's (1969) statement that the procedures used had wide generality and were applicable to general subject matter.

Achievement is an integral part of instruction. Tyler (1951) claimed that instruction involves several steps, and is not effective unless desirable changes in the behavior of students take place. Among these steps is educational measurement or achievement testing, and the outcomes could be of a multiple nature such as: knowledge, skill, interest, attitudes, and transfer of concepts. Tuckman (1974) also advocated a multiplicity of outcomes which stemmed from five categories: (1) specific knowledge and comprehension; (2) general knowledge and comprehension; (3) thinking and problem-solving; (4) attitudes and values; and (5) learning related to behavior. Other authors who have researched multiple outcomes are Worthen (1968) and Mahan (1963). Mahan investigated two modes of instruction in general science and measured problem-solving skills, attitudes, interests, and personal adjustment. Worthen, in two methods of instruction with elementary mathematics, measured tests of initial learning, retention and transfer of heuristics and measures of attitude toward the subject content. Schmalz (1973) in conjunction with her dissertation, "The Effects of Two types of Feedback in Microteaching on the Development of Mathematics Teachers' Questioning Skills," developed an instrument with five major categories of questions: rhetorical, opinion, procedural, lower-order and higher-order; the first three categories separate the non-content, non-mathematical questions from the questions of mathematic content according to the cognitive level they demand. Schmalz felt that:

> In a time of rapid technological advances, when there is need for frequent adaptation of skills it is generally agreed that teachers must do more than just teach students a certain body of facts. They are responsible for teaching students processes of thinking and learning so that they have the ability to discover something new through consideration and reorganization of the known.

(Some of the problems for the problem-solving task of this study were adapted from the higher-order questions of the instrument constructed by Schmalz).

Inherent in the measurement of achievement were the criteria set by clearly formulated objectives. Tyler (1951, p. 49) states,

> It is not possible to construct a valid achievement test . . . without clarifying the objectives which the test is supposed to measure. One cannot measure the outcomes of a course without knowing what particular changes in behavior are sought. . . .

Katona (1940) in pursuit of this concept emphasized "understanding," the sort which favored transfer of learning to a problem-solving situation. Gagné and Brown (1969) exhibited much interest in their study on a "bridge" between conceptual learning and utilization -- how concepts that were learned enter into the activity of solving problems. Gagné and Brown's study dealt with Discovery versus Rule and Example in which they found that the subjects who were exposed to the discovery method exhibited greater transfer of learning if the degree of the original learning was equated.

Roughead and Scandura (1968) alluding to Gagné and Brown's findings felt that the outcome of the study was due to uncontrolled factors; Roughead and Scandura believed the transfer ability of learning depended on "what is learned" originally, the nature of the transfer items and the relationships between them. Worthen (1968, p. 7), in his study also made reference to these two previous studies and expressed his belief that "much more exploration was necessary before it would be possible to discern which, if any, comparisons are legitimate."

Krathwohl and Payne (1971) in defining education as a process of "changing student behavior" to achieve certain specified goals have oriented their readers toward some facets of education that should be incorporated in educational programs. One of these facets stressed content "usage" and content "application" more than content "recall." The authors emphasized that what a student did with the content he learned was more important than his ability to remember it on demand; it was felt that content learned in the context of its use was more resistant to forgetting than if learned more or less by rote as a series of relatively unrelated facts. Another facet that played a role in effective behavioral change was learning methods for processing data, for solving problems, and for decision making. A third, emphasized transferability of learned behavior. Prominence was given to the display of learned behaviors in the wide array of situations and problems to which they were appropriately applicable but in which their applicability were not directly taught.

To further substantiate evidence on transfer of concepts to a problem-solving situation, Hellberg (1970) researched the relationship of concept learning to perception problem-solving and transfer through selected puzzle and design tasks. He found that the conceptual approach to learning resulted in significant gains and that defining the problem in terms of behavioral aims, identifying the concepts involved, and giving experiences to fix those concepts, resulted in significant behavioral changes. He also found that whereas perception improved for subjects receiving treatment, this was not true for the no-treatment group; moreover, the no-treatment group scored significantly lower on the problem-solving test given.

In the Elliott and Tuckman (1973) study, "Differentiated Outcomes Resulting from Individualized Instruction at a Two-Year College" although there was no significant difference in achievement on the performance test between the two groups, subjects in the individualized program spent less time in studying without decreasing achievement, spent more time solving problems and received more correct transfer problem solutions. These students had learned to function independently and accepted the responsibility for searching out the answers; the authors concluded that better performance on an initial job when leaving school would be an expectancy.

Keller (1968, p. 83) in having his students assess individualization of instruction had this report from his mythical figure John:

> Among other things, in comparison with courses taught more conventionally, this one demanded a much greater mastery of the work assignments. It (has) required greater memorization of detail and much greater understanding of basic concepts, it generated a greater feeling of achievement. It gave much greater recognition of the student as a person, and it was

> enjoyed to a much greater extent. . . . Study habits had improved during the term, (his) attitude towards testing had become more positive, worry about final grades had diminished. . . .

An individualized instruction approach in the teaching of mathematics at the community college seems to be feasible and desirable and some mathematics educators tend to support this method of instruction. In accordance with Chapman (1966, p. 37) as educators,

> we must accept the fact that we can improve our courses and methods of teaching. We must stretch our imaginations, study current and proposed practices, experiment, and then make some bold decisions. We must accept new ideas, new techniques, and the media, not because they are novel or for the sake of change alone, but because they, and the other concepts coming from them, promise to increase effectiveness as teachers.

The importance of multiple outcomes as reflected in the literature has been a major concern for several educators. Researchers have been discovering that they could adapt the principle of the differentiated outcome hypothesis and thereby utilize measures broader than achievement for evaluating less conventional styles of teaching. Individualization of instruction, one of these less conventional instructional methodologies, has received supportive evidence and wide acclaim while producing comparable results when evaluated using one criterion; however, in some instances, when multiple criteria were applied, this teaching style has produced superior results in problem-solving.

The ultimate goal of learning is the ability to apply what has been learned, which is the transferring of concepts to problem-solving situations: It is with this intent that educational behavioral objectives try to reflect the psychomotor, cognitive and the affective domains in hierarchical levels. Much of the research to date, however, has focused on measurement of content achievement while little has been accomplished in the affective domain and higher cognitive levels of achievement, but the literature cited indicated an increased trend to establish more work in these areas of study.

Hypotheses

Hypothesis 1

Students who study Intermediate Algebra by the Individualized Method of Instruction will experience greater achievement than those taught by the Traditional Lecture Method.

Hypothesis 2

Students who study Intermediate Algebra by the Individualized Method of Instruction will indicate a more positive attitude toward mathematics than those taught by the Traditional Lecture Method.

Hypothesis 3

Students who study Fundamentals of Algebra I by the Individualized Method of Instruction will experience greater achievement than those taught by the Traditional Lecture Method.

Hypothesis 4

Students who study Fundamentals of Algebra I by the Individualized Method of Instruction will indicate a more positive attitude toward mathematics than those taught by the Traditional Lecture Method.

Hypothesis 5

Students taught either Intermediate Algebra or Fundamentals of Algebra I will show significantly greater ability to transfer concepts to a problem-solving situation than those taught by the Traditional Lecture Method.

Rationale for Hypotheses

Keller's (1968) introduction of the Personalized System of Instruction (PSI) in the college classroom has led to tremendous efforts by educators to adapt the Individualized Instruction System ever more frequently and accurately to satisfy the personal needs of each individual student. The superiority of the techniques of PSI over traditional lecture method has been well documented (Born, Gledhill, and Davis, 1972; Cooper and Greiner, 1971; Morris and Kimbrell, 1972; Keller, 1968) and tend to stimulate educators as to their responsibilities. Responsiveness to students' needs or accountability is the theme for today's education in many areas of the country, hence not only concerned educators but entire educational systems have been, and should continue to be, responsive in providing the services required to help students attain their goals. Wilson and Tosti (1972, p. xii) define responsiveness of the educational system as "every time that a technique or approach is introduced which increases the frequency with which the instructional sequence can be changed for a student" and irresponsiveness as "any condition in which all students must do the same thing with the same materials at the same time."

Many students bring to the community colleges their negative attitudes resulting from previous experiences in mathematics. This continues to be a handicap for them and for the institution since certain programs demand courses in mathematics be taken (students have no alternative) and students shying away from the subject give cause to failure of the department to meet its enrollment expectancy. If the community college is a teaching college having the ability to emphasize the excellence of its teaching as Chapman (1966) has claimed, then instructors of mathematics must project this image, attract more students to the program, alleviate their fears and negativism toward the subject, attempt to remedy the poor mathematical preparation of former education, seek to avoid failure in mathematics and assist students in coping effectively with his environment. Moore (1970, p. 219) has also stated "regardless of the curriculum used, in the first analysis, it is the people -- creative people -- who make a curriculum work." Tyler (1951, p. 47) has asserted "instruction is not effective, unless some changes in the behavior of students have actually taken place." He further stated that instruction involves several steps and that in appraising the effects of the learning experiences educators must not only test but evaluate, taking into consideration that:

> Any learning situation has multiple outcomes. While the child is acquiring information, knowledges, and skills there are also taking place concommitant learnings in attitudes, appreciations, and interests. This view indicates a shift from a narrow conception of subject-matter outcomes to a broader conception of growth and development of individuals.

As educators prepare students to function in a larger society outside the classroom it is imperative that transfer of knowledge be one of their goals. Problem-solving is one such way of evaluating mastery of concepts or subject matter content, yet many instructors and researchers avoid this aspect of measurement. Gagné and Brown (1961, p. 313) stated that "concepts acquired in the course of an experiment are usually not further 'used', as in the solution of a problem but are simply measured as being 'established' in the sense that they meet a criterion of learning or recall." They further stated that only a few isolated studies have been devoted to a combination of concept learning and utilization, for example applying concepts or concept sequences which are newly learned to the solving of problems.

