## INFORMATION TO USERS

This was produced from a copy of a document sent to us for microfilming. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help you understand markings or notations which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure you of complete continuity.

2. When an image on the film is obliterated with a round black mark it is an indication that the film inspector noticed either blurred copy because of movement during exposure, or duplicate copy. Unless we meant to delete copyrighted materials that should not have been filmed, you will find a good image of the page in the adjacent frame. If copyrighted materials were deleted you will find a target note listing the pages in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed the photographer has followed a definite method in "sectioning" the material. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For any illustrations that cannot be reproduced satisfactorily by xerography, photographic prints can be purchased at additional cost and tipped into your xerographic copy. Requests can be made to our Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases we have filmed the best available copy.

University
Microfilms
International

300 N. ZEEB RD., ANN ARBOR, MI 48106

**Fisher, Harold Eugene**

# THE RELATIVE EFFECTIVENESS OF PERFORMANCE PRACTICE AND FORMAL STUDY ON ACQUISITION OF APTITUDE IN ENGINEERING IN PRECOLLEGE ENGINEERING PROGRAMS FOR MINORITIES

*St. John's University* ED.D. 1982

# THE RELATIVE EFFECTIVENESS OF PERFORMANCE PRACTICE AND FORMAL STUDY ON ACQUISITION OF APTITUDE IN ENGINEERING IN PRECOLLEGE ENGINEERING PROGRAMS FOR MINORITIES

BY

HAROLD E. FISHER

DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF EDUCATION
IN THE SCHOOL OF EDUCATION
DIVISION OF ADMINISTRATIVE AND
INSTRUCTIONAL LEADERSHIP

St. John's University
NEW YORK
1982

Harold E. Fisher

John Swoyer
Approved

May 24, 1982
Date

TABLE OF CONTENTS

I want to first thank God for excellent parents who supported me throughout my educational career. I am also thankful for my capacity to learn, for spiritual guidance, good health, an understanding family, and the ability to persevere through it all.

I want to also thank Dr. Rita Dunn, Dr. James Campbell and Dr. John Swanchak for their encouragement and support throughout my years at St. John's University.

I owe a special appreciation to my ardent supporters whose service beyond the call of duty made all of this a reality: Connie King Terri Alexa, Julie Boyles, Ruth Lewart, Ann Silcox, Lucia Ting, Marge Paradis and last, but not least, "the coordinator," Brenda Douglas.

I want to dedicate this dissertation to minority students who are committed to the struggle of increasing the number of minorities in engineering.

Most of all, I want to dedicate this research to my parents, Mr. and Mrs. Oscar Fisher, and to my lovely family: Terri, my wife, my daughters, Nicole and Kelli, and my nieces and nephews who will benefit the most from its results.

# LIST OF TABLES AND GRAPHS

The purpose of this study was to investigate and determine whether aptitude in engineering could be transferred more effectively from training involving engineering concepts which placed major emphasis on practical application, or from training involving engineering concepts which placed major emphasis on formal study, or from no training at all.

Subjects

The subjects in this experiment were 120 eleventh and twelfth grade minority high school students. Approximately 75 percent of these students were Black. The remaining 25 percent were Hispanic. These students were randomly assigned to three treatment groups, with 40 students in each group. Two of the groups, the Performance Practice Experimental Group (PP) and the Formal Study Experimental Group (FS), were participants in pre-college engineering programs for minorities. The Control Group (CO) represented the third group, which was not involved in any training.

The Performance Practice Experimental Group (PP) had 40 participants who were randomly assigned to the RCA Minority Engineering Program (MEP). The training emphasis of this group was placed on developing engineering concepts through practical applications or "hands on" activities. These activities were introduced and supervised by an engineer at an RCA plant.

The Formal Study Experimental Group (FS) had 40 participants who were randomly assigned to the Minority Introduction to Engineering Program (MITS). The training

emphasis of this group was placed on developing engineering concepts through formal study or lecture discussions. These lectures were presented by an engineering faculty on a college campus.

The other 40 participants were randomly assigned to the control group which was not involved in any training.

Procedure

The treatment period was 30 hours or the equivalent of 6 days for 5 hours per day. On the 7th day, the two experimental groups were administered the National Engineering Aptitude Search (NEAS) test. The Control Group was administered the same test. The NEAS test is comprised of four subtests: verbal, numerical, science and mechanical comprehension.

The scholastic Aptitude Test (SAT) scores were used as the coveriate to adjust the mean scores on all four subtests of the National Engineering Aptitude Search (NEAS). To determine the effect these adjusted mean subtest scores of the participants in each group had on acquisition of aptitude in engineering, treatment (PP, FS, CO), socio-economic status (high, middle, low) and sex (M, F) were combined in a 3x3x2 factorial arrangement.

Results

The results of this study indicated that minority high school students in the Performance Practice Experimental Group (PP) were significantly different from the Formal Study Experimental Group (FS) and the Control Group (CO) on all four subtests of the National Engineering Aptitude Search (NEAS). These results

also indicated that training which emphasized developing engineering concepts through practical applications or "hands on" activities did transfer aptitude in engineering more effectively than training which emphasized formal study or lecture discussion or not training at all.

The two Experimental Groups had higher adjusted mean numerical and mechanical comprehension subtest scores than the Control Group (CO). However, although the Control Group (CO) had lower adjusted mean verbal and science subtest scores than the Performance Practice Experimental Group (PP), their scores were unexpectedly higher than those of the Formal Study Experimental Group (FS) for the same subtests.

Female minority high school students in all three treatment groups had significantly higher adjusted total mean verbal scores and, although nonsignificant, slightly higher numerical scores than male minority high school students in the same groups.

Conversely, male minority high school students in all three treatment groups had higher adjusted total mean science and mechanical comprehension scores than female minority high school students in the same groups.

Other results in this study showed that minority high school students from families in the high and middle socio-economic levels had higher mean adjusted scores on all four subtests than minority high school students from families in the low socio-economic level.

# CHAPTER I

## INTRODUCTION

Since 1972, the Committee of Minorities In Engineering of the National Research Council has been involved in all aspects of education of minorities in engineering. The Committee set a goal to increase the number of minority students in engineering colleges by 1982 to 18 percent of the total number of students at accredited engineering colleges.

In an assessment of freshmen in engineering based on a cross-section of United States schools, the Engineering Manpower Commission estimates that the total enrollment for fall 1977 class was 87,300. The estimate for the four groups of minority students in engineering was 7,500 with Blacks showing 18 percent increase and Spanish surnamed students up nearly 31 percent over the previous fall. Such statistics suggested that progress was being made toward the "target" of tenfold increase in minority engineering students by 1982, when freshmen enrollment should reach 13,500. However, in a report on financial aid needs of undergraduate minority engineering students in the 1980's by the Financial Needs Study Committee (1978), it was suggested that the 1982 projection was not realistic. It was reported that the more hopeful projections for minority engineering enrollment assume that the number of first-year students will increase steadily until 1983 when it equals 18 percent of the optimistic projection of total first-year enrollment in engineering. The realistic projections assume that the number will increase steadily until 1984 when it equals 18 percent of the conservative projection of total first-year enrollments (p. 3). The study

assumed that resources currently available to cover educational costs will continue to provide necessary financial aid in the years ahead to the same number of minority students enrolled in 1977 (p. 4). The Committee concluded in its report that there will still be a need for additional resources to achieve the stated projections by some combination of the following: additional governmental support at both the federal and state levels; increased parental contributions; and greater reliance on student "self-help" (i.e., on- and off-campus earnings and long-term educational loans). Growth in the financial commitment of educational institutions strengthen minority representation, and more support from individuals, industry and foundations were also cited in the conclusion (p. 4).

To fulfill the goal of achieving a representation approaching the proportion of the nation's minority population, the percentage of minority engineers, now only 2 percent of the total of 1,072,000 practicing engineers in the United States, will ultimately need to rise some sevenfold. One critical problem in attaining that goal is the high drop-out rate for minority students in engineering. If these projections are to be achieved in the 1980s, the retention rate will have to improve substantially.

In the report, "Retention of Minority Students in Engineering," (1977) released by the Retention Task Force of the Committee on Minorities in Engineering, it was concluded that the most important factors contributing to minority

engineering student attrition are inadequate math and science preparation and inadequate motivation toward engineering as a career choice.

There has been an increasing number of precollege engineering programs, the over-all objective of which is to provide a comprehensive exposure to a significant number of young minority students to the field of engineering. These programs have been instrumental in helping minority boys and girls develop an interest in engineering. Components of these programs emphasize career opportunities in the field and what the study of engineering entails.

This study focused on two particular programs, the Minority Introduction to Engineering (MITE) and the RCA Minority Engineering Program (MEP). The curricula for each of these programs were on a continuum of two extremes. They varied in method and content.

On one extreme was the RCA program (MEP) which was designed to acquaint minority high school students with the engineering profession by providing on-site "hands on" projects. These students also participated in other engineering related activities. These selected curricula placed major emphasis on performance practice, practical application, or "hands on" activities, rather than on theory or formal study.

On the other end of the continuum was the Minority Introduction to Engineering (MITE) which was designed to acquaint

minority high school students with the engineering profession by providing college level engineering courses. These selected curricula placed major emphasis on theory or formal study rather than performance practice, practical application or "hands on" activities.

## General Statement of the Problem

During the 1960's the percentage of male merit finalists choosing Physics as a college major dropped from 18.80 to 11.16 and in engineering from 29.59 to 17.55 (Wattey, Nichols 1969, p. 5). Broudy (1973 p. 227) reported that the drastic decline in students pursuing science disciplines was the result of their disenchantment in formalized education. He contended that the decline was also due in part to the action by scholars who challenged the rationale that supported not only the study of science as a logically organized discipline, but also the study of all disciplines so organized. He suggested that the challenge extended to the study of any theory, basic or professionalized. Broudy concluded that the curricula of secondary schools, colleges and professional schools in large part are theoretically oriented.

According to Broudy (p. 230) in our instructional approach to science and other formal professional curricula such as Medicine, Engineering, Agriculture, and Business Management, we are confronted with the questions: Is theory necessary for practice? Should we bother studying theory when we could be practicing the practice? This dissertation will attempt to answer these questions.

This study investigated the relative effectiveness of transfer on student acquisition of aptitude in engineering from two types of precollege engineering programs for minorities: Formal study (MITE) and an apprenticeship form of training (MEP). Specifically, if transfer of training can justify the practical application approach (MEP) which includes theory on a limited basis, or the theoretical approach (MITE) which includes practical application on a limited basis, then evidence is needed to support the hypothesis that either approach is sound or a more efficient way of preparing minority high school students for engineering.

This study also focused on some of the charges cited by Broudy (p. 228) that challenged the need for formalized education. Berg (1970) and Livingston (1971) supported one charge that formal study (general and professional) correlates poorly if at all with life outcomes, especially vocational success. Another charge reported by Broudy (p. 228) suggested that there is a trend toward more direct practical training and a reduction of the theoretical components of professional curricula.

This study was limited to minority high school juniors and seniors who were participating in precollege engineering programs and were considering a career in engineering.

## Specific Problems

The primary focus of this research was an investigation of the relative effectiveness of transfer of training by

identical elements (MITE), transfer of training by generalization (MEP), and transfer with no specific training (control) on acquisition of aptitude in engineering.

This study sought answers to the following questions:

1. When the modified scores of minority high school students in the 11th and 12th grades are analyzed for all four subtests of the National Engineering Aptitude Search test, are there significant mean differences among the three groups when categorized according to treatment and sex?
2. When the modified scores of minority high school students in the 11th and 12th grades are analyzed for all four subtests of the National Engineering Aptitude Search test, are there significant mean differences among the three groups when categorized according to treatment and socio-economic levels - high, middle and low?

## Hypotheses

To answer the above questions, all variables other than the treatment were held constant and the following hypotheses were experimentally tested:

A. There are no significant mean differences in modified verbal scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and sex.

B. There are no significant mean differences in modified verbal scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and socio-economic levels - high, middle and low.

C. There are no significant mean differences in modified numerical scores of minority high school students in the 11th and 12th grades on the National engineering Aptitude Search test when categorized according to treatment and sex.

D. There are no significant mean differences in modified numerical scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and socio-economic levels - high, middle and low.

E. There are no significant mean differences in modified science scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and sex.

F. There are no significant mean differences in modified science scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude

Search test when categorized according to treatment and socio-economic levels - high, middle and low.

G. There are no significant mean differences in modified mechanical comprehension scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and sex.

H. There are no significant mean differences in modified mechanical comprehension scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and socio-economic levels - high, middle and low.

## Theoretical Orientation

The conceptual framework from which this thesis evolves centers on the efficacy of transfer theories by C. H. Judd and E. L. Thorndike.

Broudy (1973, p. 223) reports that transfer as interpreted by C. H. Judd rather than E. L. Thorndike yields the best results as to how and why formal study of intellectual discipline provides the promised life outcomes.

Thorndike (1906, p. 248) reported that training is highly specific. For example, if one learns to be analytical in one situation, one will be analytical more readily in all later situations where the material experiences are similar. Thorndike was also most frequently quoted in support of the view that

training in one line is relatively ineffective in improving abilities in other lines.

Conversely, Judd (1927, p. 514) stated that "generalization" and transfer are synonymous terms. He concluded that when a pupil fully grasps a scientific generalization or when he gains a view of a wide range or relations, he acquires independence and breadth of intellectual power and becomes capable of transferring training to situations that are different from which he was first trained. Generalization is another name for the relating of experiences in such a way that what is gained at one point will redound to the advantage of the individual in many spheres of thought and action.

Broudy (p. 228) contends that Judd's theory is congenial to science because it is itself a paradigm of theory in which hypothetical deductive thinking is central. He suggested that transfer by replicating identical elements seems more suited to explain the use of a skill or mastering a fixed body of information; e.g., learning the multiplication table than for scientific problem solving.

The primary focus of this study will emphasize the comparative effectiveness of general and specific transfer from two distinct precollege engineering programs and how each affects student acquisition of aptitude in engineering.

## Definition of Terms

In this study, the following definitions are used:

Aptitude in Engineering - Webster's Seventy New Collegiate

Dictionary (1967) defines aptitude as capacity for learning. In this study, aptitude will be defined as the modified mean scores of students for each of the four subtests (numerical, verbal, science and mechanical comprehension) on the National Engineering Aptitude Search (NEAS) test.

This test is designed to assist students in grades 9-12 inclusive in determining their aptitudes and qualifications for undertaking engineering studies on the college level.

Minorities refers only to American citizens or nationals who are Black, Chicano/Mexican American, Puerto Rican or American Indian. These particular 11th and 12th grade students are considering a career in engineering.

Minority Introduction to Engineering (MITE) refers to the precollege engineering program for minority high school students that places major emphasis on introducing minority students to engineering by providing instructions and training in college level engineering courses. The main component of this program focuses on introducing concepts in engineering to minority high school students in the 11th and 12th grades primarily through formal study and lecture/discussions on a college campus.

RCA Minority Engineering Program (MEP) refers to the precollege engineering program for minority high school students that places major emphasis on introducing minority students to engineering by providing instructions and training in practical applications or performance practice in engineering related

activities. The main component of this program focuses on introducing concepts in engineering to minority high school students in the 11th and 12th grades primarily through practical application or "hands on" activities at an RCA industrial plant.

Transfer of Learning/Training (General) refers to the process when a pupil fully grasps a scientific generalization or when he gains a view of a wide range or relations he acquires independence and breadth of intellectual power and becomes capable of transferring training to situations that are different from which he was first trained. The learning output is deduced from the scientific generalization the learning input (C. H. Judd, 1927, p. 514).

Transfer of Learning/Training (Identical) refers to the process when a pupil fully grasps a specific scientific theory or concept or when he gains a view of a specific relationship he acquires specific knowledge and becomes capable of transferring only those elements that are identical with those from which he was first trained. The learning input is replicated in the output (Thorndike 1913, p. 171).

Social Economic Status: In this study minority high school students from families in the high socio-economic status are considered in the top 5 percent and top quintile. Minority high school students from families in the middle socio-economic status are considered in the 2nd and 3rd quintile. Minority high school students from families in the low socio-economic status are considered in the 4th and 5th quintile.

TABLE 1.0

DISTRIBUTION OF FAMILY INCOME (1976)

| Family Rank | Percentage of All Income | Income Range in $ |
|---|---|---|
| Top 5 percent | 1.6 | 37,047 and up |
| Top quintile | 41.1 | 23,924 and up |
| 2nd quintile | 24.1 | 17,301-23,923 |
| 3rd quintile | 17.6 | 12,401-17,300 |
| 4th quintile | 11.8 | 7,442-12,400 |
| 5th quintile | 5.4 | Under 7,441 |

United States Department of Commerce Bureau of the Census, Current Population Reports: Consumer Income, series P-60, No. 114 (July, 1978).

## Limitations of the Study

The extent and manner in which the results of this study can be generalized to different subjects and settings are limited by the following factors:

1. The results of this study can be generalized only to students similar to those used in the treatment sample i.e., minorities Black, Chicano/Mexican American and other Hispanics, public high school 11th and 12th grade levels.
2. The results of this study comparing the effects of general and specific transfer of training can be generalized only within the limits set by the dependent variable; this refers to a specific standardized test.