The following therefore has been investigated in this study: If by providing a different classroom atmosphere relative to the mode of instruction and the evaluation of transfer of concepts, then more positive attitudes would occur and greater achievement be accomplished. Acknowledging that students learn at different rates and considering the concept of maximizing the gain students receive between their point of entry and their point of departure from an educational institution, it seemed pedagogically sound to implement Individualization of Instruction and analyze the gain achieved by students when compared with the Lecture Method approach commonly and currently in use. Furthermore, educators must no longer be satisfied to implement any new concept in its entirety without experimentation and assessment through research.

There were several reasons for conceptualizing that Individualized Instruction would result in greater academic achievement. Inherent in individualized instruction is student responsibility — a very vital ingredient for success in this teaching approach.

This method assists students in learning how to solve problems independently and to respond to situations which they encounter as students, workers, family leaders, community members or private citizens. Also, in the teaching-learning situation, appropriate guidance is given to each individual as the need arises; students are not bored performing tasks that they already know how to manipulate nor do they have to proceed to other assignments before grasping basic concepts. Especially in mathematics, this latter phenomenon often causes failure since the content of most mathematics courses is so structured that understanding of future material is predicated on previously learned knowledge. Another benefit derived from individualized instruction is the omission of the fear of failure syndrome, and the almost certain hope of achieving a grade of A. Bloom (1968) and Connolly and Sepe (1973) contend that with proper planning, effective methods of "teaching-learning", and a sincere desire to meet students needs, 95 per cent of the students will want to and can achieve a grade of A, given sufficient time.

This mastery of subject content can be accomplished as a result of the methodology incurred in individualized instruction. Not only are there pretests and posttests, but sample tests are included for each module and unit; students are also afforded the opportunity of taking a parallel form of any test on which mastery was not attained. These factors tend to (1) result in better grades, (2) build student confidence, (3) enhance morale, and (4) eliminate bitter anxieties, fears, and negative attitudes toward the subject matter.

Operational Definitions of Variables

Independent Variable

The methods of instruction utilized in the study were Individualized Instruction versus Traditional Lecture. Individualized instruction for this research was defined as the study of (mathematical) content via behavioral objectives either individually or in small groups. Students were allowed to request slides, films or filmstrips to be used at their disposal. The instructor served as a facilitator. Traditional Lecture was defined as verbal representation of (mathematical) content interspersed with questions and answers between instructor and students and the explanation of concepts on board with the help of audio-visual aids. The instructor lectured to the group as a whole.

Moderator Variable

The Level of Courses was the moderator variable. There were four groups in the study comprising of two levels of instruction; two classes of Intermediate Algebra and two of Fundamentals of Algebra I.

Dependent Variable

The dependent variables were (1) Achievement on Mathematical Objectives, (2) Attitudinal Change, (3) Transfer of Concepts to a Problem-solving Situation. Attitudes in this Study applied to students' responses toward or against mathematics as a result of their mental and neural state of readiness, organized through experience. Students' attitudes were categorized as positive or negative according to a weighted-score index obtained from a Mathematics Attitude Scale (Aiken, 1963). A score of fifty and above was considered positive, and a score below fifty was negative. Achievement was defined as the degree of change from pretest to posttest as exhibited by each student on the Achievement Test (Boyle, 1972). (Course grades were determined as a result of tests and quizzes administered during the semester but were not part of the statistical measurement of the study).

Transfer of Concepts to a problem-solving situation was the ability of students to retrieve knowledge and the ability to perform on an activity for which there had not been any explicit instructions given but which made use of basic principles of the course and allowed students to take initiative to find a solution. The term "greater ability" implied that students exhibited their capabilities of meaningful organization of material toward the solution of mathematical problems; the term "problem-solving situation" referred to an assigned task that students performed in a specified amount of time and which was not directly related to instruction.

Intervening Variable

Instructor's personality was a factor that could have influenced attitude and therefore had to be given some consideration since each of the two Intermediate Algebra groups had a different instructor. This was not the case with the

Fundamentals of Algebra I groups which had the same instructor.

Control Variable

These were behavioral objectives, content to be covered, the maximum amount of time to learn material before posttest was administered, and teacher effect.

Behavioral Objective was defined by Banathy (1968) adapted from Mager (1962) as what the learner is expected to do; how well the behavior is expected to be performed; and under what circumstances the learner is expected to perform.

The Content was the amount of material to be covered.

The time was one semester of 45 hours, Fall semester, 1974.

Teacher effect was the indirect result of using two instructors. Of the two instructors involved in the study, one of them taught two courses in Fundamentals of Algebra I: one of the courses was by the individualized method, and the other was by the traditional method. The Intermediate Algebra course on the other hand, was taught by two different instructors at two different colleges.

Operational Restatement of the Hypotheses

It was hypothesized that in both Intermediate Algebra and Fundamentals of Algebra I (a) students who were allowed to work individually at their own rate, discuss their work with their peers in a classroom setting, received individual assistance from their instructor and took tests and quizzes when they demonstrated understanding of content, will show greater achievement than those students whose pace was set by the instructor, and who took tests and quizzes whether or not they understood the material; (b) students exposed to this first option would tend to change their attitudes toward mathematics in a positive direction to a greater degree than those under the influence of the Lecture Method of Instruction -- those who already exhibited positive attitudes will indicate an even higher positive score on the math attitude scale; finally (c) students who studied by the Individualized Method will perform better when concepts had to be retrieved to solve a problem. That is, they will have more correct problem solutions, than those who studied by the Traditional Lecture.

Significance of the Study

Individualized Instruction is one of the most recent innovative ideas in educational reform throughout the country. It demands a new conception of the curriculum with much emphasis on the individual student's needs. There is a change of emphasis from teaching to learning; yet it is not sufficient to adapt new techniques without researching the applicability to a particular institution. It therefore behooves educators who are affiliated with community colleges to cease merely discussing the philosophy of the system and engage in more systematic research on the success of teaching methodologies, attrition, the community college as a host for training community college teachers, and the effects of community college programs on the population it serves.

Educators must also have roles delineated for them which call for programs of study and methods of instruction to fit the needs and capabilities of individual students. There is no single theory of learning; even Individualized Instruction is variegated, that is, several approaches are widely used. However, there is the need to individualize instruction in the broadest sense of the term. It has been well documented (Sheppard and McDermot, 1970; Keller, 1968, 1971; Cooper and Greiner, 1971) that this method of instruction favors critical thinking, creativity, self-direction and the development of one's self-concept. More student exposure to several styles of instruction and different modes of learning as in this and other studies may result in a climate favorable to growth of individuals in the institutions involved. Chapman (1966, p. 34) said:

> In order to ascertain the caliber of teaching at the Junior College level, a method of teaching and instructional evaluation must be the first order of business. It can be formal or informal, structured or unstructured. However, it must be designed to improve teaching in bold and revolutionary ways.

He went on to say that there should be a concerted and coordinated effort on the part of everyone to make the Junior College a teaching college and everyone must become involved.

More specifically, it is hoped that this study will begin to substantiate and shed light on the reasons for low mathematics enrollment at South Central Community College (Connecticut) and suggests, from the outcomes, other techniques which could be utilized to increase positive, and diminish negative attitudes toward mathematics. One of these techniques which might prove beneficial to the student is for the college to offer more than one method of instruction in order to provide a choice to the instructors and students. This is highly significant to this study since the researcher advocates humanism in mathematics and feels that student preferences for modes of instruction should be honored.

Several studies indicate that students have preferences as to the type of methodology by which they are taught. Tuckman and Orefice (1973) found that students of "abstract personality structures" preferred self-study via tapes and booklets over (1) programmed instruction within a classroom setting, (2) programmed instruction and lectures in a classroom and (3) traditional lecture discussion instruction (lecture coupled with programmed text was least preferred while programmed text and conventional approach was intermediate); on the other hand, students of "concrete personality structure" liked the programmed text-by-itself procedure as compared with the other methods; self-study was liked most, followed by the lecture-programmed text approach, and the conventional approach respectively.

It is therefore hoped that this study can (1) give cause for changes in the registration procedure at South Central Community College, and (2) result in fewer student failures and greater successful achievements in mathematics because of the new approaches that would be made available in the teaching-learning process.

CHAPTER II

METHOD

Subjects

The population from which the sample of this study was drawn, consisted of a diversity of students from two urban community colleges in the State of Connecticut. The diversity encompassed ethnicity, educational preparedness, socio-economic life-styles, age and interests. The two colleges are approximately 35 miles apart and share many similarities. In general, the sample was a typical urban community college group of students who commuted to classes from the city or the suburbs in close proximity, and most of whom worked and/or were responsible for families.

Of the 101 students comprising the sample, 62 were enrolled in Fundamentals of Algebra I and 39 were enrolled in Intermediate Algebra. Four intact groups were involved in the study — two Fundamentals of Algebra I and two Intermediate Algebra. Two of these groups received treatment (E_1, E_2) and two received no treatment (C_1, C_2). Enrollments were distributed as follows:

$E_1 = 28$	$C_1 = 34$
$E_2 = 15$	$C_2 = 24$
43	58

All groups were registered for the Fall semester of 1974 and consisted of both sexes with an age range extending from immediately out of high school to retirees.

Ss enrolled in Intermediate Algebra had completed Fundamentals of Algebra either at their high school or at the college level; the

Fundamentals of Algebra I Ss had a basic knowledge of Arithmetic. Two instructors were involved: one taught three classes -- two Fundamentals of Algebra I (a treatment group and a no-treatment group) and an Intermediate Algebra (treatment group), while the other taught one class in Intermediate Algebra (no-treatment).