3. This study was limited to one standardized test because of the following objections cited by participating school district officials:
    a. The NEAS is a two-hour timed test scheduled to be administered to a limited number of students during school hours.
    b. Public school students already have too many required standardized tests during the year.
    c. The objections of Black parents to standardized tests in general.
    d. The districts' reluctance to release confidential information and test results when they have no control over its use.

## Assumptions

It was assumed that the students had expressed interest in pursuing a career in engineering and were equally motivated regardless of the deciding influences or factors.

It was assumed that minority students pursuing careers in engineering differed from their majority counterparts in academic achievement and scholastic aptitude tests scores. Random assignment of students, college professors and engineers to the two treatment groups was assumed to equalize the effects of any individual personal differences within the two groups.

It was also assumed that differences in practical laboratory applications, demonstrations and individual instructor techniques would produce no bias in the study.

## Significance of the Study

In 1973, the Alfred P. Sloan Foundation supported a national task force to survey the field of engineering and make recommendations. Its report, "Minorities in Engineering: A Blueprint for Action," was published late in 1974. The report outlined an approach to increase the number of Blacks, Hispanics and Native Americans in schools of engineering.

In 1975, another task force met to formulate a more detailed blueprint for the precollege phase of the minority engineering effort. This task force recommended that six consortia should be established to stimulate precollege preparation in different parts of the country.

The main purpose of these consortia are to weld engineering schools, school districts, local and regional industries, and community groups into an alliance. It aimed at increasing the numbers and achievement levels of minority students, beginning with the seventh grade, in the subjects needed for engineering study: Science, Mathematics, English and Communication Skills.

Since 1972, the Alfred P. Sloan Foundation has invested almost $13 million for the minority engineering students. The Foundation's last major grants for this effort were made in 1979.

Subsequently, in October of 1979, the Sloan Foundation invited teachers, directors of regional consortia, a few engineering deans, and industry representatives to a two day conference in Mount Kisco, New York. The primary focus of the

conference was to attempt a preliminary assessment of the status and prospects of one crucial aspect of the total minority engineering effort, precollege education.

Dr. Louis Padulo, who was asked to summarize the discussions at the close of the conference, reported that the public schools (and occasionally private and parochial schools) are the focus of most of the consortia's efforts to interest minority students in engineering and help them prepare for it. It was concluded that schools in the inner cities, where most minority students live, need help (work in progress, 1979).

From the beginning of the minority engineering effort, industry's involvement has been financial, educational and motivational. However, corporate contributions in dollars to the precollege effort, for the most part, have been minimal. According to W. Edward Lear, Dean of Engineering at the University of Alabama, a recent study found industry contributing about $5 million a year for specific activities in minority engineering programs. He was not optimistic that national corporations could be induced to change their funding patterns in favor of precollege programs (1979, p. 7).

Edmund B. Tucker, manager of Science and Technology Support Programs for the General Electric Foundation, reported that of the $1 million a year G. E. Foundation puts into the minority engineering effort, only about 10 percent goes to precollege programs, usually on a short-term basis. According to Tucker, the reluctance by industry was because of the length of

time it takes these junior high and high school precollege programs to produce an engineer. He further explained that most companies would prefer to support programs at the college level. At this level, they feel that the impact is going to come sooner and you can get a measurable output in a reasonable period of time (1979, p. 5).

The conference participants at Mount Kisco were advised that industry wants to see evidence that the programs are being conducted with maximum efficiency. Industry wants to be kept fully informed about successes and failures. Industry wants to know what happens to the students who benefit from its assistance.

Many companies conduct special in-plant programs for minority students (RCA, Bell Laboratories and Burroughs Corporation). Other companies like the Bendix Corporation have adopted particular schools and made sure they have what they need for strong science and mathematics programs.

This study assessed the relative effectiveness of an in-plant program and a corporate sponsored precollege on-campus program. The results of this study should be of particular interest to many industries as evidence to increase financial support for these programs. Moreover, this study may have implications and significance for engineering educators and professional research oriented organizations who have a particular interest in decreasing the high attrition rate of minorities pursuing an undergraduate degree in engineering.

This study focused on transfer of training, a common element identifiable in varying degrees in each precollege engineering program. The results of this study will offer more research criteria to judge objectively similar studies involving general and specific transfer of training. One such study conducted in Europe by Piryov and Tzanev (1975) suggested that the extent and quality of transfer of knowledge from the school subjects mathematics, physics and technology of metals to the teaching of metal-cutting machines and turnery were accomplished by high school students regardless of a general or technical educational background. However, they concluded that special training was needed for the transfer of knowledge to the field of technics. Yoder (1975) conducted a study to determine the effects of previous training on college freshmen in an Agricultural Mechanics course. The study showed that Mechanical Aptitude test scores were not significantly different from those who had previous Agricultural Mechanics instruction, compared to those who did not.

The findings of this study may well add to the body of knowledge of C. H. Judd's theory of transfer by generalization and E. L. Thorndike's theory of transfer of identical elements.

Moreover, the results of this study should have implications for future research. If no significant relation between performance practice and/or formal study on acquisition of aptitude in engineering, is found then perhaps the combination of similar methods of transfer and attitude toward engineering might be studied.

If a significant relationship is found between performance practice and/or formal study on acquisition of aptitude in engineering, then further studies might focus on academic success in freshman year in engineering school and its effect on the rate of retention. Researchers then too might broaden their studies to other populations and grade levels in other settings and to other professional careers.

# CHAPTER II

## RELATED LITERATURE

This study was one attempt since the inception of the minority engineering effort to investigate the efficacy of transfer of training in precollege engineering programs for minorities. To date, the only available data collected on precollege engineering programs have been the results of questionnaires. These instruments were designed by the program directors to assess the effectiveness of individual program objectives and the participants' attitudes toward engineering. With the exception of a research project reported by Richards, Williams and Holland (1977) who validated one such questionnaire and published the results, almost all of the data gathered from individual program questionnaires do not result from controlled experimental projects.

The paucity of research that seems immediately applicable to this particular study has placed major emphasis on early research of Thorndike and Judd. In order to understand currently accepted conclusions with respect to transfer of training, it is necessary to know the background for these conclusions.

The related literature in this chapter is divided into five main sections. Reference will be made to the following:

1. The Doctrine of Formal Discipline.
2. The Theory of Identical Elements.
3. The Theory of Generalization.
4. Theoretical Interpretations of Transfer of Training.
5. Current Research

According to Weimer (1974), transfer of training is measured by many quantitative expressions. Because of their

variety, the amount of transfer from one experimental study cannot necessarily be compared from another experimental study in any standard or systemic fashion. Furthermore, in some studies it is a difficult matter to ascertain just what is being transferred in order to complete the learning task.

The majority of the studies reviewed involving transfer employed criterion tasks that were scored according to the frequency of correct answers or the amount of performance within a given time interval. These numerical values increased with learning. Other transfer measures were exemplified by such variables as the number of errors, time of response, and the number of trials to criterion; these scores decreased with improvement in performance.

## Formal Discipline

The traditional notion or theory as to the amount and method of transfer is known as formal discipline. This doctrine means that mental power or mastery gained in dealing with one situation is applicable to any field which calls for the functioning of such power or mastery. The basic premise for this theory is that the mind consists of a collection of faculties or powers such as observation, attention, memory, reasoning, will and the like, and whatever strengthens any one of these strengthens it as a whole. Thorndike (1903) reported that the common view (of transfer of training) is that the words accuracy, quickness, discrimination, memory, observation, attention, concentration, judgment, reasoning, etc. stand for some real and elemental

abilities which are the same no matter what material they work upon; that these elemental abilities are altered by a special discipline to a large extent; they retain those alterations when turned to other fields; that learning to do one thing well will more or less make one do better things that in concrete appearance have absolutely no community with it.

William James is credited with being one of the first psychologists to test the doctrine of formal discipline experimentally. The results that he obtained showed that formal discipline has little effect on improvement of memory. Norsworthy (1902) concluded that a large body of experiments were unanimous in the finding that the claims of formal discipline were greatly exaggerated. Norsworthy (1902) indicated that

> "Accuracy in Spelling is independent of accuracy in multiplication, and quickness in arithmetic is not found with quickness in marking misspelled words; ability to pick the word 'boy' on a printed page is no guarantee that the child will be able to pick out a geometrical form with as great ease and accuracy."

Other experiments such as Thorndike (1910, pp. 437-88) revealed that training in memorizing words did not help in memorizing numbers. Also training in mathematical reasoning did not mean ability to reason in general, (Lewis 1905, pp. 281-92). The ability to write neat papers in arithmetic was not found to transfer to writing neat papers in other subjects, Bagley (1905, pp. 203-4).

Stratton (1922, pp. 4-5) concluded:

> "that the mind is a convenient name for countless special operations or functions. One may train one of these functions or a number of them, but not a faculty in general, or reasoning in general. They act almost as though they were insulated from one another; when you have trained that limited function and none else. What you do to the mind by way of education knows its place; it never spreads - you train what you train."

In summary, some 19th century psychologists realized that there seemed to be little carry over from training received in one area to another area.

## Theory of Identical Elements

In 1901 as a result of the thorough and scientific investigations of Thorndike and Woodworth, formal discipline was replaced by the doctrine of identical elements.

Over 20 years of experimental evidence was accumulated on psychological theories of learning called associationism and connectionism. For it was from these theories that the doctrine of identical elements emerged.

There are questions of (1) What is meant by identical elements? (2) Are identical elements to be understood in terms of training specific individual abilities? (3) Do identical elements in two situations include both specific abilities and the statement in words of a principle used in a learning situation?

Thorndike and Woodworth (1901) believed that a correct formulation of the theory was as follows: The more definitely the principle is isolated, even to the extent of formulating it in words, the more chance of transfer - if the principles are embodied in words, they are concrete bits of behavior and their

transfer from one situation to another creates no difficulty for the theory of identical elements.

Thorndike (1906) interpreted his theory as follows:

> "A change in one mental function alters any other only in so far as the two functions have factors, identical elements. The change in the second function is in the amount that is due to the change in elements common to it and the first. The change is the necessary results upon the second function of the alteration of those of its facts which were elements of the first function and so were altered by its training." Thorndike (1910, p. 80,81) clarified his theory by his concrete example; "improvement in addition will alter one's ability in multiplication because certain other processes, for example, eye movements and the inhibition all save Arithmetical impulses, are in part common to the two functions."

In summary, the bearing of Thorndike's Theory on Transfer of Training consists in doing over again what we have learned to do before, except it is part of another situation. For example, having learned to add a column of figures, one is more able to do multiplication because addition is exactly identical with part of multiplication.

Thorndike (1906, p. 243) concluded that this doctrine of transfer through identical elements is based on the assumption that the mind is by no means a collection of a few general faculties such as observation, attention, memory, reasoning, and the like, but is the sum total of countless particular capacities.

Thorndike (1913a., p. 7) proposed two types of identities, namely, identity of substance and identity of procedure. Transfer through identity of substance means that we deal with the same data in different situations. This fixity of the situation, and its appropriate response, is clearly embodied in Thorndike's

most fundamental principle, which stipulates that the same neurone-action will always produce the same results - in the same individual the really same situation will always produce the same response.

Thorndike (1913b., p. 245) defined transfer by identity of procedure as

> "the carrying over of a habit that has been acquired in one connection to another situation. In this process, the data are different but the mode of procedure is the same. For example, 'the habit acquired in a laboratory course of cooking to see how chemicals do behave, instead of guessing at the matter, or learning statements about it out of a book, may make a girl's methods of cooking or a boy's methods of manufacturing, more scientific because the attitude of distrust of opinion and search for facts may so possess one as to be carried over from the narrower to the wider field'...The identical element that may be transferred in both cases is 'attitude of distrust of opinion and search for facts'."

Based upon his insistence of scientific procedures as a method of verifying any hypothesis which aimed at the solutions of the problem, Thorndike offered some experiments as supporting evidence for his theory of identical elements. The first experiment was made in collaboration with R. S. Woodworth. It was reported in a series of three articles in Psychological Review, Vol. 8, 1901. The general problem was to determine "the influence of training in one mental function upon efficiency of other functions." This general problem was divided into three sub-problems as follows:

> "1. To find the influence of certain special training in the estimation of magnitudes on the ability to estimate magnitudes of the same general sort; i.e., lengths of areas or weights, differing in amount in accessory qualities (such as shape, color, form or in both.

"2. To find the influence of training in observing words containing certain combinations of letters (e, g, s and e) or some other characteristic in general ability to observe words."

"3. To find the influence of special training in memorizing on the general ability to memorize."

Thorndike's general experimental methodology consisted of first ascertaining the initial ability status of the subjects in the influenced function. This was followed by an intensive training in another function until a high degree of proficiency was attained. Then the subjects were tested in the first function to find out the extent, if any, in which the subjects showed increased facility as a result of their training in the other function. Thus, in the first problem the subjects' accuracy in estimating magnitudes, e.g., lengths of lines, was determined. He was then given practice in estimating lengths within certain limits until he attained a high degree of proficiency. This is followed by a re-test in the influenced function to find out the extent to which he had profited from the training. In the second problem, the subjects' speed and accuracy in selecting and marking certain letters, words of certain lengths, geometric figures, misspelled words, etc., was determined. Again he was given practice in selecting and marking words of one special sort, until he attained a high degree of proficiency.

Thorndike (1936, p. 397-99) stated that the results of these experiments showed very clearly the influence of: The acquisition, during the special training (1) of ideas of method and habits of procedure and also (2) of facility with certain

elements that appeared in many other complexes. Instances of (1) are learning, in the 10 to 100 sq. cm. training series, that one has a tendency to overestimate all areas and consciously making a discount for this tendency no matter what the size or shape of the surface may be; learning to look especially for the less common letter (e.g., s in the case of e- words, p in the case of s-p words) in the training series and adopting the habit for all similar work; learning to estimate areas in comparison with a mental standard rather than with the objective 1 sq. cm., and 100 sq. cm. squares which each experimenter had before him after one gets mental standards of the areas he judges more accurately if he pays no attention whatever to the objective standards. An instance of (2) is the increase of speed in all the perception tests through training in one, an increase often gained at the expense of accuracy. Woodworth and Thorndike (1901, Vol. II, p. 250) concluded that improvement in any single mental function need not improve the ability in functions commonly called by the same name. It may injure it. Improvement in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for working of every mental function-group is conditioned by the nature of the data in each particular case. The very slight amount of variation in the nature of the data necessary to affect the efficiency of a function-group makes it fair to infer that no change in the data, however slight, is without effect on the function. The loss in the efficiency of a function trained with certain data, as we pass

to data more and more unlike the first, makes it fair to infer that there is always a point where the loss is complete, a point beyond which the influence of the training has not extended. The rapidity of this loss, that is, its amount in the case of data very similar to the data on which the function was trained, makes it fair to infer that this point is nearer than has been supposed. The general consideration of the cases of retention or of loss of practice seems to make it likely that spread of practice occurs only where identical elements are concerned in the influencing and influenced functions.

Another experiment was conducted in collaboration with H. A. Aikens and with the assistance of Elizabeth Hubbell and reported in the Psychological Review, (1902, pages 374-82). The general problem was to find the correlations among perceptive and associative processes. Six different tests were given by one person to 160 boys and girls in the eighth grade and to 80 in the fifth grade The objectives of these tests were to mark every misspelled word in a passage; to mark every word containing r and e in a passage; to write the opposites of 20 difficult words such as stupid, hard-working, strong, save, etc; to write the opposites of 20 easy words such as good, outside, friend, quick, etc.; to write beside each letter in a column of 15 letters the letter that comes before it in the alphabet.

In conclusion the authors pointed out that "the results reinforce the evidence showing that functions apparently closely similar may really be to a large extent independent speciali-

zations. For instance, the ability to call up quickly the opposites of good, rich, heavy, etc., is by no means identical with the ability to call up quickly letters coming before c, k, t, etc.; or with the ability to call up the answers 7 + 4, 11 + 9, 20 + 6, etc. Quickness of association is a myth. Quickness in noticing words containing the two letters r and e does not to any appreciable extent involve quickness in noticing words grossly misspelled, nor does the accuracy in the one involve anything like equal accuracy in the other. The attention and discrimination required in the two cases must therefore be two different things.

Thorndike (1924) reported in the Journal of Educational Psychology, in a series of two articles, an investigation to determine the amount of disciplinary values of high school studies. In an attempt to compare the relative merit of Algebra with Physics or sewing, in developing the pupils ability to think, examinations were administered in May, 1922 and the other in May, 1923 to 8564 pupils who in May, 1922 were in grades 9, 10 and 11.

Each pupil who was administered both examinations recorded the subjects which he studied during the school year, September 22, 1922 to June 23, 1923, and the gains made in the tests were put into relation with the subject studied. Comparison of the gains for the pupils who studied English, History, Geometry and Latin during the year with the gains for the pupils who studied English, History, Geometry, and Shopwork. Thorndike

postulated (1924, p. 1) if other factors such as initial ability, zeal in taking the examination, and special training on its content were properly equalized or allowed for, the difference in the gain represents the difference between Latin and Shopwork as taught in these schools in general training or disciplinary value or improvement in general intelligences, or whatever a gain in such an examination measures.

Instead of dealing with individual subjects, he grouped them according to two independent criteria such as similarity of content and similarity of effect, the assumption being that "the effect of study itself is not isolated from its effect through its associates."

In conclusion, Thorndike (1924, p. 95) suggested that so far as training in the ability to think is concerned, it does not much matter what one studies. Those who have the most during the year, whatever studies they take, will seem to produce large gains in intellect.

The most conspicuous finding that was indicated by Thorndike's experiments, as well as the most important basis of his theory, is the fact which he claimed to have found, that mental abilities are specific and not general. He concluded from the results he found, namely, that transfer is very limited. The correlations among mental abilities were exceedingly low even, as he reported, in functions which are obviously closely related. He also concluded that transfer is to be accounted for mainly by the fact that we do over again in new situations,

what we have learned to do in connection with other situations.

In 1916, H. O. Rugg made a careful survey of thirty transfer experiments and determined the relative amounts of transfer obtained. Fifty-one percent showed either slight or no transfer, twenty-three percent of the experiments indicated "clear evidence of considerable transfer." Rugg interpreted his findings as follows: "By one school of specialists, training has been explained as due to identical ability conditioning factors." However, the typical attitude taken today is that practice may be generalized and transferred through such factors as (1) ideational factors (2) attention factors, (3) attitudinal factors. Thus, transfer is possible with central functions through the generalization of various ones of these factors. The emphasis here is on making the method of learning a conscious matter, the conscious organization of methods of procedure, the conscious utilization of methods of improvement, better understanding of how to use mental tools, rather than any transferable change (through practice) in the constitution of the organism itself.

Orata (1928) reported that the evidence of the theory of identical elements was inconclusive. The theory was not strictly in accordance with Thorndike's own findings and those of others. He enumerated some of the most important assumptions upon which Thorndike's theory was based. The first assumption was that the amount of transfer was proportional to the amount of identical elements present in both the influencing and influenced

function. The amount of improvement in one mental function as a result of training in another function was directly proportional to the degree of similarity between the two functions (p. 53).

The second assumption was that a complex act was equal to the sum of its parts, for though an act may be the joint product of several functions, yet each function had been separately acquired, it was set in operation only by one exactly identical stimulus, it produced one exactly identical response, and it was totally uninfluenced by any other function. Two or more functions may be operated together, yet each operated in precisely the same manner, whether it was working in isolation or in any combination whatever. Transfer therefore, was a way of stating that a function which has previously operated in a certain manner along with certain other functions was operated in precisely similar manners along with a new set of other functions.

In an attempt to disprove the first assumption Orata (1928, p. 55) cited inconsistencies in the first experiment. Thorndike and Woodworth tried to determine the influence of improvement in training to estimate magnitudes on the ability to estimate magnitudes of the same general shapes. The general trend does not support the theory according to Orata. His overall findings in examining the results was that the amount of transfer does not vary proportionally with the amount of identical elements.

Further data on proportional transference dealt with the evaluation of an assumption made by Thorndike, (1903, p. 81) very

early in his discussion of the theory of identical elements. He postulated that improvement in addition will alter one's ability in multiplication because addition is absolutely identical with a part of multiplication and because certain other processes, for example, eye movements and the inhibition of all save arithmetical impulses, are in part common to the two functions.

The first evaluative experiment was made at Columbia University by one of Professor Thorndike's colleagues, Professor Poffenberger. One experiment dealt with the influence of training in addition upon ability in multiplication. The results showed interference instead of transference. Comparing the gains of the trained and control group in the test series, the former gained 11.4 seconds and the latter gained 29.7 seconds Taking the gain of the control group as typical untrained subjects, we find an interference effect from the training amounting to 18.3 seconds. Poffenberger (1915).

The other investigation was made by L. W. Cole (1925) on the interference of related mental processes. He extended Thorndike's assumption further by stating that ability in subtraction is transferred to division because substraction is absolutely identical with a part of division. However, Cole concluded that those who practiced in subtraction incurred a loss of 4.8 percent in accuracy in division and neither gained loss in speed. He attributed these statistics mentioned as having a direct relationship to interference and the habits built up there were not brought into use.

Orata (1928, p. 77) reported in his critical evaluation of Thorndike's experimental evidence that his hypothesis of proportional transference is found to be unsupported by his own findings. Orata concluded that the underlying assumption of Thorndike's psychology, namely that a complex act is the sum total of specific particular acts and that an individual reacts piece-meal or by parts to any complex situation, does not square even with the behavior of the lower animals, let alone with the behavior of man (p. 77).

Roger (1910) conducted an experiment to test Thorndike's second assumption that learning to respond to all component elements, whether such learning has been made by responding separately to these elements or in any combination, means equal ability to respond to the whole situation. Roger (p. 19) made a test in which a subject was tested with a puzzle in a given form. Then all the motor habits necessary for the rapid solution of this form were built up by practice on the separate acts of manipulation involved. The elements were organically related in the successive forms of the practice series, so that the practice was not on the separate elements, merely but on their connections. At the close of the practice series, the subject was given the complete form which was identical with that of the initial test. This form was not recognized as being related to the practice series.

Roger, (p. 349) investigated whether Thorndike's experiment resulted in maximum transfer. He reported that the

condition of the experiment departs so radically from ordinary classroom condition that it may well be questioned whether results so obtained can determine even approximately the amount of transfer possible in the case of school subjects. Even where experiments have been carried out in the schoolroom as by Winch (1908) and Sleight (1911), the methods of securing the greatest transfer was not utilized. It seems reasonable therefore to conclude that even if but slight transfer effect has been found in experimental work, judgment against widespread of improvement in general should be suspended since the conditions favorable to generalization were absent.

## Theory of Generalization

Orata (1941) in his survey of the evidence for transfer of training stated, "As the theory of identical elements tends to become obsolete, the role of insight and generalization becomes more thoroughly established."

Judd was one of the first psychologists in America to differ with the doctrine of identical elements. In his writings, he emphasized the importance of generalizations. He experimented with subjects who were taught the principle or generalization involved in a task and compared their performance with subjects who did not know the principle. His objective was to test the effect on transfer of knowledge of a generalization. Although his test group was small and there was no control group, yet his conclusion that knowledge of a principle facilitates transfer had a great effect, Judd (1908).

Contrary to Thorndike's claim that mental functions are highly specific, separate experiments by Judd (1908 pp. 30-31); Ruger (1910, pp. 18-19); Woodrow (1927, pp. 159-172); and Meredith (1927, pp. 37-45) indicated that such functions can be generalized if appropriate methods are used in their acquisition.

Judd (1908) reported that two observers were given a series of tests in the comparison of two geometrical figures. The figures compared were complex and were incorrectly perceived because of their complexity, giving rise to what is known as a geometrical illusion. One of the two figures was over-estimated; the other was under-estimated as a result of a long series of comparisons, the two observers ultimately overcame the tendencies toward over-estimation and under-estimation; that is they learned to apprehend the lines correctly. They both learned this lesson in about the same number of comparisons showing that they were both at the outset equally capable of taking on the effects of practice. During the course of the experiment, one observer was kept in total ignorance of the results of practice. While they entered upon the second stage of experiment, one had practice, but did not know its effects. The figures which they were using for comparison were reversed and a second series of tests began. When they began working with reversed figures, both observers showed confusion under the new conditions. Very soon, however, the observer who knew about the effects of practice adjusted himself to the new demands and rapidly overcame the illusion. There was in this case a speedy and advantageous transfer of practice. The

other observer who did not know the effects of his earlier experience showed a greater error than at any time in the first series, and what is still more important, he showed no disposition to improve. In spite of the difference in the final outcome it should be noted that the practice gained in the first series was transferred in both cases. In one case it was work improvement; in the other it not only worked against improvement by increasing the illusion, but it also rendered the observer incapable of rapid adjustment.

A second experiment was reported in the same article. At the suggestion of Dr. Judd, Mr. Scholakom conducted an experimental investigation of the effect of knowledge of the law of refraction upon ability to hit a target placed under water. The difficulty of hitting the target arises, of course, from the deflection which the light suffers through refraction. The target is now where it seems to be, and the boy must fit his aim with the dart with conditions which differ from those which he knows in ordinary life. The amount of refraction and the consequent displacement of the target are capable of definite theoretical explanation before one throws the dart. In this experiment, one group of boys was given a full theoretical explanation of refraction. The other group of boys was left to work out by experience without theoretical training. These two groups began practice with the target under 12 inches of water. It is a very striking fact that in the first series of trials the boys who know the theory of refraction and those who did not gave about the same results.

That is theory seemed to be of no value in the first tests. All the boys had to learn how to use the dart, and theory proved to be no substitute for practice. At this point the conditions were changed. The 12 inches of water were reduced to four. The difference between the two groups of boys now came out very strikingly. The boys without theory were very much confused. The practice gained with 12 inches of water did not help them with the 4 inches. Their errors were large and persistent. On the other hand, the boys who had the theory fitted themselves to 4 inches very rapidly. The theory evidently helped them to see the reason why they must not apply the 12-inch habit to 4 inches of water. Note that theory was not of value until it was backed by practice, but when practice and theory were both present, the best adjustment was rapidly worked out (pp. 36-37).

The experiment was continued further to determine how long those without theoretical training mastered the target at 4 inches below the surface of the water. They did master the 4 inches, but were again confused with 8 inches.

Roger (1910, pp. 18-19) reported that a given subject was tested with a puzzle thrown in chance positions. He was then trained to approximate the physiological limits in handling four special but important positions. He developed no general rule to include his treatment of these special positions. He was then re-tested with the puzzle in chance positions. Another subject was retrained entirely with chance positions, in a series approximately half the length of the first subjects series. The

second tests of the first subject showed no improvement over the initial results and were inferior to those of the second subject. This failure to profit by the highly specialized training seems to have been due to the lack of generalized rule of procedure. As it was, each chance position was first reduced to one of the four special positions and then the solution was proceeded with instead of being performed directly.

In the second attempt a certain puzzle was so arranged that it could be presented in various forms. The manipulation for these various forms could all be comprised under a single formula. This general formula could be deduced from any one of these special forms. A number of subjects were tried with this puzzle. As soon as skill was acquired in dealing with one form of the puzzle it was changed to another form. The subjects who developed the general formula during the solution of the first form were able to use the specialized habits built up in the first form in the second. Those who formed merely the special habits without developing the principle attempted to carry over the habits without modification and were greatly embarrassed by the change.

In the third attempt, the procedure was of the same order. Subjects practiced in a puzzle of one form and then were given another puzzle of the same form. "The similarity of the two puzzles was not recognized and consequently there was no transfer of training."

Roger concluded, in general, "the value of specific habits under a change of conditions depended directly on the presence of a general idea which would serve for their control" (p. 18). He said further that "transfer was more effective in those cases where the formula or general rule was developed in the first few trials, and where the formation of perceptual motor habits had been controlled and interpenetrated by it from the start, than when generalization had been arrived at after these had been setup" (p. 88).

Woodrow (1927) reported that this first experiment as well as the second were conducted primarily for the purpose of comparing the relative amount of transfer as a result of different kinds of training of the subjects in the practice series. Consequently, in each experiment there were three groups instead of two: one control group and two training groups. One of the training groups was trained according to the traditional method of practice, habit formation, and the other group was trained in conscious formulation of technique of procedure. All of these groups were given the preliminary and end test as usual. In addition to these tests the practice group was given drill in memorizing "in a routine fashion without any explanation of principles, discussion of methods or comparison of the methods to be used in the different kinds of problems." To the training group some practice was given in memorizing, but in addition there was conscious formulation, discussion, and comparison of different techniques of memorizing. The results of the experiment showed

conclusively that the group which was trained in mere routine fashion was inferior to that which was given the benefit of formulating generalization of techniques of memorizing.

Meridith's (1927) experiment was a corroboration of Woodrow's findings. It dealt with the determination of the amount of transfer from the definition of scientific terms to the definition of ordinary words in daily use. Three equivalent groups were established on the basis of scores of intelligence tests and teachers estimates. Group A was the control group, B the practice group, and C the training group. As in the experiment of Woodrow, all of these groups were given the preliminary and final tests. Group B was given training in defining scientific terms in mere routine fashion, that is, "without conscious ratification." On the other hand, the members of Group C "were trained in definition, the extent of training amounted to three periods of discussion of some 10 minutes each, which include practice in defining and critical analysis of actual definitions. The training was thus not a simple, unitary process, but a combination of several activities involving the higher critical function of the mind." That is, in Group C, in addition to drill in defining scientific terms, there was a critical analysis and evaluation of the features of a definition.

The results of Meredith's experiment supports Woodrow's findings. "Group C benefited in its training in defining scientific terms and carried this training over, or "transferred" it to the definition of ordinary terms."

Orata (1928, p. 99) concluded in his critical review that the difference between Thorndike's procedure and that of Woodrow, Meredith and Judd is quite evident. Thorndike trained his subjects in routine fashion without conscious formulation of guiding principles. The results showed very little transfer in most cases and interference in others. These findings were verified by Judd, Woodrow, and Meredith in the case of practice groups that were merely drilled in routine fashion. But besides this practice group, Judd, Woodrow and Meredith had another group which, in addition to practice, was given training in conscious formulation of guiding principles or generalization (Judd), training in technique of memorizing (Woodrow) or of "critical analysis of the important features of a definition" (Meredith, p. 99). Orata further concluded that based on these findings that when an individual is trained in mere "routine fashion" or drill, he gets fixed and mechanical habit which does not transfer. Conversely, when he is trained consciously to organize his knowledge or procedure in such a way that general principles are formulated, the result is not a mechanical habit but generalization - or adaptive and flexible form of behavior which by virtue of its flexibility transfers.

## Interpretation of Transfer

Bruner (1960), in the following passage, points out two types of transfer:

"The first object of any set of learning over and beyond the pleasure it may serve is that it should serve us in the future.

One through its specific applicability to tasks that are highly similar to those we originally learned to perform. Psychologists refer to this phenomenon as specific transfer of learning. The first type of transfer that Bruner refers to is sometimes known as vertical transfer. Gagne (1970, p. 337) suggested that vertical transfer "...is observed when a capability to be learned is acquired more rapidly when it has been preceded by previous learning of subordinate capabilities."

Thorndike (1950), reporting on how children learn the principles and techniques of problem solving, believes there are two reasons for the fact that acquiring knowledge and being able to apply it when appropriate are different abilities. An individual may have an aptitude for the former and not for the latter. Also the manner in which the knowledge is acquired has a bearing on how readily it can be used. Knowledge acquired largely by memorization, by the "pouring-in process and without many relationships being established with the individual's existing knowledge, has a low transfer ability. Knowledge which becomes understanding by virtue of teaching which fosters learning by discovery, which deliberately establishes relationships and which aims at broad concepts and generalizations has higher transferability. The ability to transfer one's knowledge and understanding - to find a meaning in a situation - facilitates the formation of hypotheses.

Transfer is used in many different contexts. Orata (1941 p. 81) reported that transfer is a fact, as revealed by nearly 80 percent of the studies; second, transfer is not an

automatic process, that can be taken for granted, but it is to be worked for, and third, the amount of transfer is conditioned by many factors, among which are age, mental ability, (possibly) time interval between learning and transfer, degree of stability attained by the learned pattern, "knowledge of directions, favorable attitude toward the learning situation, and efficient use of past experience", accuracy of learning, "conscious acceptance by the learner of methods, procedures, principles, sentiments, and ideals", meaningfulness of the learning situation, the personality of the subject - greater transfer in extroverts than in introverts, method of study, suitable organization of subject matter presentation, and provision for continuous reconstruction of experience.

## Current Research

Hagee and Stewart (1970) employed replication to determine the effects of transfer on three types of laboratory instruction from a single cylinder agricultural engine. Although the results indicated that construction method did affect task completion time, the results did not indicate significant differences among treatment groups on mean quality scores. Yoder (1978) employed specific transfer in his study to determine the effects of previous high school training in agricultural mechanics upon achievement of students enrolled in a college level agricultural mechanics course. Yoder concluded that students who had received high school instruction in vocational agricultural and industrial arts did not perform significantly better than those

who did not, and mechanical aptitude test scores were not significantly different from those who had previous agricultural mechanics instruction compared to those who did not.

McClintock (1974) reported in his study designed to compare the effects of three methods of mathematics instruction on variables related to transfer of learning, that for all groups, transfer to tasks similar to the training tasks was greater than transfer to very dissimilar tasks. Students in the highest achievement category showed greatest transfer for all variables. No significant differences attributable to instructional method were determined.

Bruner's (1960) second type of transfer is usually referred to as horizontal or lateral transfer. He suggested that a second way in which earlier learning renders later performance more efficient is through what is conventionally called non-specific transfer, or more accurately, the transfer of principles and attitudes. In essence, it consists of learning initially not a skill but a general idea, which can then be used as a basis for recognizing subsequent problems as a special case of the idea originally mastered. This type of transfer is at the heart of the educational process...(p. 17). For Gagne (1970, p. 335), lateral transfer refers to "...a kind of generalizing that spreads over a broad set of situations at roughly the same level of complexity." Wixson (1969), in his study using mathematical approaches to teaching two topics in high school biology, reported that tests of lateral and vertical mathematics transfer, biology

achievement and attitudes toward the place of mathematics in society were administered to the experimental group and to comparable group using the "standard" technique for each group. In the cell topic, the mathematical treatment enhanced later transfer. In the genetics topic, the mathematical treatment had vertical value. Wixson (1969) concluded that the variation in approach had no effect on attitudes toward the place of mathematics in society. Hancox (1969), in his study to determine the effectiveness of programmed instruction in mathematics as a means of increasing college student achievement in electronics, concluded after 12 weeks' attendance in an electronics technician school that course test results revealed no significant differences between the two groups.