Tasks

All Ss met two and one-half hours per week for fifteen weeks. During the first week of the semester a pretest consisting of (1) an achievement test and (2) an attitudinal inventory was administered and at the end of semester, a posttest was given; in addition, a problem-solving task was assigned during the fourteenth week of the semester to be completed within one week.

Intermediate Algebra Ss received during the first week of classes hand-out material consisting of (1) course syllabus, type of instruction and grading procedures and (2) behavioral objectives encompassing sets and polynomials, equations, order relations and Cartesian plane, relations and functions, and linear and quadratic functions. The treatment group also received a flow-chart illustrating how they were to proceed with their study and information explaining individualized instruction.

Fundamentals of Algebra I Ss were also the recipients of these hand-outs; the only difference was that their behavioral objectives covered operations with algebraic expressions, special products and factoring, operations with functions, and first degree equations in one unknown.

Independent Variable

Individualized Instruction Ss enrolled in Fundamentals of Algebra I received behavioral objectives (Appendix A) covering four units, each of which had four module and one unit tests. The tests reflected the behavioral objectives; each test consisted of parallel A and B forms. Module tests were teacher-made, but unit tests were those provided by the author of the Teacher's Manual. Course grades were determined by performance on these tests. Teacher-made tests were previously tested on another group of students which allowed for ineffective questions to be eliminated; however, all Ss received the same test therefore the validity was not threatened. Ss utilized a textbook and a workbook which were recommended by the instructor, and in addition, several reference books were placed in the library for their convenience. Success on sample tests prepared by the instructor determined the preparedness of the Ss to request Form A of the tests and each module or unit was mastered before proceeding to the next. Ss studying Intermediate Algebra via Individualized Instruction also received behavioral objectives (Appendix B) for the course, utilized a textbook and a programmed Study Guide, and made necessary use of the library reference resources. The test was planned to cover material and each test was available in parallel Forms A and B.

Lecture Ss received verbal presentations each time the class met, and were subjected to heuristic techniques. Content was the same as for those receiving the treatment and quizzes and chapter tests (referred to as module and unit tests in the treatment groups) were administered. These tests and quizzes were administered by the instructor at his discretion when he thought that the class was prepared.

Both the treatment and no-treatment groups had access to slides, films, film-strips and tapes.

Instruments

The dependent variables were Ss' achievement on (1) the Algebra Achievement Posttest, (2) the Attitude Inventory Posttest, and (3) the problem-solving task. All Ss were given the same Achievement Test, Attitude Inventory and problem-solving task. Achievement was measured by the number of problems each student correctly completed on the Achievement Test (Appendix C) after performing for one-half hour. Reliability data for the achievement test include a test-retest correlation range from 0.75 to 0.85 on total scores and ratio scores obtained toward the end of the school year. Data obtained during the early weeks of the school year for Algebra students showed a 0.55 test-retest correlation. Boyle and Littrell (1972) gave supportive evidence for the mitigation of familiarity of students with the test items because of the branched-program format. Validity data for the achievement test are illustrated in Appendix D. Content validity and concurrent validity were established by a pilot study and subsequent tests administered at Columbus Technical Institute. Scores were obtained from six different levels of mathematics. As illustrated in Appendix D, the Algebra test has a mean ratio score of 0.49 for students completing one year of Algebra.

Positive and negative attitude attainment was measured by a five-point Math Attitude Scale whose test reliability was 0.94

(Aiken, 1961, p. 20). The Attitude Scale (Appendix E) consists of twenty items, ten connoting positive attitudes with responses scored from five to one -- five being most positive for positive items and five being most negative for negative ones.

Transfer of concepts to a problem-solving situation was measured by the number of correct solutions achieved by each student from the assigned problem-solving task (Appendix F). The total number of points attainable was 120 and the minimum was zero.

Design

The design of the study was of the pretest-posttest factorial (two-factor) type, which is illustrated in Figure 1 with achievement and attitudes as dependent variables.

TREATMENT

	Individual Instruction	Traditional Lecture
Fundamentals of Algebra		
Intermediate Algebra		

Figure 1

Two-by-two Factorial Design

The two independent variables were (1) Teaching Methodology with two levels, Individualized Instruction and Traditional Lecture; and (2) the nature of Course with two levels, Fundamentals of Algebra I and Intermediate Algebra (which has been labeled as the moderator variable).

This design was employed in testing for significance of posttest scores on all three dependent variables: achievement, attitudes, and problem-solving skill. On all three measures, pretest score served as the control variable (for problem-solving it was pretest achievement).

Statistical Analysis

An analysis of covariance was conducted for the posttest scores using the pretest scores as a covariate for the attitude and achievement; and an analysis of covariance was conducted from the problem-solving (posttest only) scores, using the posttest achievement scores as a covariate.

With an unequal number of observations in each cell, the technique of unweighted means analysis was utilized in which the mean scores of the original cell entries were added to equalize the number of scores in each cell.

Procedures

The study commenced with all groups receiving hand-out material and taking the Achievement Test and Attitude Inventory; the same test and inventory served as posttest at the end of the semester. All Ss were told that the test results would be utilized by the instructor for diagnostic purposes in trying to meet their needs. They were also informed that no grade would be assigned for their performance on the test. All Ss used textbooks and/or workbooks as directed by instructor, followed the prescribed procedure as outlined in the hand-outs, and pursued the tasks as enumerated by the objectives of the course.

The Fundamentals of Algebra I treatment group, after studying designated areas of the textbook, took sample module tests and having achieved mastery on the sample proceeded to request Form A of the test. If the score from Form A was satisfactory to both instructor and Ss, Ss advanced to the subsequent module or unit. In cases where the score did not reflect mastery (90 per cent or better) of the concepts tested, Ss were counseled individually, assigned additional prescribed tasks to remedy indicated deficiency, and then were allowed to take Form B of the test. If mastery was still not attained, further counseling occurred and other forms of instructional media were utilized to assist Ss in achieving mastery of objectives. Ss repeated the test items on which they previously demonstrated poor performance. At all times Ss worked at their own pace, consulted the instructor (if necessary) who acted as a facilitator, had their tests corrected immediately after completion and received feedback on an individualized basis.

In the case of the Intermediate Algebra treatment group, procedures were slightly different. Although problems were delineated to constitute module testing, these were checked only by the student for proficiency. When Ss thought that they were sufficiently prepared to take the unit test, they requested and were given Form A. Mastery on Form A meant Ss proceeded with the next unit; if not, the process as enumerated for the Fundamentals of Algebra I Ss followed.

The no-treatment Ss received traditional lecture, homework assignments, designated times for testing, with everyone moving at the same pace which was determined by the instructor.

All Ss were encouraged to complete objectives in one semester; however, provisions were made and afforded the treatment groups to complete the course prior to the end of the semester and up to six weeks after. Late completion of course did not jeopardize the study per se since Ss were given the posttest whether or not they completed the course at that time. The problem-solving activity designed to be completed within one week, just before the end of semester, afforded Ss the opportunity to use a variety of means to obtain solutions. Solutions, however, had to be clearly and logically explained. The task entailed application of basic skills learned in Algebra and Ss' own abilities to draw on concepts learned earlier or during the semester.

To control for Hawthorne effect, all Ss were given a chart whereby they could record their progress and plot a cumulative graph.

Experimental procedures and pertinent literature were afforded both Department Chairmen and the second instructor (the investigator was the other instructor) in advance. Publishers of the Achievement Test were also contacted and agreement was made for scoring both the Achievement Test and the Attitude Inventory.

CHAPTER III

RESULTS

The posttest scores on achievement and attitudes were analyzed by analysis of covariance using pretest scores as a covariate. The acceptance level of significance was set at the .01 level. Problem-solving scores were also analyzed by analysis of covariance, however, the achievement posttest scores were utilized as a covariate; the level of significance was set at .05.

Hypothesis 1.

> Students who study Intermediate Algebra by the Individualized Method of Instruction will experience greater achievement than those taught by the Traditional Lecture Method.

Hypothesis 3.

> Students who study Fundamentals of Algebra I by the Individualized Method of Instruction will experience greater achievement than those taught by the Traditional Lecture Method.

In Table 1 is reported the findings of the analysis of covariance of the achievement posttest scores using the pretest scores as a covariate. The F-ratio ($F = .07$; $df = 1/67$; $p > .01$) indicated that there was no significant difference across treatments, but the F-ratio of 29.37 showed that there was a significant difference between courses ($F = 29.37$; $df = 1/67$; $p < .01$). The AB interaction showed a F-value of .62 ($F = .62$; $df = 1/67$; $p > .01$) which did not attain significant level.

TABLE 1

Analysis of Covariance of the Posttest Achievement Scores Using the Pretest Scores as a Covariate

SV.	SS_x	SP	SS_y	D.F.	SSI_y	MSI_y	F
A	3600.00	2250.00	1410.00	1	2.09	2.09	0.07
B	3860.00	5820.00	8760.00	1	911.00	911.50	29.37*
AB	2050.00	1080.00	570.00	1	19.30	19.34	0.62
Error	1940.00	1290.00	2940.00	67	2080.00	31.03	
Total	11500.00	10400.00	13700.00	70			

$F_{.99}(1/67) = 7.04$

* $p < .01$

A : treatment

B : course

In Table 2 can be found the achievement means for each group.

TABLE 2

Mean Pretest and Posttest Achievement Scores

by the Four Groups

Means

	Fund. of Alg. I (B_1)		Interm. Alg. (B_2)	
	Pre	Post	Pre	Post
Indiv. Instruc. (A_1)	7.3	7.7	11.3	24.1
Trad. Lecture (A_2)	10.8,	10.9	36.1	38.6

Adjusted Means

	Fund. of Alg. I (B_1)	Interm. Alg. (B_2)	
Indiv. Instruc. (A_1)	13.66	27.48	20.57
Trad. Lecture (A_2)	14.59	25.56	20.07
	14.12	26.52	

$\overline{Y}\ A_1 = 20.57$

$\overline{Y}\ A_2 = 19.23$

$b_w = 0.73$ Regression Weight (within)

Fundamentals of Algebra I Ss who received Individualized Instruction had a pretest mean of 7.3 and a posttest mean of 7.7; the Traditional Lecture group had a pretest mean of 10.8 and a posttest mean of 10.9. The Intermediate Algebra Ss who received the Individualized Instruction had a mean score of 11.3 on the pretest and a mean score of 24.1 on the posttest; the Traditional Lecture group had pretest and posttest means of 36.1 and 38.6, respectively. The adjusted means which are also reported in Table 2 shows that the adjusted cell mean for Fundamentals of Algebra I Ss who received Individualized Instruction was 13.66 and for those who received Traditional Lecture was 14.59. The adjusted cell means of Intermediate Algebra Ss for Individualized Instruction and Traditional Lecture were 27.48 and 25.56, respectively. The Individualized Instruction group had a marginal mean of 20.57 and the Traditional Lecture group had a marginal mean of 20.07. Fundamentals of Algebra I had a marginal mean of 14.12 and Intermediate Algebra had a marginal mean of 26.52.

The results reported allows hypotheses 1 and 3 to be rejected. Figure 2 illustrates the results graphically.

Hypothesis 2.

> Students who study Intermediate Algebra by the Individualized Method of Instruction will indicate a more positive attitude toward mathematics than those taught by the Traditional Lecture Method.

Hypothesis 4.

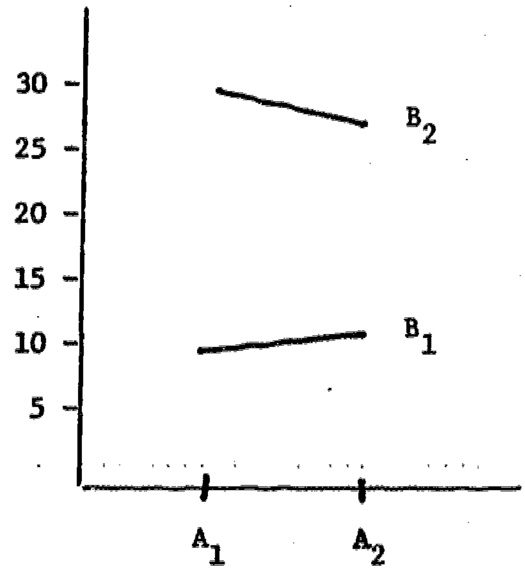
> Students who study Fundamentals of Algebra I by the Individualized Method of Instruction will indicate a more positive attitude toward mathematics than those taught by the Traditional Lecture Method.

A_1 : Individualized Instruction

A_2 : Traditional Lecture

B_1 : Fundamentals of Algebra I

B_2 : Intermediate Algebra



Treatment

Figure 2

Adjusted Mean Achievement Scores by Treatments (A_1 and A_2) and Courses (B_1 and B_2).

In Table 3 can be found the attitude posttest scores when the analysis of covariance was applied using the pretest scores as a covariate. There is no significant A effect, the F-ratio value being .41. There was, however, a significant B effect ($F = 15.83$; $df = 1/67$; $p < .01$). No significant AB interaction was indicated; the F-value was 3.76.

Means and adjusted means of the attitude scores are reported in Table 4. The means of the Fundamentals of Algebra I Ss who received the treatment (Individualized Instruction) were 57.6 on the pretest and 67.3 on the posttest; the no-treatment (Traditional Lecture) Ss had a 66.2 on the pretest and 68.1 on the posttest. The Intermediate Algebra Ss who received the treatment had a pretest mean of 68.1 and a posttest mean of 62.1, while the no-treatment Ss had a pretest mean of 77.3 and posttest mean of 71.1. The adjusted cell means of Fundamentals of Algebra I Ss were 75.04 for Individualized Instruction and 69.02 for Traditional Lecture. For the Intermediate Algebra Ss, they were 61.26 and 63.91 for Individualized Instruction and Traditional Lecture, respectively. The marginal mean for Individualized Instruction was 68.15 and for Traditional Lecture, it was 66.47. For the Fundamentals of Algebra I course, the marginal mean was 72.03 and for the Intermediate Algebra, it was 62.59. This result allows hypotheses 2 and 4 to be rejected.

A graphical representation of these results appears in Figure 3.

Hypothesis 5.

> Students taught either Intermediate Algebra or Fundamentals of Algebra I by the Individualized Method of Instruction will show greater ability to transfer concepts to a problem-solving situation than those taught by the Traditional Lecture Method.

TABLE 3

Analysis of Covariance of the Posttest Attitude Scores Using the Pretest Scores as a Covariate

S.V.	SS_x	SSP	SS_y	D.F.	SSI_y	MSI_y	F
A	1350.00	765.00	435.00	1	32.40	32.44	0.41
B	2210.00	-215.00	21.00	1	1240.00	1238.00	15.38*
AB	-0.56	3.75	300.00	1	294.00	294.30	3.76
Error	9500.00	6970.00	10400.00	67	5240.00	78.19	
Total	13100.00	7530.00	11100.00	70			

$F_{.99}$ (1/67) = 7.04

* $p < .01$

A : Treatment

B : Course

TABLE 4

Mean Pretest and Posttest Attitude

Scores by Four Groups

Means

	Fund. of Alg. I (B_1) Pre	Fund. of Alg. I (B_1) Post	Interm. Alg. (B_2) Pre	Interm. Alg. (B_2) Post
Indiv. Instruc. (A_1)	57.6	67.3	68.6	62.1
Trad. Lecture (A_2)	66.2	68.1	77.3	71.1

Adjusted Means

	Fund. of Alg. I (B_1)	Interm. Alg. (B_2)	
Indiv. Instruc. (A_1)	75.04	61.26	68.15
Trad. Lecture (A_2)	69.02	63.91	66.47
	72.03	62.59	

A_1 = 67.86

A_2 = 66.47

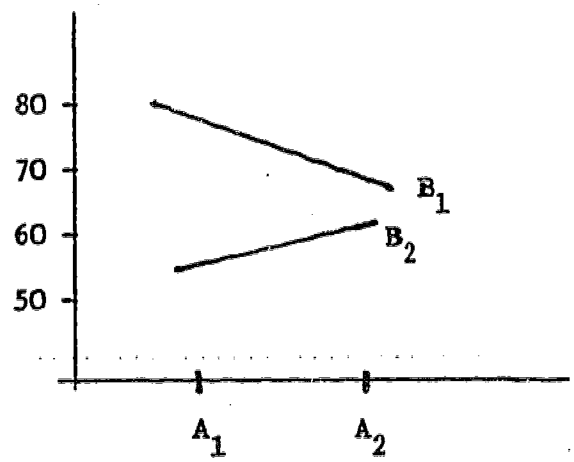
b_w = 0.73 Regression Weight (within)

A_1 : Individualized Instruction

A_2 : Traditional Lecture

B_1 : Fundamentals of Algebra I

B_2 : Intermediate Algebra



Treatment

Figure 3

Adjusted Mean Attitude Scores by Treatments (A_1 and A_2) and Courses (B_1 and B_2).

Posttest achievement scores, used as a covariate for the problem-solving scores are reported in Table 5. The results indicated there was a significant A effect (type of instruction) of 6.50 which leads to the acceptance of the hypothesis ($F = 4.00$; $df = 1/63$; $p < .05$). There was a B effect (Course) of 1.19 ($F = 1.9$; $df = 1/63$; $p < .05$) and an AB effect of .30 ($F = .30$; $df = 1/63$; $p < .05$) neither of which was significant.

Table 6 reflects the means of the achievement test and the problem-solving scores; it also indicates the adjusted means of these scores. The problem-solving means of the Fundamentals of Algebra I Ss were 82.00 for the Individualized Instruction group and 63.53 for the Traditional Lecture. Intermediate Algebra Ss had means of 88.59 and 95.88 for treatment and no-treatment, respectively. The adjusted cell means were: Fundamentals of Algebra I Ss instructed by Individualized Instruction, 86.40 and Ss instructed by Traditional Lecture 73.28; Intermediate Algebra Ss instructed by Individualized Instruction, 89.25 and Ss instructed by Traditional Lecture, 81.08. Individualized Instruction reported an 87.83 marginal mean and Traditional Lecture reported a 77.18 marginal mean. Fundamentals of Algebra I reported a marginal mean of 79.84 and Intermediate Algebra reported one of 85.16.

In Figure 4 is presented a graphical representation of the adjusted means.