For Hansen (1967, p. 24), transfer of learning "...refers to the applications of knowledge learned in one setting to problems in a setting which is only remotely similar to the setting in which the learning took place." According to Ray (1957, p. 5), "transfer occurs when old learning and new problem situations are interrelated because of common components, factors, stimuli, or relations."

Leighbody and Kidd (1966) made these comments correlating transfer with skill development: "In attempting to understand how individuals learn new skills or ideas, it is important to know what part is played by the learner. One of the first things to realize is that the teacher cannot give the learner any skill or knowledge by simply presenting this skill or knowledge to the

student. It is not a matter of transferring what the teacher knows into the hands or minds of his pupils. The one who is to learn must do something in which his mind and muscles will take on new ideas or skills from the teacher by observing and listening, but he must attempt to use these skills and ideas himself. It is only when the pupil is engaged in putting into practice what he has seen, heard or read, that the learning process becomes complete.

Conversely, rather than the pupil using the skill as part of the learning process, Piryov and Tzanev (1975), in their study, emphasized presenting the skill or knowledge to the student through the transfer of creative and technical thinking. They reported that one of man's contemporary vocational activities is his increasing "intellectualization." This requires constant improvement of the vocational and prevocational training of students, especially with respect to technical thinking. The transfer of knowledge is one of the aspects of technical thinking, more especially of creative thinking. In fact, the transfer of knowledge is simultaneously a result and a criterion of the development of creative thinking (p. 105).

The purpose of their investigation was to study the extent and quality of transfer of knowledge from the school subjects mathematics, physics and technology of metals to the teaching of metal-cutting machines and turnery. Four groups of students from the highest classes of the gymnasium (secondary general polytechnic school) and the two highest classes of a

technical (technicum) school in Sofia, Bulgaria, were subjected to experimental testing. The coefficients of correlation between the results of problem solving and the school marks of students were calculated, as well as the relations between the results of the experiments and the time taken by each student for the work on the problems (p. 105).

Piryov and Tzanev (1975) concluded the following:

> "1. As a rule, students find it difficult to transfer knowledge from mathematics to the realm of technics.
>
> "2. The school marks of the students show low coefficients of correlation with the type of problems set up in the experiment, while the coefficients of correlation between the school subjects are high and reliable. This shows that the transfer of knowledge does not depend, as a rule, on the school record of the student.
>
> "3. The type of school (general polytechnical and vocational) had no statistically significant bearing upon the transfer of knowledge (p. 105)."

These findings indicated that students in both general polytechnical and vocational schools were able to master the subject matter but special training is required for the transfer of knowledge to the field of technics.

A series of five related studies (Ray, 1957; Rowlett, 1960, 1964; Moss, 1960; and Grote, 1960) have compared the relative effectiveness of direct-detailed and directed-discovery methods of teaching technical subject matter from the area of industrial education. Presumably, technical subject matter was chosen because of its unfamiliarity to the learner. In each study, approximately 1 hour of instruction was presented by means of

tape recordings integrated with student workbooks. The studies by Ray, Rowlett and Moss employed instructional aids or models. All studies used subjects stratified into three ability levels to test for levels-by-treatments interaction. All studies included an uninstructed control group which took all criterion tests.

Essentially, in the direct-detailed method, the learning task was presented in a detailed, step-by-step procedure, where leading questions and sequences of questions, each followed by a pause, were used to direct the student's attention to problems or applications to be discovered by the students. For each study, five criterion measures were employed: initial learning, early and late transfer, and early and late retention. The studies differed in methods of experimental analyses and each study used the student score as the experimental unit rather than the class mean. The tape recorded instruction was group presented, and there is the possibility that a student's nonverbal behavior, when manipulating models, could have provided clues to other students. Indiscriminate pooling of the data was also common to these studies; the experimental conditions for learning within each class were not completely controlled; e.g., time of day, physical setting and random external events, rendering different treatment effects under the same method.

Only one of the five studies using high school students reported significant findings concerning retention or transfer. Rowlett (1964), in his study comparing the direct-detailed and

directed discovery methods of teaching orthographic skills and principles to 147 female students concluded that (1) the directed-discovery group was superior to the direct-detailed group on the 6 week transfer test; (2) there was no interaction; (3) the average ability direct-detailed students were superior to the average ability direct-detailed students on 6 weeks retention test; and (4) the low ability directed-discovery students were superior to the low ability direct-detailed students on the 6 weeks transfer measure. However, Weimer (1975) concluded that Rowlett's findings should be considered tentative due to a questionable analysis of the data and evidence of contamination of the treatments. Weimer suggested that a Factoral Anova design would have been more appropriate for checking the presence of interaction (p. 211).

## Summary

After Thorndike and Woodworth, the most important formulation of a theory of transfer of training is that given by Judd in his doctrine of generalization. Judd was the first to experiment with the effect of knowledge of a principle involved in a task on transfer. He pointed out the importance of understanding of concepts and experimented with the effect of such understanding on skills.

Of all the theories of transfer reviewed in this chapter, that of formal discipline is the only one that has been thoroughly discredited. All of the others have been accepted, if not totally then in part, by all groups of psychologists.

According to Rosskoff (1953), there remains much experimental work to be done on transfer. He stated:

> "that we not only need to learn more about what is transferred, but we need to experiment to see how transfer can be facilitated. Experimental research indicates that transfer is a fact. How to make the percentage of transfer larger is a problem that every teacher recognizes and that every teacher works on in his own classroom (p 220)."

# CHAPTER III

## SUBJECTS, MATERIALS, PROCEDURES AND DESIGN

This study investigated the relative effectiveness of general and specific transfer on acquisition of aptitude in engineering in precollege engineering programs for minorities. Descriptions of the subjects, materials, procedures and design follow.

### Subjects

The subjects in this experiment were 11th and 12th grade high school students in the northeastern and midwestern parts of the United States. The total population was comprised of members of minority groups, Blacks and Hispanics. All of the subjects in this experiment were participants in precollege engineering programs. The two programs selected for this study were the RCA Minority in Engineering Program (MEP) and the Minority Introduction to Engineering Program (MITE).

The Financial Aid Needs Committee of the Committee on Minorities in Engineering 1978 reported incomes of families of minority students enrolled in engineering programs were higher compared with all minority students enrolled in post secondary education. It was also reported that there is a high correlation between parental income and student ability, thus concluding that engineering students have greater measurable academic ability than the average post secondary student.

The sample of subjects used in this experiment were approximately 120 male and female 11th and 12th grade students classified as college preparatory; i.e., enrolled in or completed a minimum of three physical science and mathematics courses. A

majority of the subjects were enrolled in or had completed chemistry, earth science, general physics, algebra and geometry. A minority of students had enrolled in or completed advanced or honors courses in science and mathematics. A majority of the subjects had received a "C" or better grade in each course.

The average composite SAT score ranged from 600 to 1300 with the math score being the higher of the two. A significant number of subjects ranked in the upper half of his/her class.

The social economic status of the families of the subjects included all income levels - low, middle and high - with the majority of the subjects in low and middle income families.

## Materials

The Engineering Sciences Aptitude Test (ESAT) is a battery that is designed to predict success in the first year of engineering school. The battery was designed during the period of 1965-67 to be used with high ability students in grades 9 through 12.

### Validity

A validity study was carried out in the academic year 1967-68 in nine engineering schools, and one technical school. The test battery was administered to entering students at the beginning of the freshman year and test scores were related to grades obtained by these students during the year. The test battery consisted of three tests, verbal, numerical and science. The verbal was a 70 item test of word knowledge requiring the student to identify synonyms. It was felt that such a verbal

test provided a good measure of verbal ability. Although it might be expected that verbal ability is not the most important ability for success in engineering, the high verbal demands of academic work in general was the reason that the verbal test was included (Psychological Corporation 1967-68).

The numerical test, referred to by the test constructors as a basic mathematics test, consisted of 45 multiple choice items covering fundamentals of algebraic operations, geometry, and number systems.

The science test contained 70 items of information and problem solving cutting across many areas of science and engineering. The questions were designed to deal primarily with applied rather than basic areas and the problems emphasized the use of mathematical formulation.

Several factors were cited that affected the validity study. First, the meaning of the criterion first-year grade point average (GPA) may differ from college to college.

Another factor affecting validity was preselection of students. Since the test was administered only to freshman students who had already been admitted, lower ability applicants who may have been rejected by colleges were not tested.

Some of the colleges tested the complete freshman class and some tested only part of the class. Not all of the students in all of the 10 colleges took all three tests. Since the science Verbal and Numerical subtests each took about one class period, some schools gave only the science, some the verbal and numerical

and some the total battery.

The number of students involved in the validity study affected the stability of results. Where relatively small numbers are included, statistical measures such as the mean score and the correlation coefficient may be expected to fluctuate widely by chance alone.

The results from the validity study for the verbal test varied widely from school to school. The one technical institute in the group had the lowest mean (32.6) and the means of the other schools ranged from (38.6) to (50.2). For six of the schools the correlation between the verbal test score and first-year grade point average was r = .25 or greater. Although for most colleges this correlation is statistically significant, it does not indicate a generally high verbal test-GPA relationship. The results indicated that verbal ability was more closely related to GPA in some colleges than in others (Psychological Corporation p. 3).

For the numerical test also, wide variation appeared from college to college in the mean scores obtained. The technical institute had the lowest mean by a margin of about one standard deviation. The other means ranged from (26.9) to (36.0). All of the test score-GPA correlations were higher for the numerical test; all were over r = .40, with a range of r = .41 to r = .57. The correlations indicated that the test is an effective predictor

of success, even among students who had already been chosen as likely to succeed in engineering school (Psychological Corporation p. 3).

The mean scores on the science test varied from college to college from (42) to (52.9), with the exception of the technical institute which had a science mean of (34.4). The test GPA correlation were statistically significant for most of the colleges (Psychological Corporation p. 4).

An intercorrelation study was carried out to establish whether the subjects represented relative independence measuring what each purports to measure. The correlation of r = .41 between the verbal and numerical indicated a relative independence of these two measures. The science test correlated about equally with both the verbal and numerical sections r = .59 and r = .54 (Psychological Corporation p. 5).

The ESAT-Verbal correlates highest with the ACT-Social Science Test r = .68 The high correlation of r = .78 between the ESAT numerical and the ACT Math indicated substantial overlap in abilities measured by these two tests. The ESAT science test correlates highest with the science section of ACT r = .69. The correlation of r = .82 between the two totals established high reliabilities of the test (Psychological Corporation p. 5).

The conclusion in the validity study suggested that although there were limited comparisons with other commonly used test batteries (the ACT and CEEB-SAT), the ESAT was as good a predictor as either of those tests(Psychological Corporation p. 7).

The Bennett Mechanical Comprehension Test (BMCT)

This is a test for grades 9 through 12 and adults to measure the ability to perceive and understand the relationship of physical forces and mechanical elements in practical situations. Bennett (1969).

Reliability

The manual indicates a range of coefficients from r = .81 to r = .93 with a median value of r = .86. The standard errors of measurement range from 3.0 to 3.8. The reliability coefficients are split-half (odd-even) coefficients corrected for the full length of the test by the Spearman Brown formula. More evidence of form to form stability is provided by the manual of the Differential Aptitude Tests. Over a period of several months, the Mechanical Reasoning Test correlated about r = .70 across forms, with associated standard errors of measurement of around 4.4 points. (Bennett p. 7.)

Validity

The authors reported that BMCT measures a type of aptitude which is important for wide variety of jobs, but those same jobs may require other types of aptitudes as well. It is suggested that the BMCT is most effective when used in combination with some other test. For example, if a job or training requirement involves the use of technical manuals or textbooks, a mental ability test yielding verbal and numerical scores at a reasonably demanding level, such as the Wesman Personnel Classification, is

frequently desirable (Bennett p. 8).

A number of studies of validity of mechanical comprehension tests have been undertaken with its various forms. Resulst of these studies indicate that validity coefficients vary over a considerable range. The authors report that these differences are the results of the intrinsic importance of this aptitude for respective tasks. They further contend that these fluctuations represent differences in the reliability and authenticity of the tests content (Bennett p. 8).

Bechtoldt (1972) reported that the objective of the test as stated by the authors measures the ability to perceive and understand the relationship of physical forces and mechanical elements in practical situations, and seems to have face validity. He also observed that no direct evidence of accurate prediction of rate of acquisition of skill or a change in performance with practice or training is provided.

Sex Differences in Mechanical Comprehension

Bennett and Cruikshank (1942) reported that mechanical aptitude has much less significance for women than for men. They further stated that the prevalent culture in the United States places the mechanical trades, engineering, and physics in the male domain. They concluded that girls are usually discouraged by their parents if they display interest in electrical or mechanical toys or in automotive repairs. According to the 1960 census statistics cited in the manual, women are almost never admitted to apprenticeship as electricians or machinists, and the

percentage of women who achieve a bachelor's degree in engineering is very small indeed.

More recent statistics reported in the Scientific Manpower Commission (1979) that the proportion of bachelor's degrees granted to women continues to increase in nearly every field. In 1971-72 only 1.0 percent of the proportionate number of bachelor's degrees were awarded to women in engineering. However, in 1976-77, 4.5 percent of engineering degrees were awarded to women. In the area of computer and information sciences, the total women receiving degrees has increased from 13.6 percent in 1971-72 to 23.9 percent in 1976-77.

The BMCT Manual reported that only about 10 percent of high school senior girls reach or exceed the mean of high school senior boys in the understanding of how simple machines operate. Since more women are pursuing technical fields, however, it is expected that the percentages for girls will be significantly higher than the reported 10 percent.

## Treatment Period Procedures

Both programs have administered pre and post questionnaires to assess the affective aspects of each program. In addition, the MITE program has followed up with annual questionnaires sent to past participants. In 1976, 51 percent of the total number of MITE participants responded to the questionnaire.

According to O'Bryant (1977), 78 percent (85 percent of the males and 68 percent of females) indicated engineering or science as their field of choice. Fifty-three percent said they

intended to study engineering or a related area both prior to and after the program. Twenty-seven percent said they intended to study engineering or a related area, whereas prior to attending the program they did not. Four percent decided engineering was not for them, and 15 percent both before and following the program were not intending to go into engineering. Eighty-nine percent responded that the MITE program helped them to determine career goals.

O'Bryant (p. 5) reported that 20 percent of the MITE respondents changed their senior high school year program. The most common reason was "because engineering requires a strong background in mathematics and science."

O'Bryant (p. 6) concluded that the questionnaire results for each year replicated the previous years totals. The percentages are nearly identical with the results from the 1975 and 1974 programs.

In 1977 data was collected and analyzed as a follow up to the 1975/1976 and 1976/1977 RCA Minority Engineering Program. The primary objectives of the questionnaire were to determine whether the components of the program established an image of engineering as a desirable profession and to encourage the participants to consider their suitability and interest in engineering through their experiences. According to Jenny (1977) of the total number of participants in the 1976/1977 program, 61 percent indicated that they had developed an understanding of engineering as a career, 35 percent indicated that they had developed "some"

understanding and four percent indicated "very little" or no understanding of engineering as a career. Similarly, the totals tabulated in 1976/1977, 64 percent and 36 percent were almost identical to the totals tabulated for the previous year.

Jenny (p. 2) also reported that results of the 1975/1976 program had indicated that 40 percent of the total number of participants had been stimulated to consider engineering as a career, 58 percent had indicated some stimulation toward engineering and two percent had very little or no stimulation toward engineering. The percentages for the 1976/1977 program were 44 percent, 50 percent and 6 percent respectively.

Although the questionnaires for both programs lacked psychometrical qualities, it was the opinion of this researcher that the results suggested that these programs did accomplish what they have purported to do, stimulate an interest in engineering with a majority of their participants.

Because so much emphasis had been directed to the affective phase of these programs, this study did focus on the cognitive phase to determine whether the participants do acquire an aptitude in engineering as a result of the training.

Activities of the experiment included random selection of minority high school students in the 11th and 12th grades. The high schools selected for this experiment had a significant percentage of minority students, 30 percent to 90 percent Blacks and

Hispanics, in relation to the total school population. The random selection came from a pool of minority students who met four or five of the following criteria:

1. Year in school.
2. Passing grades in mathematics and science courses.
3. Interest in science as indicated by completed courses.
4. Recommendations by math and science teachers.
5. Completion of precollege program application form.

One hundred and twenty subjects in this experiment met the same preselection criteria and were randomly selected from a pool of minority high school students and randomly assigned to the three treatment groups: MITE, MEP and the Control Group.

Each of the subjects in the experimental precollege engineering programs, MITE and MEP, participated for approximately 30 hours or the equivalent of 5 hours per day for a total of 6 days.

The objective of the RCA (MEP) program was to identify minority students with an interest and aptitude in engineering to expose them to what was involved in pursuing an engineering career and to provide them with a role model. A group of 40 students who participated in engineering-related experiences were instructed in related engineering concepts by an engineer. This program allowed the participants to experience what an engineer does on his job and at the same time expose them to what competencies they need in mathematics and sciences as applied to solving engineering problems. The program was designed to involve

the student, in a simple way, in the tasks the engineer encounters: planning, analyzing, designing, computing, building, and evaluating. The program placed major emphasis on performance practice or "hands on" projects rather than theory or formal study. These sessions were conducted at one of the RCA locations in New Jersey.

The MEP treatment component was divided into sessions. In a 6-day schedule, the following topics were covered:

DIGITAL ELECTRONICS

| SESSION SUBJECT | TEACHING AIDS | STUDENT PARTICIPATION |
|---|---|---|
| FIRST DAY | | |
| Get Acquainted MEP Plan, goals, activities introduction to RCA, course content and objectives (what we will do and hope to accomplish) | MOVIE: "A Piece of the Action" Handout | Introductory comments by students. Group discussion on the movie |
| What is Engineering? Types, jobs, accomplishments guided design: digital electronics their use and future | MOVIE: "Nothing but Common Sense" handout | Rap session, salaries, job hang-ups group exercise |
| Number Systems Decimal/binary and hexadecimal use and manipulation | handout | conversion exercise |
| SECOND DAY | | |
| Logic Building Blocks Gates and truth tables, led indicators. What can you do with this? | Experimental verification with training kit | |

| | | |
|---|---|---|
| Boolean Algebra | Logic and applications to simple but useful examples | |
| FOURTH DAY | | |
| Computer programming | COSMAC microtutor | Terminal use |
| Computer applications what uses engineers are making of computers | handout | tour |
| FIFTH DAY | | |
| Construction project - what is a calculator, how does it work? Electronic calculator numerical method | Calculator kits movie: Micro Electronics | students build kits |
| SIXTH DAY | | |
| Electronic calculator numerical method | Calculator kits | Students build kits |
| SEVENTH DAY | | |
| Summary Program Evaluation Administer NEAS Test | | |

At the end of the treatment period, the National Engineering Aptitude Search test was administered to the RCA (MEP) Group. The scores on this test determined to what extent performance practice, through practical applications, can transfer aptitude in engineering.

This particular program was designed to develop a general understanding of basic engineering concepts and skills.

Minority Introduction to Engineering (MITE)

The objective of MITE was to significantly increase future minority student enrollments in schools of engineering. This objective was accomplished by means of resident 1-week or 2-week summer programs for minority high school juniors and seniors. A group of 40 students attended classes and were introduced to engineering. The program allowed the participants to experience college life and attempted to motivate them to set high career goals. It did expose them to the different fields of engineering and science. The major component of the program included lectures on science, mathematics and introductory engineering courses. The minor component of the program introduced the students to engineering through field trips to industrial installations, demonstrations, tours, laboratory experiments and mathematics as applied to the solving of engineering problems. This program placed major emphasis on theory or formal study rather than performance practice or "hands on" projects.

The MITE treatment component was divided into classes. In a 6-day schedule, the following courses were covered:

| SESSION SUBJECT | TEACHING AIDS | STUDENT PARTICIPATION |
|---|---|---|
| FIRST DAY | | |
| Organization Orientation and Welcome | Handouts | Discussion |
| Engineering Science Lecture | Textbook/Handouts | Lecture |
| Computer Science Lecture | Textbook/Handouts | Notes |
| Metallurgy and Mineralogy Engineering Lecture | Textbook/Handouts | |

SECOND DAY

| | | |
|---|---|---|
| Math and Engineering Problems | Textbook/Handouts | |
| Civil Engineering Lecture | Textbook/Handouts | Lecture |
| Ceramic Engineering Lecture and | Textbook/Handouts | Notes |
| Demonstrations | Lab Equipment | |
| Metallurgy and Mineralogy | Textbook/Handouts | Lab |
| Lab | Lab Equipment | Notes |

THIRD DAY

| | | |
|---|---|---|
| Physics Lecture | Textbook/Handouts | |
| Strength of Materials Lab | Handouts/Lab Equip | Lab Notes |
| Electrical Engineering Lecture | Textbook/Handouts | Lecture |
| Math and Engineering Problems | Textbook/Handouts | Notes |
| Computer Science Lecture | Textbook/Handouts | |

FOURTH DAY

| | | |
|---|---|---|
| General Engineering Lecture | Textbook/Handouts | |
| Math and Engineering Problems | Textbook/Handouts | Lecture |
| Nuclear Engineering Lecture | Textbook/Handouts | Notes |
| Mechanical and Industrial | Textbook/Handouts | |
| Engineering Lecture | Textbook/Handouts | |

FIFTH DAY

| | | |
|---|---|---|
| Math and Engineering Problems | Textbook/Handouts | |
| Opportunities in Chemistry | Handouts | |
| Physics Lecture | Textbook/Handouts | |
| Aviation Lecture | | |
| Demonstrations in Mechanical and | Lab Equip. | |
| Industrial Engineering | Handouts | |

SIXTH DAY

| | | |
|---|---|---|
| Electrical Engineering Labs | Lab Equip. | Lab |
| Nuclear Engineering Lab | | Notes |
| Agricultural Engineering | Textbook/ | Lecture |
| Lecture | Handouts | Notes |
| Hydraulics Lab | Lab Equip./Handouts | |

SEVENTH DAY

Summary, Program Evaluation
Administer NEAS Test

At the end of the treatment period, the National Engineering Aptitude Search test was administered to the MITE Group. The scores on this test did determine to what extent formal study, through lectures and laboratory demonstrations, transferred aptitude in engineering.

This particular training was designed to develop a specific understanding of elements identical to basic engineering concepts and skills.

## Control Group

The Control Group did not participate in either the MITE or the MEP treatment components. These 40 students were administered the National Engineer Aptitude Search Test to determine whether there was a significant difference on acquisition of aptitude in engineering among the three groups.

The results of the treatment did attempt to determine whether there was a significant difference in mean scores of the National Engineering Aptitude Search Test among the three treatment groups: the RCA Minority Engineering Program (MEP) which placed major emphasis on performance practice or "hands on" projects; the Minority Introduction to Engineering (MITE) which placed major emphasis on theory or formal study; and the Control Group, which did not participate in either the RCA program or the MITE program.

## Design

The independent variables in this experiment were the two methods of transfer in precollege engineering programs for minorities:

a. Performance Practice

RCA Minority Engineering Program (MEP)

b. Formal Study

Minority Introduction to Engineering Program (MITE)

The dependent variable was the acquisition of aptitude in engineering as measured by the National Engineering Aptitude Search test.

The basic design of the experiment was a modification of Campbell's and Stanley's (1963) post test only control group design #6.

The experiment compared three groups on the dependent variable on acquisition of aptitude in engineering. The "X" represents the experimental groups RCA (MEP) performance practice, MITE program formal study, and the third group was the control group, nonparticipants in either program.

$$\begin{array}{lll} R & X_1 & O_1 \\ R & X_2 & O_1 \\ R & & O_1 \end{array}$$

## Statistical Tests

The hypotheses were tested by a 3x3x2 analysis of covariance multivariate design using SAT scores as the covariates

The data was analyzed to determine differences in engineering aptitude between groups when categorized according to treatment groups, sex and socio-economic levels - high, middle and low.

# CHAPTER IV

## RESULTS AND CONCLUSIONS

Data collected in the completion of the design described above were subjected to statistical analyses to test the research hypotheses posed in this study. Results of the analyses, along with the statistical decisions regarding each research hypothesis are presented in this chapter. Conclusions are discussed and interpreted in Chapter V.

An alpha level of .05 was selected to test for statistical significance of all hypotheses presented separately. Numerous related tables and graphs are presented for conciseness and clarity in Appendix A and Appendix B.

Tables 2.1 through 5.2 referred to in this chapter, have been placed in the Appendix A. These tables show the adjusted mean verbal, numerical, science and mechanical comprehension subtest scores for treatment, sex and socio-economic status.

Levels of aptitude in engineering were measured by subjects' total number of keyed responses to the 70 items in the verbal section on the National Engineering Aptitude Search test. Resultant mean values for all subtests were treated through analysis of covariance procedures for a three-way by two-way design.

In analyzing and interpreting the data for hypotheses I and II, Table 2.0 presents the sum of squares for the verbal subtest scores adjusted by the covariates, SAT scores.

TABLE 2.0

ANALYSIS OF COVARIANCE

VERBAL SUBTEST SCORES ADJUSTED BY SAT SCORES

| SOURCE | df | SS | F |
|---|---|---|---|
| TREAT | 2 | 10317.239 | 20.62** |
| TREAT X SEX | 2 | 723.616 | 1.46 |
| SEX | 1 | 1714.888 | 6.85* |
| TREAT X SEX | 4 | 2935.250 | 2.93* |
| SES | 2 | 82.415 | 0.16 |

P < 01**
P < 05*

Hypothesis I, which states there are no significant mean differences in modified verbal scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to treatment and sex, failed to be rejected at the .05 level.

Hypothesis IA, which states there are no significant mean differences in modified verbal scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to treatment, was rejected at the .01 level.

The computed F-value for the adjusted mean verbal scores for treatment is (20.62) which is statistically significant at the .01 level. In examining Table 2.1, the statistical significant F-value for treatment is attributable to the mean adjusted verbal scores for female (80.23) and male (65.74) in the Performance Practice Experimental Group (PP).

Hypothesis IB, which states there are no significant mean differences in modified verbal scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to sex, was rejected at the .05 level.

The computed F-value for the adjusted mean verbal scores for sex is (6.85) which is statistically significant at the .05 level. The statistical significant F-value for sex is attributable to the mean adjusted verbal score for female (80.23) in the Performance Practice Experimental Group (PP).

Hypothesis II, which states that there are significant mean differences in modified verbal scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and socio-economic levels - high, middle and low, was rejected.

The results of the second hypothesis presented in Table 2.0 is the computed F-value for treatment and socio-economic status (2.93) which is statistically significant at the .05 level.

Presented in Table 2.2 are the factors influencing the significant difference for treatment and socio-economic status. The factors are the mean adjusted verbal scores of minority high school students in the Performance Practice Experimental Group (PP) in the high, middle and low socio-economic levels.

Hypothesis II-A, which states there are no significant mean differences in modified verbal scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to socio-economic Levels - high, middle and low, failed to be rejected at the .05 level.

Levels of aptitude in engineering were measured by subjects' total number of keyed responses to the 44 items in the numerical section on the National Engineering Aptitude Search test.

In analyzing and interpreting the data for hypotheses III and IV, Table 3.0 presents the sum of squares for the numerical subtest scores adjusted by the covariates, SAT scores.

TABLE 3.0

ANALYSIS OF COVARIANCE

NUMERICAL SUBTEST SCORES ADJUSTED BY SAT SCORES

| SOURCE | df | SS | F |
|---|---|---|---|
| TREAT | 2 | 2010.514 | 4.08* |
| SEX | 1 | 5.106 | 0.02 |
| TREAT X SEX | 2 | 68.044 | 0.14 |
| TREAT X SES | 4 | 2984.702 | 3.04* |
| SES | 2 | 1919.357 | 3.91* |

P < 05*

Hypothesis III, which states that there are no significant mean differences in modified numerical scores of minority high school students in the 11th and 12th grades on the National

Engineering Aptitude Search Test when categorized according to treatment and sex, failed to be rejected at the .05 level.

Hypothesis III-A, which states that there are no significant mean differences in modified numerical scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to treatment, was rejected at the .05 level.

The computed F-value for the adjusted mean numerical score for treatment is (4.09) which is statistically significant at the .05 level.

In examining Table 3.1, the statistical significant F-value for treatment is attributable to the mean adjusted numerical scores for female (59.55) and male (59.88) in the Performance Practice Experimental Group (PP).

Hypothesis IV, which states there are no significant mean differences in modified numerical scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to treatment and socio-economic levels - high, middle and low, was rejected at the .05 level.

The results of the fourth hypothesis presented in Table 3.0 is the computed F-value for treatment and socio-economic status (3.04) which is statistically significant at the .05 level.

In examining Table 3.2, the statistical significant F-value for treatment and socio-economic status is attributable to the mean adjusted numerical scores for the minority high

school students from families in the high and middle socio-economic levels particularly in the Performance Practice Experimental Group (PP).

Hypothesis IV-A, which states there are no significant mean differences in modified numerical scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to socio-economic levels - high, middle and low, was rejected at the .05 level.

In Table 3.2 the statistical significant F-value for socio-economic status is attributable to the mean adjusted numerical scores for the minority high school students from families in the high socio-economic status in all three groups.

The significant F-value is also the result of the mean adjusted numerical subtest scores for students from families in the middle socio-economic status in the Performance Practice Group (PP) and the Formal Study Group (FS).

Levels of aptitude in engineering were measured by subjects' total number of keyed responses to the 69 items in the science section on the National Engineering Aptitude Search test.

In analyzing and interpreting the data for hypotheses V and VI, Table 4.0 presents the sum of squares for the science subtest scores adjusted by the covariates, SAT scores.

TABLE 4.0

ANALYSIS OF COVARIANCE

SCIENCE SUBTEST SCORES ADJUSTED BY SAT SCORES

| SOURCE | df | SS | F |
|---|---|---|---|
| TREAT | 2 | 2230.453 | 5.53* |
| SEX | 1 | 424.841 | 2.10 |
| TREAT X SEX | 2 | 310.018 | 0.77 |
| TREAT X SES | 4 | 1947.443 | 2 41* |
| SES | 2 | '109.275 | 0.27 |

P < .05*

Hypothesis V, which states there are no significant mean differences in modified science scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and sex, failed to be rejected at the .05 level.

Hypothesis V-A, which states there are no significant mean differences in modified science scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to treatment, was rejected at the .05 level.

In Table 4.0, computed F-value for the adjusted mean science score for treatment is (5.53) which is statistically significant at the .05 level.

In examining Table 4.1, the statistical significant F-value for treatment is directly related to the mean adjusted science score for female (42.02) and male (50.30) in the Performance Practice Experimental Group (PP). Although sex was not significant, male participants in the two experimental groups had

higher mean adjusted science scores than female participants in the same groups and higher than male and female in the Control Group.

Hypothesis VI, which states there are no significant mean differences in modified science scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to treatment and socio-economic levels - high, middle and low was rejected at the .05 level.

The results of the sixth hypothesis is presented in Table 4.0. The computed F-value for the adjusted mean science score for treatment and socio-economic status is (2.41), which is statistically significant at the .05 level.

In Table 4.2, the significant difference for treatment and socio-economic status is associated with the mean adjusted science scores for minority high school students in the Performance Practice Experimental Group from families in the high and low socio-economic levels. Minority high school students in the Formal Study Group (FS) from families in the middle socio-economic level have higher mean adjusted science scores than minority high school students from families in the middle socio-economic levels in the Performance Practice (PP) and the Control Group (CO).

Levels of aptitude in engineering were measured by subjects' total number of keyed responses to the 66 items in the mechanical comprehension section on the National Engineering Aptitude Search Test.

In analyzing and interpreting the data for hypotheses VII and VIII, Table 5.0 presents the sum of squares for the mechanical comprehension subtest scores adjusted by the covariates, SAT scores.

TABLE 5.0

ANALYSIS OF COVARIANCE

MECHANICAL COMPREHENSION SUBTEST SCORES ADJUSTED BY SAT SCORES

| SOURCE | df | SS | F |
|---|---|---|---|
| TREAT | 2 | 9311.284 | 10.59** |
| TREAT X SEX | 2 | 1331.115 | 1.51 |
| SEX | 1 | 4437.461 | 10.09** |
| TREAT X SES | 4 | 522.131 | 0.30 |
| SES | 2 | 908.501 | 1.03 |

P < 01**

Hypothesis VII, which states there are no significant mean differences in modified mechanical comprehension scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to treatment and sex, failed to be rejected at the .05 level.

Hypothesis VII-A, which states there are no significant mean differences in modified mechanical comprehension scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to treatment, was rejected at the .01 level.

In examining Table 5.1, the statistical significant F-value for treatment is attributable to the mean adjusted

mechanical comprehension scores for male (68.97) and female (48.33) in the Performance Practice Experimental Group (PP). The mean adjusted mechanical comprehension scores for male (58.63) and female (40.70) in the Formal Study Experimental Group (FS) are significantly higher than male (32.92) and female (29.57) in the Control Group (CO).

Hypothesis VII-B, which states there are no significant mean differences in modified mechanical comprehension scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search Test when categorized according to sex, was rejected at the .01 level.

In Table 5.1, the significance is directly related to the higher male mean adjusted mechanical comprehension scores recorded for all three groups. Male minority high school students in all three groups had higher mean adjusted mechanical comprehension scores than female minority high school students in the same groups.

Hypothesis VIII, which states there are no significant mean differences in modified mechanical comprehension scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and socio-economic levels - high, middle and low, failed to be rejected at the .05 level.

In examining Table 5.2, the results reveal, although nonsignificant, higher mean adjusted mechanical comprehension scores for all three socio-economic levels for the experimental groups.

# CHAPTER V

## DISCUSSION CONCLUSION AND RECOMMENDATIONS

This chapter discusses the findings in this study. The implications of these results are qualified as a function of the study's limitations. Some suggestions for further research conclude the chapter.

The review of the literature seems to indicate that transfer does occur. In general transfer is used in many different contexts and is conditioned by many factors, among which are age, mental ability and time interval between learning and transfer. Other factors are favorable attitude toward the learning situation and efficient use of past experience. Weimer (1974) reported that transfer of training is measured by many quantitative expressions and because of their variety, the amount of transfer from one experimental study can not necessarily be compared to another experimental study in any standard or systemic fashion.

The present research was an attempt to empirically investigate the theory of transfer on a continuum of two extremes. One extreme was the RCA program (MEP) which was a precollege engineering program designed to acquaint minority high school students in the 11th and 12th grades with the engineering profession by providing on site "hands on" projects. These students also participated in other engineering related activities. These selected curricula placed major emphasis on practical application rather than on theory. The efficacy of transfer of training was

investigated to determine whether aptitude in engineering was acquired as measured by the four subtests on the National Engineering Aptitude Search Test.