TABLE 5

Analysis of Covariance of Problem-solving Scores Using the Posttest Achievement Scores as a Covariate

S.V.	SS_x	SP	SS_y	D.F.	SS_y	MS'_y	F
A	369.00	-0.44	531.00	1	1830.00	1830.00	6.50*
B	2880.00	4310.00	6450.00	1	336.00	335.80	1.19
AB	1560.00	2100.00	2820.00	1	83.00	83.03	0.30
Error	6690.00	7270.00	25000.00	63	17700.00	281.40	
Total	11500.00	13200.00	35400.00	66			

$F_{.95}\ (1/63) = 4.00$

$^{*}\ p < .05$

A : Treatment

B : Course

TABLE 6

Mean Posttest Achievement and Posttest Problem-solving by Four Groups

Means

	Achiev. Post	Prob.-solv.	Achiev. Post	Prob.-solv.
Indiv. Instruc. (A_1)	15.80	82.00	19.24	88.59
Trad. Lecture (A_2)	10.88	63.53	33.47	95.88

Adjusted Means

	Fund. of Alg. I (B_1)	Intermediate Algebra (B_2)	
Indiv. Instruc. (A_1)	86.40	89.25	87.83
Trad. Lecture (A_2)	73.28	81.08	77.18
	79.84	85.16	

$A_1 = 88.64$ $A_2 = 76.37$ $b_w = 1.087$ Regression Weight (within)

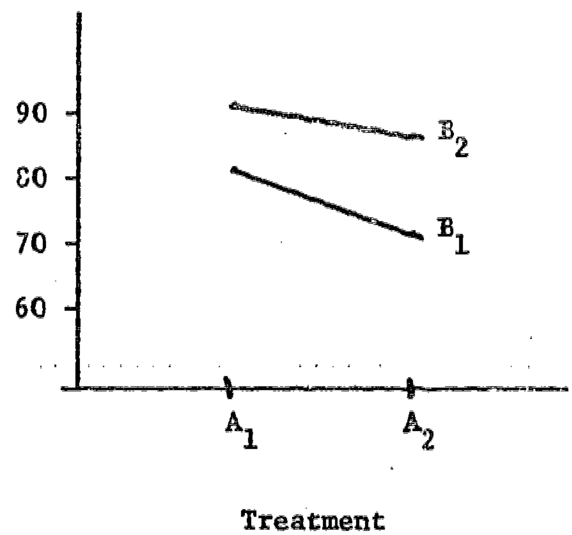


Figure 4

Adjusted Mean Problem-solving Scores by

Treatments (A_1 and A_2) and Courses (B_1 and B_2).

CHAPTER IV

DISCUSSION

Findings

A statistical analysis of the data revealed the following:

There was no significant main effect of A (type of instruction) but there was a significant main effect of B (course) indicating that Ss who were enrolled in Intermediate Algebra performed better than those enrolled in Fundamentals of Algebra I, regardless of treatment. Since the degree of learning which took place from one course to the other was not a major concern of this study, and since Intermediate Algebra is a more advanced course than Fundamentals of Algebra I, the superior performance demonstrated by Intermediate Algebra Ss was not unusual. Moreover, the achievement test is sensitive to the materials taught and learned in the mathematics sequence as can be observed in the ratio scores and total scores when respondents who are tested have different levels of experience (See Appendix D).

Selection of Ss was not done on a randomized basis. Observation of the means revealed that in both courses, Ss who received individualized instruction had higher achievement gains, but Intermediate Algebra Ss who received traditional lecture instruction exhibited pretest scores three times as large as the pretest scores of their counterparts. The achievement scores were therefore subjected to an ANCOVA which regulated the unequal entry of the groups and adjusted the means. When the degree of initial learning was then equated the difference in performance was negligible which suggested that the treatment evoked comparatively the same performance from both courses. There was no significant interaction between A and B which implied that the relationship between the two kinds of treatment was not significantly different from one course to the other. On the basis of these results hypotheses 1 and 3 were rejected.

Attitudes of Ss who studied Fundamentals of Algebra I showed positive changes from pretest to posttest under both treatments, with the Individualized Instruction group showing a larger mean. The Intermediate Algebra Ss, however, showed a loss from pretest to posttest under both types of treatment; moreover, the loss was comparable in both cases. The effects of the adjusted means on these scores resulted in the Individualized Instruction Ss of Fundamentals of Algebra I having a higher mean than the Traditional Lecture Ss taking this course. In Intermediate Algebra the results were reversed; the Traditional Lecture Ss who took Intermediate Algebra displayed a higher mean than those Ss who took the course by the Individualized Method. Thus, an AB effect resulted, which approached significance at the level of .05.

There was a significant main effect of B which indicated that the Ss in Fundamentals of Algebra I had made greater positive changes than those in Intermediate Algebra. The reason for this differential finding may have been a function of the level of courses. Intermediate Algebra is a more advanced course than Fundamentals of Algebra I, which would imply that Ss of Intermediate Algebra have had more experience both with mathematics and possibly traditional learning styles. As a result, Ss who took individualized instruction may not have been as readily willing to change their learning styles, and the Ss taking the Traditional Lecture approach have been less flexible to participate in completing the instruments administered. It can be concluded that the treatment worked in one course -- Fundamentals of

Algebra I, but not in the other -- Intermediate Algebra. There was no significant main effect of A; the notable positive changes as observed from the treatment were in favor of Individualized Instruction but these differences did not reach the significant level.

Problem-solving means indicated the need to control for selection bias, since it was evident from pretest achievement scores that the groups were not homogeneously matched; one group in particular, the Intermediate Algebra control, showed pretest scores three times as large as their counterparts under investigation. When the adjusted means were computed, they revealed a significant A effect in favor of Individualized Instruction. There is some evidence from the B effect that one course achieved more than the other regardless of the treatment, but again, this can be attributed to the level of courses and the differences were not significant. There was no significant interaction between A and B, but it was noticeable from information contained in the graph of Figure 4 and the adjusted means of Table 6 that the treatment resulted in higher means across courses; Intermediate Algebra means were also higher than Fundamentals of Algebra I for both types of instruction. The latter result can be attributed to Ss' mathematical maturity.

Interpretation

The results of the study suggested that when students were tested for (1) achievement based on behavioral objectives content and (2) ability to transfer what has been learned to a situation in which no direct teaching was given, several events were noticeable.

Ss performance on achievement testing was comparable within the purview of each course and the more advanced course had greater means than the less advanced course. The treatment was also equally effective in both courses judging from the small F-value (F = .62) exhibited. On the basis of A effect obtained from achievement scores, it also suggested that there was no difference in performance because of the treatment.

In measuring achievement on the problem-solving, Ss' abilities to utilize initiative, mathematical skills, and skills of independence gained through individualized instruction were very pronounced. The transfer of knowledge was demonstrated and the learning experience which occurred favored the individualized approach when the degree of original learning was equated.

This overall achievement result can be interpreted that individualized instruction produced equal outcomes from classroom learning experiences but when higher cognitive demands were made, Ss who had experienced Individualized Instruction excelled to a greater degree than those who received instruction from the Traditional approach.

Attitudinal changes toward mathematics were also the subject of this study. There were positive as well as negative attitudinal changes. In one course -- Fundamentals of Algebra I, the results were as hypothesized. Ss whose attitudes were negative, experienced positive changes and those whose attitudes were already positive demonstrated an even higher positive attitude score. There were but two exceptions; one instance, where the S's negative attitude became more negative, and another event, where the S's attitude changed in a negative direction but remained positive. The Intermediate Algebra results did not follow this pattern. Ss' attitude toward mathematics declined from pretest to posttest in both courses taught by the two different instructors and in both colleges. The decrease, however, was proportional; this implied that the intervening variable, teacher effect, did not adversely affect the outcome of the study. Reasons for this differential finding suggest Ss' mathematical maturity and/or the nature of the courses. Evidently, the more academically sophisticated the Ss, the more reluctant they were to participate in completing questionnaires. Also, the more accustomed Ss were to a particular teaching style, the more resistant they were to a new teaching methodology.

Declining attitude scores are not unfamiliar, as studies referenced in the review of the literature have shown. Also referenced was the students' unwillingness to accept responsibility for learning, labelled "learner control." In this study the more advanced course under the traditional teaching methodology indicated a 2.65 higher mean which could be attributed to the preference of "teacher control" -- the characteristic which is in direct contrast to "learner control."

In general, performance on achievement and attitudinal outcomes of this study support earlier reports of the equable results that may have occurred from two different teaching techniques, teacher-oriented, versus learner-oriented. This study has also replicated previous findings which support the superiority of Individualized Instruction over Traditional Lecture, when higher order cognitive skills were required as in a problem-solving situation. The significant difference which was exhibited in the transfer of concepts in this study has significant importance since learning outcomes of this type are usually more complex than those for which a one-to-one relationship exists between behavioral objectives and behavioral responses subsequently measured on an examination. Other features which addressed themselves to this study were randomization and attrition, enrollment, and the achievement instrument.

Randomization, the ideal method of selecting students for study, was impossible in this investigation since intact groups had to be used. The college's policy could not accommodate this method for establishing classes. The sample size was limited to four classes totalling 101 students. This number dwindled further when some students changed their schedules after the first or second week of the semester, withdrew from class or school, and/or were absent for at least one of the tests administered. The sample size of four classes also limited the participating instructors to two (2).

Small enrollments in mathematics at South Central Community College could not provide four or more classes for which there would be a treatment group and a no-treatment group enrolled in the same level of mathematics; many classes had only one section. As a result three groups had to be chosen from South Central and one group had to be chosen from Greater Hartford Community College. Neither college had enough students registered for two Intermediate Algebra classes. Teacher-effect was therefore difficult to be controlled.

Branched-program achievement testing is a comparatively new idea being encouraged for test-retest situations. Students, however, despite the explanation of how to manipulate this technique in answering questions, tried to treat the instrument in the style to which they had been accustomed, namely, working problems in consecutive order. A branched-program instrument requires the selection of successive problems depending on the students' previous answer. The instrument is also designed for computer scoring; lack of students' adherence to directions given, contributed to loss of Ns for the sample.

Implications

With the Carnegie Commission's recommendation of the open-door policy for community colleges, several educators have researched and practiced various teaching methodologies to accommodate those students who were less capable of mastery of college material. Others have viewed the quiet influx of large numbers of students with poor academic records as a threat to the image of the establishment of higher education. The community college can be viewed as the institution of the future which will be functional in (1) preparing a l[illegible] percentage of students for four-year colleges, (2) preparing a massive number of the community for career occupations, (3) affording educational enrichment to the masses with limited financial means and (4) accommodating the late-bloomer who has experienced educational deficiences, but who, given exposure to non-traditional teaching styles which allow for individual differences, will acquire some degree of success.

Success often promotes a positive self-image and a positve self-image often influences expectation, attitude, and future performance. Among some of the innovations in education that have provided this level of success is individualized instruction, which is not limited to the college-age group, nor to the less-capable student. It proclaims that egalitarianism and individual differences, can proceed through college in varied ways and rates, and can exit from college with different competencies to satisfy their individual needs; it also recognizes that teachers too have distinctive cognitive styles that affect their teaching; and it supports the theory of mastery learning whereby 95 per cent of students can learn a subject to a high level of mastery with time as the varying factor and not achievement.

This study was aimed at investigating a form of the Keller Plan and supported the contention that students who studied by the Individualized Method of Instruction would tend to take the initiative in setting their individual goals, an accomplishment which can lead them into life-long self-directive learning; the study also supported other theories that students who studied by this method of instruction performed as well as or better than those studied by the traditional lecture style of teaching, and that individualized instruction favors creativity, critical thinking, development of self-concept and the ability to transfer concepts to problem-solving situations.

One of the students in this study, with reference to the problem-solving task wrote: "I thought that this test really required a sense of how-to-do mathematics. This took me three days to finish but after finishing, I felt a sense of great satisfaction." As educators, one of the implications of this study is that learning experiences should constitute educational exposure to problem-solving approaches; moreover, students should acquire the skill to successfully apply the techniques when confronted with transfer situations.

Individualization of Instruction is but one style of innovation in education; the search for alternatives to meet students' individual needs continues. If by developing students' initiative and helping them experience success — a sense of accomplishment — they can internalize personal achievement and development as goals, then their motivation for learning would not terminate with a degree, but becomes life-long.

Suggestions for Further Research

The results of this study has implications for further research and refinement. Among the salient features:

1. Replication with a larger sample.
2. A practice session with the branched-program achievement test before administering the instrument.
3. Experimentation with randomized groups especially to measure transfer of concepts to situations outside the realm of content directly taught.
4. Further comprehensive and systematic research on other affective variables in academic achievement.
5. Institutional implementation of more than one teaching methodology, and evaluating the outcomes through on-going research.

Such research may have beneficial significance in guidance and placement of students, identification of high and low achievers through diagnostic testing, helping to discover effective means to diminish 'fear' of mathematics and humanizing mathematics without sacrificing excellence.

Implementation

The ultimate goal of educational research should be to analyze present, educational techniques and to suggest improvements for increased maximization of learning. Attitudes can indirectly affect learning since individuals' self-concepts often dictate the extent to which they might master the control of their destinies. Individualization of instruction has been cited in several studies in this investigation as a source whereby students were afforded the opportunity to gain self-esteem. South Central Community College can also be benefited by such innovative curricula changes. Institutional plans for additional individualized projects have been organized by the Head of Interdisciplinary Studies and the writer (Appendix G). A three-day staff workshop, scheduled for May 27 through May 29 and a summer institute, scheduled for June 2 through June 20, were devised.

The department of Interdisciplinary Studies has been recently (six months) conceived at South Central Community College and the summer institute was the first in the college's history. The theme of the institute was Innovations in Education and the writer was one of the guest speakers at the workshop. It was the writer's concept that the program should address itself to individual student's needs. The design of the learning experiences during the three weeks was the responsibility of the writer who organized a program for learning in accordance with students' needs. Appendix H illustrates the procedures for individualization of instruction during the institute and cites some of the observations during the initial stages. There were 193 applicants to the institute, of which 123 attended on the first day; 75 of those who attended were enrolled in the mathematics program. Statistical results were not yet available but a subjective evaluation indicated that students were highly enthusiastic about the program and demonstrated this enthusiasm by their zealous participation.

The writer and the Head of Interdisciplinary Studies are in agreement that individualized instruction can meet some students' needs and have made plans to incorporate this teaching methodology as a part of the regular yearly program. To determine the type of instruction which might best serve the students' needs, a cognitive mapping of individual students would be produced. Student preferences, as well as their strengths and weaknesses would be considered, with the ultimate goal of maximizing learning.

Also, in the mathematics department of South Central Community College, the department head has sanctioned further development and utilization of individualized instruction. In this department, two of the four instructors have planned to proceed beyond the experimental stage and teach more of their classes by this method, sometimes using a team approach.

The mathematical needs of the community are vast; if by implementation of individualized instruccion more success among students can be realized and attitudes and self-concept can be favorably changed during this process, then one of the major goals of education would have been accomplished.

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APPENDIX A

Behavioral Objectives -- Fundamentals of Algebra I

FUNDAMENTALS OF ALGEBRA I — M 101

Behavioral Objectives
Unit I

The student will be able to:

1. Understand how algebra began and be able to represent numbers with symbols.
2. Know the language of algebra, that is, know the meaning of factors, terms, exponents, monomials, multinomials.
3. Find the sum by combining like terms given a set of monomials and/or multinomials.
4. Subtract one algebraic expression from the other, given two algebraic expressions.
5. Find the product given two or more monomials.
6. Find the product, given a monomial and a multinomial.
7. Find the product, given two multinomials.
8. Know the meaning of Distributive Property and use it to multiply a monomial by a multinomial and a multinomial by a multinomial.
9. Know the order of the operations in an algebraic expression that contains several operations and demonstrate the ability to reduce the expression by grouping to its simplest form.
10. Identify polynomials from a set of algebraic expressions.
11. Divide a monomial by a monomial, given two monomials.
12. Divide a multinomial by a monomial, given a multinomial and a monomial.
13. Find the quotient of two multinomials.

Behavioral Objectives
Unit II

The student will be able to:

1. Factor into primes two and three digit integers.
2. Know the meaning of symmetric property.
3. Know the meaning of binomial.
4. Know the meaning of trinomial.
5. Identify binomials, trinomials, symmetric property, given a list of algebraic expressions.
6. Multiply two binomials by inspection.
7. Use the reverse process of multiplying two binomials to factor a trinomial perfect square.
8. Find the product of two binomials with the same literal numbers.
9. Factor trinomials that are not perfect squares.
10. Factor an algebraic expression by extracting its greatest common factor and a simpler multinomial.
11. Find the product of the sum and the difference of the same two numbers.
12. Factor the difference of two perfect squares.
13. Factor the sum or difference of two perfect cubes.
14. Factor an algebraic expression by grouping.

Behavioral Objectives
Unit III

The student will be able to:

1. Simplify fractions using the rules for changing signs in pairs.
2. Find the product, quotient, sum and difference of rational numbers.
3. Find the product and express the answer in simple form, given two algebraic fractions.
4. Find the quotient of two algebraic fractions.
5. Find the least common multiple of three expressions.
6. Find the sum (difference) of two or more algebraic fractions.
7. Find the sum of a fractional term and a non-fractional term.
8. Find the simple form of a complex fraction.

Behavioral Objectives
Unit IV

The student will be able to:

1. Select the postulate that makes one equation equivalent to another, given a pair of equations.
2. Select the equation that represents an identity, that represents a conditional equation or one that has no solutions.
3. Identify each of the reflexive, symmetric, transitive, addition and multiplication axioms when given a set of equations in which these are used.
4. Read an algebraic expression written in set-builder notation, understand the meaning and write the solution set utilizing set notation.
5. Find the L.C.D. and find the solution set of a linear fractional equation in one variable.
6. Solve for one variable in terms of the other(s) given an equation with more than one variable.
7. Analyze the data of a stated problem, write an equation that can be used to solve the problem, and find the solution set.

APPENDIX B

Behavioral Objectives -- Intermediate Algebra

INTERMEDIATE ALGEBRA -- M 119

Behavioral Objectives
Unit I

The student will be able to:
1. Use set notation and set language.
2. Identify natural numbers, integers, rational numbers, irrational numbers and real numbers.
3. Apply the properties of positive integral exponents.
4. Add, subtract, multiply and divide polynomials.
5. Work problems (write answers by inspection) involving special products.
6. Factor polynomials.
7. Reduce rational expressions to simple form.
8. Add, subtract, multiply and divide fractions.
9. Simplify complex fractions.
10. Apply the properties of rational exponents to simplify expressions.
11. Apply the properties of radicals to simplify expressions.

Behavioral Objectives
Unit II

The student will be able to:
1. Solve first degree equations.
2. Solve word-problems which involve first-degree equations.
3. Understand order relations and their properties.
4. Solve first-degree inequalities and show their solutions on the number line.
5. Understand the absolute value definition relative to the number line.
6. Solve absolute value equations.
7. Solve absolute value inequalities.
8. Locate points in the Cartesian Plane.
9. Find the distance between two points in the plane.

Behavioral Objectives
Unit III

The student will be able to:
1. Define a relation and a function.
2. Determine functional values.
3. Graph functions involving linear equations, quadratic equations, cubic equations, and rational equations.
4. Find f + g, given functions f and g.
5. Find f - g, given functions f and g.
6. Find f . g, given functions f and g.
7. Find f / g, given functions f and g.
8. Classify functions as odd, even or neither.
9. Determine symmetry of functions with respect to the y-axis or the origin.
10. Determine the domain of a function.
11. Determine the range of a function.
12. Determine if the function is increasing or decreasing.

Behavioral Objectives
Unit IV

The student will be able to:

1. Find the equation of a line given the slope and one point.
2. Find the equation of a line given two points.
3. Graph a line given the equation.
4. Determine the slope of a line perpendicular to the line.
5. Solve systems of linear equations by:
   (i) Substitution method
   (ii) Elimination method.
6. Solve quadratic equation in order to find the x-intercept of a quadratic function by:
   (i) the factoring method
   (ii) completing the square
   (iii) the quadratic formula.
7. Determine the domain of a quadratic function.
8. Determine the range of a quadratic function.
9. Determine the extreme point of a quadratic function.
10. Graph a quadratic function.
11. Solve quadratic inequalities.
12. Solve quadratic and radical equations.