The other extreme was the Minority Introduction to Engineering (MITE), which was a precollege engineering program designed to acquaint minority high school students in the 11th and 12th grades with the engineering profession by providing college level engineering courses on campus. These selected curricula placed major emphasis on lecture discussion or theory rather than on practical application or "hands on" projects. The efficacy of transfer of training was investigated to determine whether aptitude in engineering was acquired as measured by the four subtests on the National Engineering Aptitude Search Test.

The theoretical framework for this search was E. L. Thorndike's theory of identical elements, the basis for the training received by the Formal Study Experimental Group, and C. H. Judd's theory of generalization, the basis for the training received by the Performance Practice Experimental Group. The primary focus of this study was an investigation of the relative effectiveness of transfer of training on student acquisition of aptitude in engineering. This investigation asked the following questions:

1. When the modified scores of minority high school students in the 11th and 12th grades are analyzed for all four subtests of the National Engineering Aptitude Search Test, are there significant mean differences

among the three groups when categorized according to treatment and sex?

2. When the modified scores of minority high school students in the 11th and 12th grades are analyzed for all four subtests of the National Engineering Aptitude Search Test, are there significant mean differences among the three groups when categorized according to treatment and socio-economic levels - high, middle and low?

The study's treatment groups were 120 minority 11th and 12th grade students. All of the randomly selected subjects participated in either of the two experimental groups or the control group. Each group consisted of 40 participants each randomly selected from a pool of minority students who met the same preselection criteria.

The subjects in the experimental groups were involved in training for a total of 30 hours or the equivalent of 5 hours per day for 6 days.

The experimental and control group were very similar on several demographic variables: sex (a balance between male and female); math courses (at least three completed); science courses (at least three completed); grade level and race (11th and 12th grade minority high school students); SAT scores (600 to 1200 composite scores).

The students investigated in this study had similar characteristics as those students described in a study by Richards, Williams and Holland (1978). In their evaluation of

the 1977 Minority Introduction to Engineering Summer Program, they reported that participants in MITE program come from relatively privileged family backgrounds and their test scores are high as compared to other minority students. They also reported that the model MITE participant is a 17 year old black male. The second largest group consists of participants with one form or another of Spanish heritage and the third largest group consists of native Americans (p. 18). In this study males (N=41) outnumbered females (N=38) in the two experimental groups with the dominant ethnic groups being Black and Hispanic. However, in the control group females (N=24) outnumbered males (N=17) which may have accounted for the within group differences of this particular group.

The results of this study did reveal a statistically significant difference among treatment groups on all four subtests. In particular, for the Performance Practice Experimental Group, these test results proved to be effective measures in determining the success of the training. Another way these results might be expressed is to say that the training received by minority high school students in the 11th and 12th grade in the Performance Practice Experimental Group was more effective, as measured by all four subtests on the National Engineering Aptitude Search test than either of the other two groups. The fact that the training received by the Performance Practice Experimental Group placed major emphasis on learning engineering concepts through extensive practical application or "hands on" activities supports the

hypothesis: If preparing minority high school students for engineering is more effective through a practical approach that includes theory on a limited basis, then less emphasis should be placed on the theoretical approach that includes practical application on a limited basis.

The basic premise of the training received by the Performance Practice Experimental Group was deducing relevant information from a general principle.

The analysis of covariance was the statistical procedure used in this study with the Scholastic Aptitude Test scores as the covariate adjusting the means of four subtests on the National Engineering Aptitude Search Test.

The contribution of analysis of covariance is to yield the within group coefficient of correlation r. Since the sum of squares and cross products are calculated within each group separately, the differences between the groups do not influence the calculated r. Thus, the within r is the "best" estimate of the "true" r between x and y (Kerlinger 1973, p. 371). For the purpose of this study, the within group means were the main focus in the analysis of the data. The following findings are based on the computed results of the groups' scores.

Hypothesis I, which stated there are no significant differences in modified verbal scores of minority high school students in the 11th and 12th grades on the NEAS according to treatment and sex failed to be rejected. However, sub-hypotheses I-A for treatment and I-B for sex were rejected.

In the information bulletin of the National Engineering Aptitude Search Testing Program, it is reported that students who score in the top quarter on the verbal subtest may consider the highly selective colleges that specialize in preprofessional education. The verbal subtest is probably the best predictor of how well a student will do in college, especially in academic subjects.

There were significant differences in the adjusted mean verbal scores for treatment. The Performance Practice Experimental Group had significantly higher adjusted mean verbal scores than the other two groups. Surprisingly, the adjusted mean verbal scores for the Control Group were higher than those of the Formal Study Experimental Group. These results indicated that the lecture discussion training received by the Formal Study Experimental Group was not as effective as the Control Group which received no training at all.

The adjusted mean verbal scores of females in all three groups were higher than males in the same groups. The adjusted mean verbal scores of females in the Performance Practice Group were higher than males and females in all three groups. These data do not support the results reported by the college board indicating that in 1981 males continue to have higher Scholastic Aptitude Test scores than females. Although males continue to score higher on both math and verbal, females have higher standard written English scores. However, these results are supportive of studies by Aiken (1975, 1976) and

Maccoby and Jacklin (1974) that suggested that girls tend to model their behavior after mothers who tend to be more verbal than quantitative.

Hypothesis II, which stated that there are no significant differences in modified verbal scores of minority high school students in the 11th and 12th grades on the NEAS according to treatment and socio-economic levels - high, middle and low was rejected.

The within group adjusted mean verbal scores according to treatment, socio-economic levels - high, middle, low and sex, presented the most significant results. Females in the Performance Practice Experimental Group from families in the high and middle socio-economic levels had verbal scores of 78.05 and 70.53 respectively. These data supported the research by the Committee Entrance Board (1973) which reported a significant correlation between income and student ability.

However, females in that same group from families in the low socio-economic level had adjusted verbal scores of 92.10 out of a possible 99. Considering that the majority of minority families are categorized as members of the low and middle income levels, as it was expected the smallest number of subjects (N=27) in this study were from families in the high socio-economic level. Another approach in analyzing this data was to delete the test results of the minority students from families in the high socio-economic status in each treatment group.

This analysis is illustrated graphically in Appendix B, Figure 1. These results show that minority high school students from families in the low and middle socio-economic status who received training which emphasized practical application had more success in acquiring engineering concepts as measured by the verbal subtest than minority high school students who did not receive this training. Further inspection of the graph reveals that minority high school students from families in the middle socio-economic status who received training which emphasized lecture discussion had more success in acquiring of engineering concepts as measured by the verbal subtest than minority high school students who did not receive any training at all. Also these results show that minority high school students from families in the low socio-economic level who received training which emphasized lecture discussion had less success in acquiring engineering concepts than minority high school students who did not receive any training.

Hypothesis III, which stated there are no significant mean differences in modified numerical scores of minority high school students in the 11th and 12th grades on the NEAS when categorized according to treatment and sex, failed to be rejected. However, the sub-hypothesis III-A for treatment was rejected.

In the Performance Practice Experimental Group male and female minority high school students had higher adjusted mean numerical scores than males and females in both the Formal Study Experimental Group and the Control Group. Surprisingly,

females and males in the Performance Practice Experimental Group had almost identical adjusted mean numerical scores. Females in the Formal Study Experimental Group had higher adjusted mean numerical scores than males in the same group. Males in the Control Group had higher adjusted mean numerical scores than females in the same group. These data affected the overall adjusted mean numerical score for sex groups with females having a slightly higher adjusted mean score than males.

In the Information Bulletin of the National Engineering Aptitude Search Testing Program, it is reported that the content of the numerical test is that to which most college bound 12th grade students have been exposed. The questions have been designed to test understanding of concepts and manipulation of ideas rather than computation skill. Students who are planning to study engineering will be expected to have relatively high numerical scores. Eleventh and twelve graders should be at the 75th percentile or higher in their respective norm groups. High school grade averages should be C or better. It is further stated that scores between the 50th and 75th percentiles for 11th and 12th grade students, the range that all three treatment groups scores are located, should consider technical training for trades and crafts. It is concluded that such training is especially likely to be suitable if the verbal score is markedly lower than the numerical.

The results of the numerical subtest did not support the findings of the college board on the 1981 Scholastic Aptitude

Test scores. Males continue to do better than females on the math and verbal sections of the SAT.

In this study the high scores recorded by females on the numerical subtest may be attributable to their taking more advanced math courses than males. Both experimental groups had higher adjusted mean numerical scores than the Control Group.

These results indicated that minority high school students who received training which emphasized practical application and lecture discussion were more successful in acquiring engineering concepts than the Control Group, which received no training at all.

Hypothesis IV, which stated there are no significant mean differences in modified numerical scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and socio-economic levels - high, middle and low, was rejected. Sub-hypothesis IV-A for socio-economic status - high, middle and low, was also rejected.

The within group adjusted mean numerical scores according to treatment, socio-economic levels - high, middle, low and sex, presented the most significant results.

Females and males in the Performance Practice Group from families in the high socio-economic level had adjusted mean numerical scores of 76.34 and 73.76. According to the Information Bulletin of the National Engineering Aptitude Search Testing Program, both sex groups in the Performance Practice Experimental

Group, on the basis of their adjusted mean numerical scores, should be encouraged to pursue a career in engineering.

In Appendix 3, Figure 2, minority high school students from families in the high socio-economic level have been excluded. These results show minority high school students from families in the middle socio-economic level who received training which emphasized practical application and lecture discussion had more success in acquiring engineering concepts, as measured by the numerical subtest, than minority high school students who did not receive any training at all. Further inspection of the graph reveals that minority high school students from families in the low socio-economic level who received no training had more success in acquiring engineering concepts, as measured by the numerical subtest, than minority high school students who received training which emphasized practical application and lecture discussion.

The latter results, which indicated the Control Group being more successful than the experimental groups, may be attributable to the process of randomization. According to Kerlinger (1973), one can assume that the groups are approximately equal in all possible independent variables. The larger the groups, the safer the assumption. There is no guarantee of not drawing a deviant sample. There is no guarantee that the groups are equal in all possible independent variables. Nevertheless, it can be said that the investigator has used randomization to equalize his groups, or as it is said, to control influences on the dependent variable other than that of the manipulated independent variable (p. 23).

Hypothesis V, which stated that there are no significant mean differences in modified science scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and sex, failed to be rejected. However, sub-hypothesis V-A for treatment, was rejected.

Although the adjusted mean science scores for males and females in the Performance Practice Experimental Group were higher than males and females in the Formal Study Experimental Group and the Control Group, they were only between the 40th and 50th percentiles.

In the Information Bulletin of the National Engineering Aptitude Search Testing Program it is reported that the science score is an indication of general background in the physical sciences, with emphasis on applications of physics and chemistry. The test consists of problem-solving questions which require the students to apply or reformulate information about real or hypothetical physical situations. Since the educational curriculum in engineering is increasingly oriented toward the sciences, it is important for prospective engineering students to demonstrate high levels of aptitude in these areas. Scores above the 80th percentile are recommended for 11th and 12th grade students. It is further recommended that students achieving scores at those levels, accompanied by high verbal and numerical scores, may consider scientific and technical fields including engineering. Weakness in science, especially with low numerical scores, suggests

the advisability of considering nontechnical fields of endeavor.

These low science scores may be the result of several factors. Helgeson, Blosser and Howe (1977) reported that the science programs in the secondary schools of the United States have undergone considerable change from 1955 to 1976. Materials produced during most of the last two decades tended to show reduced emphasis on "practical" science (how things work, industrial processes, chemistry of household items, etc.) and until the early 1970s generally did not reflect much emphasis on the interaction of science and society (pp. 22-24). They also reported that since 1971 the percentage of students enrolled in chemistry appears to have declined slightly. Since 1971 or 1972 the percentage of students studying physics and physical science has decreased slightly (p. 28). They concluded, although percentage enrollments in advanced courses (second year biology, chemistry and physics) have shown a slow, but steady increase, the percentage is small compared to the total enrollment school population (p. 29).

Halgeson, Bosser and Howe (1977) enumerated a key point in their summary that is of particular interest to this study. They reported that a substantial number of science teachers do not emphasize laboratory activities. Lecture discussion is the most common learning activity followed by student demonstration. Reports and surveys indicated a substantial number of teachers (probably about 30 to 40 percent) teach science largely as a reading/lecture class (p. 32). The results of the science subtest scores in this study indicated that minority high school students

who received training which emphasized practical application were more successful in acquiring engineering concepts than training which emphasized lecture discussion. Moreover, training involving lecture discussion was less effective in transferring aptitude in engineering as measured by the science subtest than the control which did not participate in any training.

Hypothesis VI, which stated that there are no significant mean differences in modified science scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and socio-economic levels - high, middle and low, failed to be rejected.

The adjusted mean science scores were higher for minority high school students from families in the high and middle socio-economic levels. This data supports the research that indicates a high correlation between socio-economic level and student ability (1973). The within-group adjusted mean science scores according to treatment, socio-economic levels - high, middle, low and sex presents a distribution of scores. The Performance Practice Experimental Group had the highest adjusted mean science scores for minority high school students from families in the high and low socio-economic levels in all three groups. These results are attributable to the scores of males from families in the high and low socio-economic levels, 61.04 and 49.35 respectively. Furthermore, studies have detected a trend for males to perform better on higher level cognitive tasks and for females to perform better at

lower cognitive levels (Fenema, 1974; Fenema and Sherman, 1976: National Longitudinal Study of Mathematical Abilities [NLSMA]). Also differential course-taking behavior seems to be a plausible explanation for sex differences in achievement. In a study by the Wisconsin Department of Public Instruction, 1975-76, it was concluded that fewer females than males enroll in more advance courses.

In Appendix B, Figure 3, minority high school students from families in the high socio-economic level have been excluded. These results show that minority high school students from families in the low and middle socio-economic levels who received training which emphasized practical application and lecture discussion had more success in acquiring engineering concepts, as measured by the science subtest, than minority high school students who did not receive any training at all.

Hypothesis VII, which stated there are no significant mean differences in modified mechanical comprehension scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and sex, failed to be rejected. However, sub-hypothesis VII-A for treatment was rejected.

In the Information Bulletin, the National Engineering Aptitude Search Testing Program reported that mechanical comprehension is to test the ability of students to perceive and understand the relationship of physical forces and mechanical elements in practical situations. This is particularly important for

success in engineering and students considering this field should achieve scores at or above the 65th percentile.

The adjusted mean mechanical comprehension scores for treatment groups indicate that the Performance Practice Experimental Group had higher scores than the other two groups. The scores recorded by the Performance Practice Experimental Group was lower than the recommended 65th percentile, however, the within group adjusted mean mechanical comprehension scores for males in that same group were above the 65th percentile. Although the adjusted mean mechanical comprehension scores for males in the Formal Study Experimental Group was not at or above the 65th percentile, their score coupled with those of the Performance Practice Experimental Group, gave a clear indication, that males and females in the experimental groups did better on the mechanical comprehension subtest than males and females in the Control Group.

Hypothesis VIII, which stated that there are no significant mean differences in modified mechanical comprehension scores of minority high school students in the 11th and 12th grades on the National Engineering Aptitude Search test when categorized according to treatment and socio-economic levels - high, middle, and low, failed to be rejected.

The within group adjusted mean mechanical comprehension scores according to treatment, socio-economic level - high, middle, low and sex presented interesting results. Males in the Performance Practice Experimental Group from families in the high, middle and low socio-economic levels had adjusted mean mechanical comprehension

scores of 76.37; 68.56 and 61.99 respectively. Males in the Formal Study Experimental Group from families in the high socio-economic level had an adjusted mean mechanical comprehension score of 76.70.

Further interpretation of the data is presented in Appendix B, Figure 4, here minority high school students from families in the high socio-economic level have been excluded. These results show that minority high school students from families in the middle and low socio-economic levels who received training which emphasized practical application and lecture discussion had more success in acquiring engineering concepts, as measured by the mechanical comprehension subtest, than minority high school students who did not receive any training at all.

The most significant results were the interaction of the middle and low socio-economic levels on all four subtests: minority high school students from families in the low socio-economic levels who had received training which emphasized practical application were more successful in acquiring engineering concepts as measured by the verbal and science subtests than the other two groups. Minority high school students from families in the middle socio-economic level who had received training in practical application were more successful in acquiring engineering concepts, as measured by the numerical and mechanical comprehension subtests than the other two groups.

## CONCLUSION AND RECOMMENDATIONS

The above findings offer several major conclusions for discussion. Since the study investigated the comparative effectiveness of general and specific transfer from two distinct precollege engineering programs and how each affected student acquisition of aptitude in engineering, this issue is analyzed first. It is important to reiterate that Judd (1927 p. 514) argued when a pupil fully grasps a scientific generalization or when he gains a view of a wide range or relations he acquires independence and breadth of intellectual power and becomes capable of transferring training to situations that are different from which he was first trained. The learning output is deduced from the scientific generalization and the learning input (p. 514). Whereas Thorndike argued when a pupil fully grasps a specific theory or concept or when he gains a view of a specific relationship he acquires specific knowledge and becomes capable of transferring only those elements that are identical with those from which he was first trained. The learning input is replicated in the output (Thorndike, 1913, p. 171).

The results of all four subtests on the National Engineering Aptitude Search test clearly indicated that males and females in the Performance Practice Experimental Group were able to acquire aptitude in engineering through training involving practical application of concepts in engineering more effectively than the other treatment group and the Control Group. More specifically, transfer of training which focused on deducing aptitude in engineering as measured by the National Engineering

Aptitude Search test through practical application proved to be more effective than transfer of training which focused on replication of lecture discussions of engineering concepts and also more effective than no training at all.

Another issue investigated in this dissertation: Is Theory Necessary For Practice? Broudy (1973, p. 228) suggested that there is a trend toward more direct practical training and a reduction of theoretical components of professional curricula. Not surprisingly, the present findings indicated that aptitude in engineering was transferred more effectively from practical application and "hands on" activities. Yet, there is a unique aspect to the present results. The Control Group, although it was not involved in any training, had more success in acquiring engineering concepts, as measured by the verbal and science subtests, than the Formal Study Experimental Group who received training which emphasized lecture discussion. The results of this study carries implications for changes in future precollege engineering programs for minorities. With the increase in technological advancements such as computers, microprocessors and lasers, more engineering schools are offering courses in application and less in theory. Most students in engineering schools are involved in summer employment that provides them practical experience.

The lowest adjusted mean scores were recorded on the science and numerical subtests. Both subtest areas were recommended as critical for engineering study in the precollege phase of the minority engineering effort. However, these low scores

reflect the trend which has led to a substantial decline in the quality of precollege education in science and mathematics. According to a study by the National Research Council, the "back to basics" movement in elementary and secondary education combined with declining enrollments and strained finances has led to a substantial decline in the quality of precollege education in science and mathematics. Among the reasons offered for the declines are reduced graduation requirements, competition from other electives and the feeling among students that physics and chemistry are not "relevant" (Scientific Manpower Commission, 1979, p. 28).

Teaching emphasis has shifted toward developing minimal skills in reading, writing and arithmetic and away from science which is not included in the definition of basic education.

The results of the mechanical comprehension subtest on the National Engineering Aptitude Search test indicated that males had higher adjusted mean scores than females in all three treatment groups. More specifically, male minority high school students in the Performance Practice and the Formal Study Experimental Groups had higher adjusted mean mechanical comprehension subtest scores than male minority high school students in the Control Group.

Other results were the within sex group mechanical comprehension mean scores. Female minority high school students in the Performance Practice and Formal Study Experimental Groups had higher mean mechanical comprehension scores than females in

the Control Group. However, the lack of training for subjects in the Control Group resulted in less difference between female and male mechanical comprehension scores as compared to scores of females and males in the experimental groups.

Although more recent statistics reported by the Scientific Manpower Commission (1979, pp. 12,13) that the proportion number of bachelor's degrees awarded to women in engineering, computer and information sciences increased considerably from 1971 to 1977. These data supported the study by Bennett and Cruikshank (1942) that mechanical aptitude has much less significance for women than for men.

The results of this study gives credence to the continuation and financial support by industry to precollege engineering programs for minorities such as those represented in this research. The Minorities Introduction to Engineering Program (MITE) represented as the Formal Study Experimental Group, clearly indicated its effectiveness by the results of the within group means for treatment and sex. More specifically, the results of the numerical and mechanical comprehension subtests were significantly different from those of the Control Group.

The results analyzed for the Formal Study Experimental Group (MITE) indicated that another training component should be added involving practical application or "hands on" engineering related activities with on-the-job engineers in order to increase the transferability and acquisition of aptitude in engineering.

The results of the Performance Practice Experimental Group represented in this research as the RCA Minority Engineering Program (MEP) was superior in overall performance on all four subtests for treatment groups. The results of the between means and within group means for the numerical, verbal, science and mechanical subtests indicated that aptitude in engineering was effectively transferred through training emphasizing practical application and "hands on" engineering related activities. Although it was not discussed in Chapter Four or Five, the instruction provided by an engineer and the competencies he needed to fulfill his job expectations was significant in the overall success of the RCA Minority Engineering Program.

The results of the numerical and science subtest scores for all treatment groups had confirmed the conclusion in the report released by the Retention Task Force of the Committee on Minorities in Engineering that the most important factors contributing to minority engineering student attrition are inadequate math and science preparation.

It is the belief of this researcher that the answer to this critical problem does not lie in the suggestion that precollege engineering programs should place more emphasis on the mathematics and science components but that industries who will benefit the most should follow the lead of the Bendix Corporation and adopt particular schools and make sure they have what they need for strong science and mathematics programs.

Moreover, the results of this study should have implications and significance for engineering educators and professional research oriented organizations who have a particular interest in decreasing the high attrition rate of minorities pursuing an undergraduate degree in engineering to provide the expertise wherever it is necessary to alleviate this obstacle.

## RECOMMENDATIONS

If precollege engineering programs for minorities are to attain the ultimate goals of the minority engineering effort, to increase the number of minorities in engineering schools tenfold in the 1980;s and practicing engineers in the United States some sevenfold in the future, then on-going research becomes a necessity. The present findings offer several considerations for future research. Other investigators may wish to consider the following recommendations:

1. If feasible, a follow-up study might be employed to compare the results of this study with academic success in the freshman year in engineering school.
2. A similar study could be researched employing a practical application group, a combination of a practical application and formal study group, and a control group to determine whether the added component to the Formal Study Group will increase the subtest scores of the participants over those received by Formal Study Group participants in this particular study.
3. This study could be replicated by taking noncognitive variables into account such as locus of control, motivation, and self-concept to determine their effect on acquisition of aptitude in engineering on minority high school students.
4. This investigation could be replicated on a different population (younger, junior high school, other minority groups included).

In conclusion these precollege engineering programs have two common characteristics: A preference for the abstract (theoretical) or 'pure' engineering and involvement of the learner in direct inquiry.

The results of this study suggested that theoretical knowledge alone is not sufficient for preparing minority high school students for engineering studies, that technical know-how is required. However, theory should be included in the curriculum to understand and interpret problems encountered as engineers' the ability to apply engineering to solve problems is not the same thing as understanding them.

## REFERENCES


Aiken, Lewis R. Jr., "Update on Attitudes and Other Affective Variables in Learning Mathematics, "Review of Educational Research" 1976, 46, 293-311.

Aiken, Lewis R. Jr., "Some Speculations and Findings Concerning Sex Differences in Mathematical Abilities and Attitudes." In Fennema, Elizabeth (Ed.), Mathematics Learning: What Research Says About Sex Differences, December 1975, Columbus, Ohio: ERIC Mathematics, Science and Environmental Education Clearinghouse, 13-20.

Bagley, W. C., Educative Process, MacMillan, 1905, pp. 203-4.

Bechtoldt, H. Professor of Psychology, The University of Iowa, Iowa City, Iowa, Buros, O., The Seventh Mental Measurement Yearbook Vol. 11, 1972, p. 1484.

Berg, Ivar, Education and Jobs: The Great Train Robbery, Praeger, New York, 1970.

Bennett, G. K., Bennett Mechanical Comprehension Test, Grade 9-12 Psychological Corporation, 1969, New York, New York.

Bennett, G. K. and Cruikskank, R. M., Sex Differences in the Understanding of Mechanical Problems, The Journal of Applied Psychology, 1942, 26, pp. 121-127.

Broudy, H. S., "Can Research Provide a Rationale for the Study of Science?, Journal of Research on Science Teaching, Vol. 10, No. 3, pp. 227-233, 1973

Bruner, J. S., The Process of Education, Cambridge, Massachusetts: Harvard University Press, 1960.

Buros, O., The Seventh Mental Measurements Yearbook, Vol. 11, The Gryphon Press, Highland Park, New Jersey, 1972.

Campbell, D. T. and Stanley, J. C., Experimental and Quasi - Experimental Designs for Research Rand McNally, College Publishing Company, Chicago, 1963.

Chambers, D. W., Putting Down the Discovery Learning Hypothesis, Educational Technology, Vol. 11, pp. 54-9, March 1971.

Cole, L. W., Interference of Related Mental Unpublished Abstract in Psychological Bulletin, 1925.

Cronbach, Lee J., Essentials of Psychological Testing, Third Edition, New York, Harper and Row Publishers, Inc., 1970, pp. 752.

Fehr, H. F., The Learning of Mathematics Its Theory and Practice, National Council of Teachers of Mathematics Yearbook 21; 1953.

Fennem, Elizabeth, "Mathematics Learning and the Sexes: A review, Journal For Research in Mathematics Education 1974, 67(5), p. 235.

Fennem, Elizabeth and Shermin, Julia, Sex Related Differences in Mathematics Learning: Myths, Realities, and Related Factors, 1976, Eric ED 129 G33.

Financial Aid Needs of Undergraduate Minority Engineering Students in the 1980's, The National Fund for Minority Engineering Students, 220, East 42nd Street, Suite 3105 New York, New York 10017, 1978

Gagne, R. M., The Conditions of Learning, New York; Holt Rinehart and Winston, 1970.

Grote, C. N., A Comparison of the Relative Effectiveness of Direct Detailed and Directed Discovery Methods of Teaching Selected Principles of Mechanics in the Area of Physics, Unpublished Ed. D. Thesis, University of Illinois, 1960.

Hagee, G. and Stewart, B., A Study with Replication of Transfer on Psychomotor Task in Agriculture Power, Journal of the American Association of Teacher Education in Agriculture, Vol. 19, No. 3, November 1978, pp. 18-24.

Hancox, F. J., An Investigation of Programmed Instruction in Mathematics as a Measure of Electronic Achievement Ph. D. Dissertation, The American University, 1969, 1450.

Hanson, L. E., Inductive Discovery Learning, Reception Learning and Format Verbalization of Mathematical Concepts, Unpublished Ph. D. Thesis, the Florida State University, 1967.

Helgeson, Blosser and Howe, The Status of Precollege Science, Mathematics, and Social Science Education: 1955-1975 Volume 1. Science Education pp. 260, 1977.

Hilgard, E. R., Bower, G. H., Theories of Learning, 3rd Edition, Century Psychology Series, Appleton Century Crofts Educational Division, Meredith Corporation, 1948, 1966.

Holton, G., Harvard Project Physics, Physics Today, pp. 20-34, March 1967.

James, William, The Principles of Psychology, Chapter XVI, Henry Holt and Company, 1890, pp. 666-667.

Jenny, H. K., Returns from 11 RCA-MEP's with 160 Students Held During the 1975/76 School Year 1976/77-197 (Plus 90 Camden and Somerville) RCA Corp. Research and Engineering, Cherry Hill, New Jersey.

Jets National Engineering Aptitude Search, 1965, Grades 9-12, United Engineering Center, 345 East 47th Street, New York 10017; Publisher Psychological Corporation, New York, New York.

Judd, C. H., Educational Psychology, Copyright 1939, The Riverside Press, Cambridge, MA.

Judd, C. H., Psychology of Secondary Education, Copy right 1927, Ginn and Company, Boston p. 514.

Judd, C. H., Psychology of High School Subjects, 1915, Ginn and Company, Athenaen Press.

Judd, C. H., The Relation of Special Training to General Intelligence, Education Review, 36: 28-42, 1908.

Kauffmann, H. E., Minorities in Engineering, The National Effort, Engineering Education, January 1980, pp. 331-334.

Kerlinger, F. N. Foundations of Behavioral Research Second Edition, Holt, Rhinehart and Winston, 1973 pp. 741.

Leighbody, G. B. and Kidd, D. M., Methods of Teaching Shop and Technical Subjects, Delmar Publishers, Inc., Albany New York, 201p 1966.

Lewis, F. C., A Study in Formal Discipline School Review, April 1905, pp. 281-92.

Maccoby, Eleanor E. and Jacklin, Carol N., "The Psychology of Sex Differences." Stanford, California: The Stanford University Press, 1974.

Livingston, S., Myth of the Well Educated Manager, The Harvard Business Review, January and February 1971.

McClintock, C. E., An Investigation of Transfer of Learning as Mediated by The Instructional Methods of Teaching Selected Mathematical Generalizations, Ed. D. Dissertation, University of Georgia, 221p., 1974.

Meredith, G. P., Consciousness of Method as a Means of Transfer of Training, The Forum of Education, 5, 37-45, February 1927.

Moss, J. Jr., An Experimental Study of the Relative Effectiveness of the Direct-Detailed and the Directed Discovery Methods of Teaching Letter Press Imposition, Unpublished Ed. D. Thesis, University of Illinois, 1960.

Minorities in Engineering, Volume 4, Number 1, Winter 1978 Publication of Committee on Minorities in Engineering, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418, pp. 1-2.

Norsworthy, N., Formal Training, New York Teachers Monograph, Vol. IV, 1902, pp. 96-99.

O'Bryant, D. C., Minority Introduction to Engineering (MITE), Department of General Engineering, University of Illinois at Urbana-Champaign. Prepared for the Annual Technical Design Associates Meeting, Hartford, Connecticut, October 18, 1977, pp. 9.

O'Bryant, D. C., Summer Guidance Programs for Minority High School Students (MITE), Special Guidance Issue, Engineering Education, American Society for Engineering Education, 1979.

Orata, P. T., The Theory of Identical Elements; A Critique of Thorndike's Theory of Identical Elements and a Re-Interpretation of the Problem of Transfer of Training; The Ohio State University Press, Columbia, Ohio, 1928, p. 53.

Orata, P. T., Recent Research Studies on Transfer of Training with Implications for the Curriculum Guidance and Personnel Work, Journal of Educational Research 35; 81-101; October 1941.

Piryov, Tzanev, The Transfer of Knowledge in Polytechnical Education, Studia Psychologia, Vol. 17, No. 2, 1975, pp. 105-109.

Poffenberger, A. T., Jr., The Interference of Improvement in One Simple Mental Function Upon Other Related Processes, Journal of Educational Psychology, Vol. 6 459-474.

Profile of the Entering Minority Freshman, The Minority Engineering Effort, 345 East 47th Street, New York, New York 10017.

Ray, W. E., An Experimental Comparison of Direct-Detailed and Direct-Discovery Methods for Teaching Micrometer Principles and Skills, Unpublished Ed. D. Thesis, University of Illinois, 1957.

Richards, J. M. Jr., Williams, G. D. and Holland, J. R., An Evaluation of the 1977 Minority Introduction to Engineering Summer Program, The Center for Social Organization of Schools, The Johns Hopkins University, Baltimore, Maryland.

Retention of Minority Students in Engineering, A Report of the Retention Task Force Committee on Minorities in Engineering, National Research Council, 1977.

Rogers, Teachers College Record, Vol. 17, p. 349.

Rosskopf, Teachers College; Columbia University, Transfer of Training, pp. 205-228 (see Fehr, H. F., 1953).

Ruger, H. A., The Psychology of Efficiency, Archives of Psychology, 19, No. 2, pp. 18-19, 1910.

Ruger, H. A., The Psychology of Efficiency, Archives of Psychology, No. 15, 88p June 1910.

Rugg, H. O., The Experimental Determination of Mental Discipline in School Studies, Educational Psychological Monographs, No. 17, 132p., 1916.

Scientific Manpower Commission, Vol. 16, No. 8, October 1979, Women and Minorities in the Sciences, pp. 12-13,28. Stratton, G. M., Developing Mental Power, Houghton Mifflin Company, 1922, pp. 4-5.

Thorndike, E. L., Educational Psychology 1903 Edition, Lemcke and Bueckner Chapter VIII, pp. 80-93.

Thorndike, E L., Educational Psychology, Vol. 1, The Original Nature of Man, Teachers College, Columbia University, p. 171, 1913a.

Thorndike, E. L., Educational Psychology, Vol. 2., Teachers College Press, Chapter XII, pp. 350-434, 1913b.

Thorndike, E. L., Principles of Teaching, A. G. Seiler, Col, Chapter XV, pp. 235-257, 1906.

Thorndike, E. L. and Woodworth, R. S., The Influence of Improvement in One Mental Function Upon the Efficiency of Other Functions, Psychological Review, Vol. 8, p. 247-261; 384-395; 553-564, 1901.

Thorndike, E. L., Aikens, H. A., and Hubbell, E., Correlations Among Perceptive and Associative Processes, Psychological Reviw, Vol. 9, 374-382, 1902.

Thorndike, E. L., Mental Discipline in High School Studies, Journal of Educational Psychology, Vol. 15: 1-22; 83-98, 1924.

Thorndike, E. L., Human Learning, Century Psychology Series, New York, 1931, pp. 162-183.

Thorndike, E. L., The Relation Between Memory For Words and Memory For Numbers and the Relation Between Memory Over Short and Memory Over Long Intervals, American Journal of Psychology, Vol. 21:487-88, 1910.

The Psychological Corporation, Report of the 1967-68 Validity Study of Engineering Sciences Aptitude Test, New York, New York 10017.

The U.S. Bureau of the Census, U.S. Census of Population: 1960 Subject Reports Occupational Characteristics, Final Report PC [2]-7A U.S. Government Printing Office, Washington, D.C., 1963.

The United States Department of Commerce Bureau of Census, Current Population Reports: Consumer Income, Series p. 60 No. 114 (July 1978).

Toward Equal Opportunity for Higher Education, a report of the Panel on Financing Low-Income and Minority Students in Higher Education, published by the College Entrance Examination Board, 1973.

Watley, D. J. and Nichols, R. C., Career Decisions of Talented Youth; Trends Over the Past Decade, National Merit Scholarship Copr., Evanston, IL, 1969, P.S.

Webster's Seventh New Collegiate Dictionary, G. & C. Merrian Company, Published Springfield, Massachusetts, U.S.A., 1967.