Behavioral Objectives
Unit V

The student will be able to:

1. Divide polynomials and apply the division algorithm.
2. Use synthetic division.
3. Use the Remainder Theorenm to graph functions.
4. Use the Factor Theorem to find roots of a polynomial.
5. Determine zeros of polynomial functions.
6. Graph polynomial functions.
7. Graph rational functions.

APPENDIX C

Achievement and Diagnostic Test

APPENDIX C, PAGES 73-80 WERE REMOVED FROM THIS
DOCUMENT PRIOR TO ITS BEING SUBMITTED TO
THE ERIC DOCUMENT REPRODUCTION SERVICE.

APPENDIX D

Validity Data for the Achievement Test

VALIDITY DATA
for
THE ACHIEVEMENT TEST

The early planning for the test to be used at Columbus Technical Institute (CTI) was done by selection, from a pool of mathematics test items, those judged most appropriate to the instructional sequence in technical mathematics I and II. The selection of items was facilitated by data obtained from a programmed algebra test administered there in November, 1971. After selecting and matching test items, and augmenting where necessary, the following combinations of subtests was adopted.

Major Subtests	Subsidiary Subtests
Technical Mathematics I	1. Straight line equations, elementary algebraic operations.
	2. Simple trigonometry, radian measure, trig tables.
	3. Common angle functions.
	4. Algebraic functions and factoring.
Technical Mathematics II	5. Exponents and logarithms.
	6. Vectors and complex numbers.
	7. Arc and periodic functions.

Tests were administered as follows:

DESIGNATION	NUMBER	GROUP
1	17[illegible]	1972 starts at Columbus Technical Institute, tested between July 11 and September 30, 1972.
2	30	CTI students having completed Technical Mathematics I, tested in February, 1973.
3	37	CTI students having completed Technical Mathematics II, tested in June, 1973.
	37	CTI students having completed Technical Mathematics III, tested in June, 1973.

During the early summer of 1973, the test was administered to 57 new Columbus Tech students. The resulting scores were practically the same as those from Group 1. Some additional comparisons in trend are based upon scores obtained from administration of a branched-program algebra test during 1971-72. This series includes an administration to 119 CTI students in November, 1971.

SCORE TRENDS

An overall impression of the trends in test scores, and their values at different stages of technical mathematics study, can be obtained from Table 1.

TABLE 1

Mean Test Scores for Columbus Technical Institute Students
at
Four Levels of Technical Mathematics

Group	n	Total Score	Items Attempted	Ratio Score	TMI Score	TMII Score
1	171	5.1	42.3	0.116	4.3	0.78
2	30	6.9	28.0	0.224	4.7	2.1
3	37	9.2	29.6	0.330	6.4	2.7
4	46	11.4	23.7	0.482	7.7	3.8

Group key: 1=beginners, 2=complete TMI, 3=complete TMII, 4=complete TMIII
(Test M-67)

The principal trends to be noted are the generally increasing scores concurrent with a substantial decrease in the number of items attempted. The latter decrease may be attributed in part to inadequate control of time during the first administration. In some instances the time allowed for completion of initial testing was somewhat greater than the 30 minutes recommended. Additionally, during a first encounter with a test of this type, students will frequently resort to rapid guessing. As they become more familiar with the materials represented on the test, they become more inclined to attempt thoughtful answers, and as a result consider fewer test items in a given amount of time.

Notwithstanding the reduction in the number of items attempted, the total scores, as well as the principal subtest scores, are observed to increase. The trend in ratio score reflects both the advance in total score, as well as the reduction in the number of items attempted. The mean ratio score for Group 4 is seen to be more than four times the corresponding score for Group 1. The regular advance which is evident in the ratio score, supports the contention that the test is sensitive to the materials taught and learned in the mathematics sequence at Columbus Tech.

Once again regarding the experience with the Columbus Tech test as a pilot plant oper[illegible] some comparison is possible with score trends noted in simi[illegible] se[illegible]es of administrations of another test. During 1971-72 a pro[illegible] algebra test was administered to students of six different leve[illegible] mathematics study. The scores resulting from administration of this elementary test illustrate application over a more extensive range of related achievement.

TABLE 2

Mean Algebra I Test Scores for Six Student groups

Group	n	Total Score	Items Attempted	Ratio Score	Standard Derivation
A. Algebra I students, Jan. '72	102	8.6	30.8	0.30	0.23
B. Same as A, tested in June '72	102	16.8	35.1	0.49	0.22
C. Algebra II students, Sept. '72	67	19.1	32.5	0.58	0.18
D. Algebra II students, June '73	70	30.8	37.8	0.82	0.15
E. CTI-TMI* students, Nov. '71	119	23.7	32.3	0.72	0.20
F. Freshmen engineers, Jan. '72 (Test M-06)	42	53.7	58.1	0.93	0.07

*Columbus Tech. Inst. Technical Math I

The data obtained under pilot plant conditions with the CTI test show trends sufficiently like those shown in Table 2 to support for viction that the CTI test is capable of doing some of the things planned for it. In both instances there is to be noted a steady increase in the total score and especially in the ratio score as the respondents are tested at more advanced levels. A difference to be noted is in the degree of difficulty evident in the two tables. Table 2 confirms the intended level of use for the algebra (M-06) test. The mean ratio score of 0.49, for students completing one year of algebra, indicates a near optimum application of the test at this level. The test may be of service with students of lesser experience, however it is more difficult for them. For students who were more advanced in their mathematics study the test is, of course, easier. Nevertheless this test is capable of discriminating among more advanced students, for exam le those in Groups C, D, and E.

APPENDIX E

Attitude Scale

REVISED MATH ATTITUDE SCALE

Directions: Please write your name in the upper right hand corner. Each of the statements on this opinionnaire expresses a feeling which a particular person has toward mathematics. You are to express, on a five-point scale, the extent of agreement between the feeling expressed in each statement and your own personal feeling. The five points are: Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), Strongly Agree (SA). You are to encircle the letter(s) which best indicates how closely you agree or disagree with the feeling expressed in each statement AS IT CONCERNS YOU.

1.	I am always under a terrible strain in math class.	SD D U A SA
2.	I do not like mathematics, and it scares me to have to take it	SD D U A SA
3.	Mathematics is very interesting to me, and I enjoy math course.	SD D U A SA
4.	Mathematics is fascinating and fun.	SD D U A SA
5.	Mathematics make me feel secure, and at the same time it is stimulating.	SD D U A SA
6.	My mind goes blank, and I am unable to think clearly when working math.	SD D U A SA
7.	I feel a sense of insecurity when attempting mathematics.	SD D U A SA
8.	Mathematics makes me feel uncomfortable, restless, irritable, and impatient.	SD D U A SA
9.	The feeling that I have toward mathematics is a good feeling.	SD D U A SA
10.	Mathematics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.	SD D U A SA
11.	Mathematics is something which I enjoy a great deal.	SD D U A SA
12.	When I hear the word math, I have a feeling of dislike.	SD D U A SA
13.	I approach math with a feeling of hesitation, resulting from a fear of not being able to do math.	SD D U A SA
14.	I really like mathematics.	SD D U A SA

15. Mathematics is a course in school which I have always enjoyed studying.	SD	D	U	A	SA
16. It makes me nervous to even think about having to do a math problem.	SD	D	U	A	SA
17. I have never liked math, and it is my most dreaded subject.	SD	D	U	A	SA
18. I am happier in a math class than in any other class.	SD	D	U	A	SA
19. I feel at ease in mathematics, and I like it very much.	SD	D	U	A	SA
20. I feel a definite positive reaction to mathematics; it's enjoyable.	SD	D	U	A	SA

APPENDIX F

Problem-Solving Test

Problem-Solving Test

Name:
Period:
Date:

Directions:

This is a problem-solving situation in which you may find it necessary to utilize intuition or mathematical concepts that you have learned. Be sure to try ALL the problems. If library resources are needed, please make use of them; indicate clearly how you arrive at your answer. The maximum amount of time for you to return the test and your answers is ONE week.

1. A set is enclosed under a particular operation # when for any a and b in the set, a # b is in the set. Is the set of rationals closed under multiplication? Why?

2. What is meant by the expression "division is not associative"? Explain fully giving pertinent illustration.

3. Suppose John's age is represented by X. If you were told John's brother's age was x + 5, what would you know about his brother's age? If 5 years ago their combined ages were 49, how old are they now?

4. Here is a point ".". If you were asked to find all points equidistant from this point, what kind of figure would you have? Can you find objects in real life that resemble this figure? Give examples if you can.

5. Consider this set: $A = \{3, 9, 15, 27, 45, 72, 105\}$. Is there something that each of these elements has in common? If so, identify.

6. Mrs. Smith's living-room-dining area is 9 feet longer than it is wide. If the perimeter is 82 feet, what are the dimensions? Her rug is 12 feet by 18 feet, can this rug cover the entire floor? If the answer is negative, how much of the floor is not carpeted?

7. Bob thinks the following: Any time Susan comes to a party, Tony comes with her. But Tony is out of town this weekend. I guess Susan isn't at this party tonight. Is Bob's thinking correct? Explain.

8. $(X * Y) * (Z * W) = (X * Z) * (Y * W)$ holds whenever the operation is addition or multiplication because of the properties of commutativity and associativity. Can we then assume that this does not hold for subtraction since subtraction is neither commutative nor associative? Give logical reasoning through mathematical illustration.

9. S_2, S_3, S_5, S_7 are fields. S_4, S_6, S_8, S_{10} are not fields. For what values of n do you think S_n is a field?

10. You are trying to find the number of subsets of a set of 40 elements. What information might you gather to help you answer this question?

11. If $\frac{a}{c} + \frac{b}{d} = \frac{a + b}{c + d}$ was a definition, what would be some of the consequences

of this definition? List as many as possible.

12. Give a story to fit this open sentence: $t + 5 > 18$.

APPENDIX G

Communication for Implementation of

Individualized Instruction

April 15, 1975

Dr. Earl Braxton, Chairman
Interdisciplinary Studies
South Central Community College

Dear Dr. Braxton:

The Summer Institute which you are in the process of planning can be a rewarding experience for many of our students.

As an educator who sincerely and ardently subscribes to the importance of meeting the student's needs, I would like to be afforded the opportunity to share with you during the workshop a synopsis of my Major Applied Research Project which is a part of the requirements for my Ed. D degree. I have great interest in individualized instruction.

In my opinion, the three-week Institute would be an ideal situation for some innovation in education at the college. I will be delighted to discuss this matter more thoroughly with you at your convenience.

Very Sincerely,

M. Inez Everest

M. Inez Everest
Assistant Professor, Mathematics
South Central Community College

dlg

STATE OF CONNECTICUT
SOUTH CENTRAL COMMUNITY COLLEGE
111 WHITNEY AVE. - NEW HAVEN, CONNECTICUT 06510

(203) 772-3472

June 20, 1975

Mrs. Inez Everest
Assistant Professor, Mathematics
South Central Community College
New Haven, Connecticut

Dear Inez,

Your interest and involvement in the Summer Institute has been very rewarding for all concerned.

The workshop which you have run on an individualized approach to Mathematics was considered highly informative by attending faculty members. In addition to your workshop, the Summer Institute which was just completed profited immensely from your leadership and enthusiasm in the Mathematics area. It was an exciting experience for me to see the impact of the individualized instructional Math component which you so effectively put together.

It is clear to me that you not only understand the model, but you work with it exceptionally well. The enthusiasm, commitment and involvement you demonstrated will go a long way toward getting this institution re-evaluated on its present instructional directions.

Sincerely,

Earl T. Braxton P.C.

Earl T. Braxton, Ph. D.

Chairman, Interdisciplinary Dept.

APPENDIX H

Procedures for Summer Institute Learning Experiences
and Initial Observations

Procedures for Summer Institute Learning Experiences and Initial Observations.

Among the several variations of individualized instruction that have been in use is the Westinghouse Learning Corporation program known as Program for Learning in Accordance with Needs (PLAN). The learning experiences at the summer institute, in most part, resembled this program as outlined by the writer during the workshop. The following abbreviated procedures formed the basis for instruction in english, mathematics, science and social science during the three-week period.

Students' needs were diagnosed on entry into the program, and a program of study was prescribed for each student. This process was a time-consuming task but was realized easily with the aid of a work-study student and esprit de corps.

A diagnostic test was administered on the first day to teach the 123 students who attended; some tests were given orally and some written depending on the subject matter. Thus each student's needs were evaluated. When students returned on the second day, their deficiencies were discussed with them and together, student and instructor agreed on the three-week program of study. Flexibility was a necessary ingredient in constructing the program and this allowed students to make changes as they progressed or as there were needs.

In the mathematics program, the structure was more precise. Each problem on the diagnostic test had a behavioral objective which was referenced by a number. (See sample at the end of Appendix H). Students worked through objectives which, when completed, were noted on their prescribed sheets. Students' folders were kept and this arrangement allowed progress records to be easily accessible. Participants in the mathematics program were also asked to fill out an attitude inventory at the beginning and end of the institute.

Since instructors as well as students have different cognitive styles, a variety of instructional media was available and utilized by students and instructors. The media consisted of several texts for each of the disciplines taught, some of which had different reading levels, tapes, filmstrips, films, transparencies, small group-discussions, and the tutorial approach on an individual basis.

Formal and informal evaluations were being made but no statistical results were yet available. Casual observation has indicated much student enthusiasm with some hesitancy during the first week of the institute. Also notable was the period of adjustment to a new teaching style; many made the adjustment very readily, but a small number of students (13) did not return after the diagnostic session. Several students needed remedial skills, but several also participated in advanced learning. There was a marked difference during the second week. Students attended regularly and everyone appeared relaxed and striving to gain additional knowledge.

The following excerpts were taken from a tape on which students expressed their feelings about the summer institute.

"I was scared to death about math until I had some instructors who worked with me and showed me that it was not at all that bad. I have enjoyed it here and I hope to take the course during the summer. I did not get any grade but when I take the course during the summer I hope to get a good grade."

"I'm going to college next year. This program helped me out a great deal toward my college activities. I hope to attend South Central in September and I hope I'll be able to keep up. I will like to become an accountant."

"I have accomplished a lot from coming to the summer institute. I enjoyed the students and tutors. I took three courses; psychology, english and math. I will like to thank you all for being so concerned."

"The institute should have been instituted long ago for people who are having problems in different subjects; it needs to be expanded so that more students can benefit from it."

Summer Institute June 2-20
Student Contractual Form

Name: Martin C. Ezeagu Subject: Algebra

Description of status of student on entering program	What problems were diagnosed	Describe the designed prescription	Was assignment completed-Explain Yes	No	Any further assessment of the student's progress and attitudes; further assistance needed
College student	Objectives:				
	7308	List subsets.	x		Student accomplished most of his objectives; due to unforeseen circumstances he must leave the institute a few days before its duration.
	9	Reading graphs of a number line.	x		
	10	Order of operations.	x		
	11	Evaluating algebraic expressions.	x		
Diagnostic Test Score: 30/50	13	Given replacement set, graph and truth set.	x		
	14	Translate into algebraic expressions.	x		
	15	Identify properties of number system.	x		
	16	Identify the distributive property.	x		
	17	Use addition or subtraction to solve equations.	x		
	18	Use mult. or div. to solve equation.	x		
	19	Solve equation with more than one equation in example.	x		
	20	Solve word problems		x	

AUTOBIOGRAPHY

AUTOBIOGRAPHY

Born June 18, 1933, in Nevis, West Indies, the author was the last of five children -- three brothers and one sister. She attended a private school from three and one-half years of age to seven and one-half years of age, after which she attended a public (government) Girls' School. At the ages of twelve and thirteen she received two certificates for proficiency in Mathematics, English Reading, Geography, Writing. At age fourteen she won a scholarship to attend the private and highly selective Excelsior High School.

Five more years elapsed, and the author completed her high school career with a Senior Cambridge (England) certificate in English, English Literature, Mathematics, History, Geography, Religious Knowledge, Health Science, and French.

She was employed as a teacher during which time she studied educational philosophies, principles and practice of teaching, elementary science and home economics on an independent basis.

Outstanding work in teaching was rewarded with a six-months' scholarship to study in a specialized area -- the "Junior" years of elementary school, ages seven to nine. This led to further experience in teaching at all levels with all boys, all girls, and coeds, five of these years at the Secondary School.

The author climaxed her teacher preparation in the West Indies with a one-year scholarship at Spring Gardens Teaching Training College where she received the Psychology Award and the Principles and Practice of Teaching Award; the Awards exemplified the highest achievement exhibited in these areas of study during that college year. The years spent in Nevis saw many friendships, most of which still exist. The author enjoyed participating in church activities and civic affairs. The first Brownie pack in Nevis was established by her; she was also a Girl Guide leader and became the first District Commissioner of Girl Guides on the island of Nevis.

A second phase of the author's life began when she entered a four-year Higher Education institution in the United States. Her educational pursuits continued, resulting in a one-year scholarship as an undergraduate, two National Science Foundation Scholarship Grants, a Bachelor of Science degree from Southern Connecticut State College, a Master of Arts in Teaching degree from University of Cincinnati, and a Doctor of Education degree from Nova University. The author finds it challenging and exciting to teach at the Community College, prior to which she taught at high school level. She has been innovative in her teaching methodologies, has written a Mathematics Manual, Mathimagination, for her Intermediate Algebra students who study by the individualized method of instruction, and philosophizes about humanism in mathematics. Other innovations include speaking at a Summer Institute Workshop on Individualized Instruction and designing a program for learning in accordance with needs.

A member of several professional organizations, the author subscribes to many professional journals, and attends several conferences yearly. Organizations include: National Education Association, Connecticut Education Association, National Council of Teachers of Mathematics, National Association of Two Year Educators in Mathematics, and Mathematics Association of Two Year Educators in Connecticut.

Other civic and educational involvements include: Board member of Friends of South Central, Board member of International Student Center, Board member of NAACP (Meriden-Wallingford Branch) and committee member of Southern Connecticut State College Alumni Association. The author has served as an officer and/or chairperson of various committees at South Central Community College, has established a Foreign Student Club there and served as the Foreign Student Advisor for three years. She sponsors a yearly International Food Fair at the college and established a Martin Luther King Club at the high school prior to teaching at the college level.

Married for the past five years, the author has no children, enjoys traveling and all outdoor activities. Hobbies include stamp collecting, coin collecting, reading, and indoor and outdoor gardening. Fond of suburban living, the author also enjoys a retreat to the woods where tranquility reigns except for the sounds of the beetles, birds and frogs, and where nature in its splendor can be appreciated.

SIGNATURE PAGE

I certify that I have read and am willing to sponsor this Major Applied Research Project submitted by M. INEZ EVEREST. In my opinion it conforms to acceptable standards and is fully adequate in scope and quality, as a Major Applied Research Project for the degree of Doctor of Education at Nova University.

Bruce W. Tuckman

1 Dr. Bruce W. Tuckman, MRP Advisor

I certify that I have read this Major Applied Research Project and in my opinion it conforms to acceptable standards for a Major Applied Research Project for the degree of Doctor of Education at Nova University.

W. Richard Krall

2 Dr. W. Richard Krall, Cluster Coordinator

This Major Applied Research Project was submitted to the Central Staff of the Nova University Ed.D. Program for Community College Faculty and is acceptable as partial fulfillment of the requirements for the degree of Doctor of Education.

R. E. Moreton

3 Dr. Ross Moreton, Director of Research and Evaluation