Weimer, R. C., A Critical Analysis of the Discovery Versus Expository Research Studies Investigating Retention or Transfer Within the Areas of Science, Mathematics, Vocational Education, Language and Geography from 1908 to the Present, Ph. D. Dissertion, University of Illinois, Urbana, IL, p. 292, 1974.

Wixson, E. A. Jr., The Effects of a Mathematic Approach to Teaching Two Topics in High School Biology on Student Achievement and Attitudes, Ph. D. Dissertation, University of Michigan, P. 197, 1969.

New York, Work in Progress, A Newsletter from the Alfred P. Sloan Foundation, New York, Fall 1979.

Yoder, B. A., Effect of Previous Agricultural Mechanics Training on Achievement in a Basic Metals and Welding Course at Iowa State University, Master's Thesis, Iowa State University p. 88, 1978.

# APPENDIX A

TABLE 2.1

ADJUSTED MEAN VERBAL SCORES

ACCORDING TO TREATMENT AND SEX

| TREAT | VERBAL MEAN | SEX | VERBAL MEAN | TREAT | SEX | VERBAL MEAN |
|---|---|---|---|---|---|---|
| CO | 50.77 | F | 61.45 | CO | F | 51.33 |
| FS | 47.57 | M | 52.77 | CO | M | 50.21 |
| PP | 72.98 | | | FS | F | 52.80 |
| | | | | FS | M | 42.34 |
| | | | | PP | F | 80.23 |
| | | | | PP | M | 65.74 |

TABLE 2.2

ADJUSTED MEAN VERBAL SCORES

ACCORDING TO TREATMENT AND SOCIO-ECONOMIC STATUS

| SES | VERBAL MEAN | TREAT | SES | VERBAL MEAN |
|---|---|---|---|---|
| H | 58.02 | CO | H | 58.89 |
| L | 55.71 | CO | L | 45.50 |
| M | 57.60 | CO | M | 47.93 |
| | | FS | H | 42.86 |
| | | FS | L | 42.69 |
| | | FS | M | 57.17 |
| | | PP | H | 72.31 |
| | | PP | L | 78.93 |
| | | PP | M | 67.71 |

TABLE 3.1

ADJUSTED MEAN NUMERICAL SCORES

ACCORDING TO TREATMENT AND SEX

| TREAT | NUMERICAL MEAN | SEX | NUMERICAL MEAN | TREAT | SEX | NUMERICAL MEAN |
|---|---|---|---|---|---|---|
| CO | 47.45 | F | 52.90 | CO | F | 46.85 |
| FS | 50.81 | M | 52.42 | CO | M | 48.05 |
| PP | 59.72 | | | FS | F | 52.29 |
| | | | | FS | M | 49.33 |
| | | | | PP | F | 59.55 |
| | | | | PP | M | 59.88 |

TABLE 3.2

ADJUSTED MEAN NUMERICAL SCORES

ACCORDING TO TREATMENT AND SOCIO-ECONOMIC STATUS

| SES | NUMERICAL MEAN | TREAT | SES | NUMERICAL MEAN |
|---|---|---|---|---|
| H | 59.23 | CO | H | 51.26 |
| L | 46.60 | CO | L | 49.02 |
| M | 52.15 | CO | M | 42.08 |
| | | FS | H | 51.34 |
| | | FS | L | 47.06 |
| | | FS | M | 53.98 |
| | | PP | H | 75.05 |
| | | PP | L | 43.71 |
| | | PP | M | 60.39 |

TABLE 4.1

ADJUSTED MEAN SCIENCE SCORES

ACCORDING TO TREATMENT AND SEX

| TREAT | SCIENCE MEAN | SEX | SCIENCE MEAN | TREAT | SEX | SCIENCE MEAN |
|---|---|---|---|---|---|---|
| CO | 35.52 | F | 36.57 | CO | F | 35.28 |
| FS | 34.51 | M | 40.89 | CO | M | 35.26 |
| PP | 46.16 | | | FS | F | 31.90 |
| | | | | FS | M | 37.11 |
| | | | | PP | F | 42.02 |
| | | | | PP | M | 50.30 |

TABLE 4.2

ADJUSTED MEAN SCIENCE SCORES

ACCORDING TO TREATMENT AND SOCIO-ECONOMIC STATUS

| SES | SCIENCE MEAN | TREAT | SES | SCIENCE MEAN |
|---|---|---|---|---|
| H | 39.59 | CO | H | 35.00 |
| L | 37.13 | CO | L | 35.53 |
| M | 39.47 | CO | M | 36.03 |
| | | FS | H | 30.14 |
| | | FS | L | 31.27 |
| | | FS | M | 42.11 |
| | | PP | H | 53.63 |
| | | PP | L | 44.60 |
| | | PP | M | 40.26 |

TABLE 5.1

ADJUSTED MEAN MECHANICAL COMPREHENSION SCORES

ACCORDING TO TREATMENT AND SEX

| TREAT | MECHANICAL MEAN | SEX | MECHANICAL MEAN | TREAT | SEX | MECHANICAL MEAN |
|---|---|---|---|---|---|---|
| CO | 31.25 | F | 39.53 | CO | F | 29.57 |
| FS | 49.66 | M | 53.51 | CO | M | 32.92 |
| PP | 58.65 | | | FS | F | 40.70 |
| | | | | FS | M | 58.63 |
| | | | | PP | F | 48.33 |
| | | | | PP | M | 68.97 |

TABLE 5.2

ADJUSTED MEAN MECHANICAL COMPREHENSION SCORES

ACCORDING TO TREATMENT AND SOCIO-ECONOMIC STATUS

| SES | MECHANICAL MEAN | TREAT | SES | MECHANICAL MEAN |
|---|---|---|---|---|
| H | 51.47 | CO | H | 34.22 |
| L | 43.46 | CO | L | 30.26 |
| M | 44.64 | CO | M | 29.27 |
| | | FS | H | 59.82 |
| | | FS | L | 43.57 |
| | | FS | M | 45.60 |
| | | PP | H | 60.36 |
| | | PP | L | 56.56 |
| | | PP | M | 59.04 |

# APPENDIX B

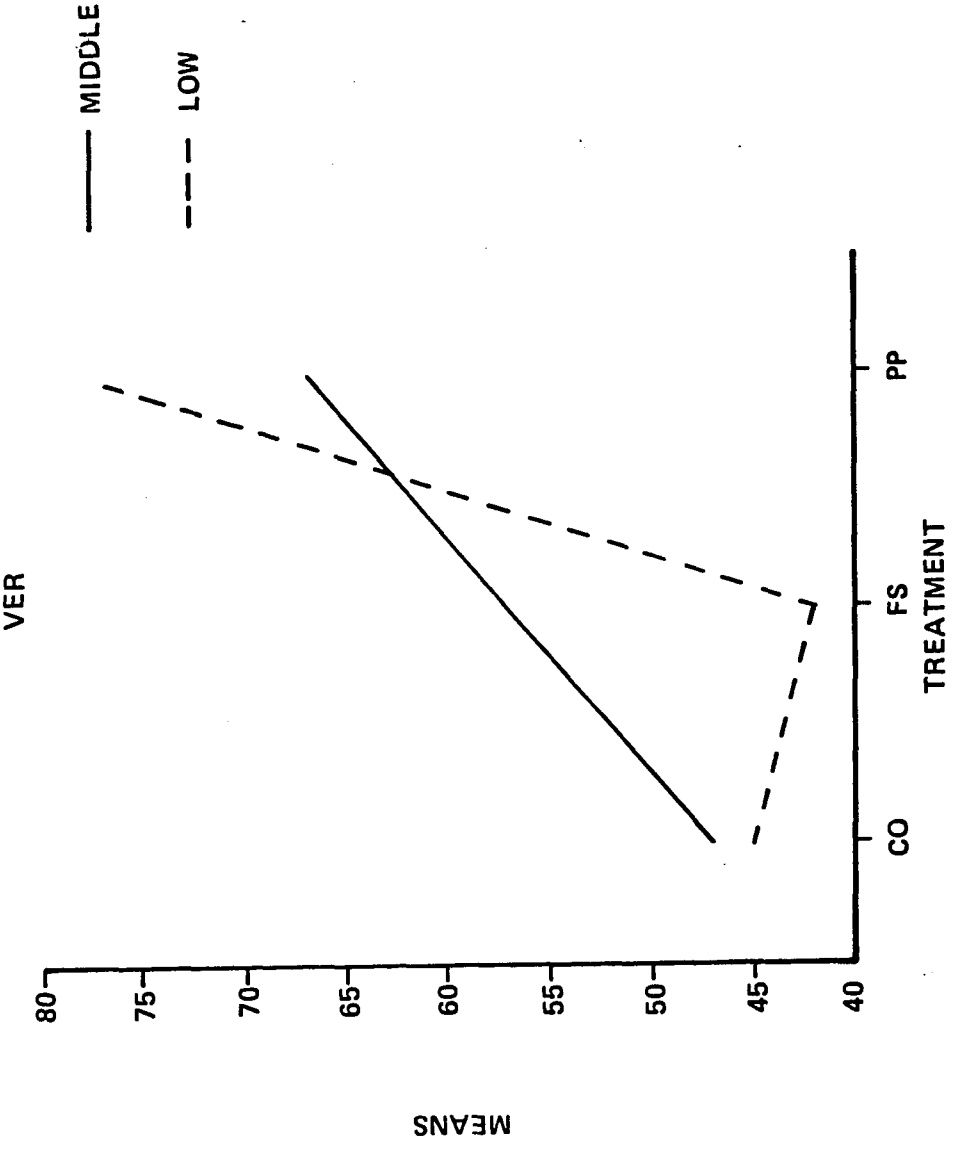
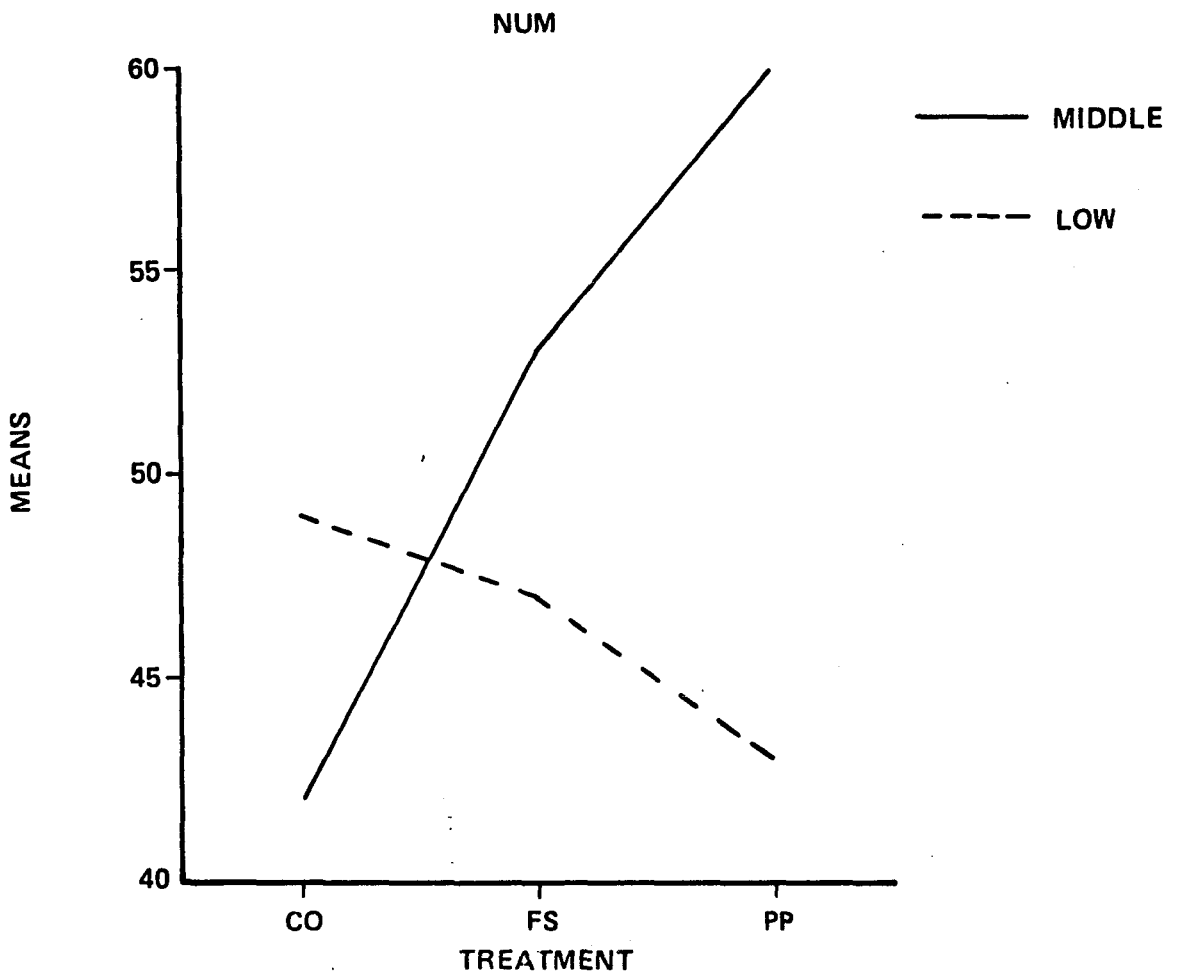



FIGURE 1

ADJUSTED MEAN VERBAL SUBTEST SCORES FOR MINORITY HIGH SCHOOL STUDENTS FROM FAMILIES IN THE LOW AND MIDDLE SOCIO ECONOMIC LEVELS.

FIGURE 2 ADJUSTED MEAN NUMERICAL SUBTEST SCORES FOR MINORITY HIGH SCHOOL STUDENTS FROM FAMILIES IN THE LOW AND MIDDLE SOCIO ECONOMIC LEVELS.



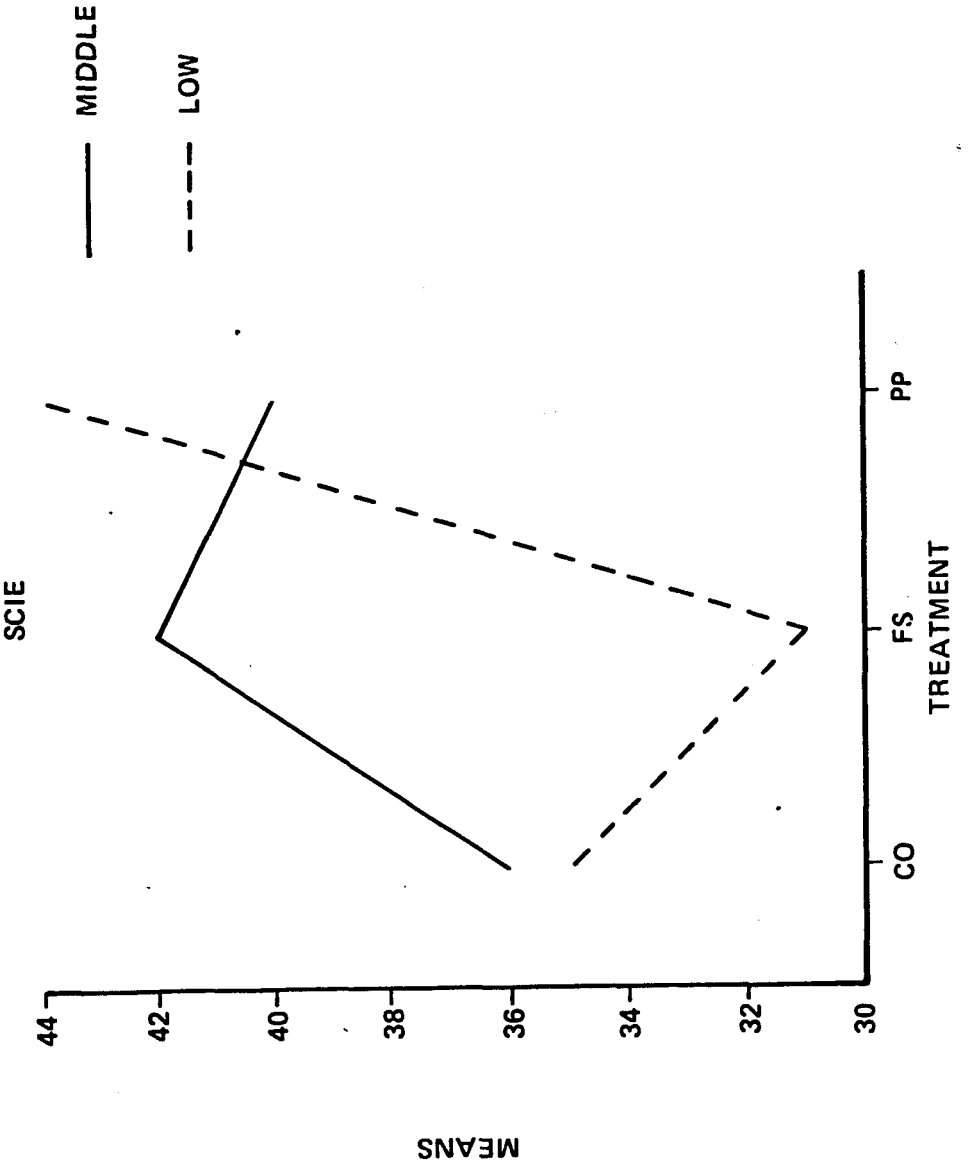
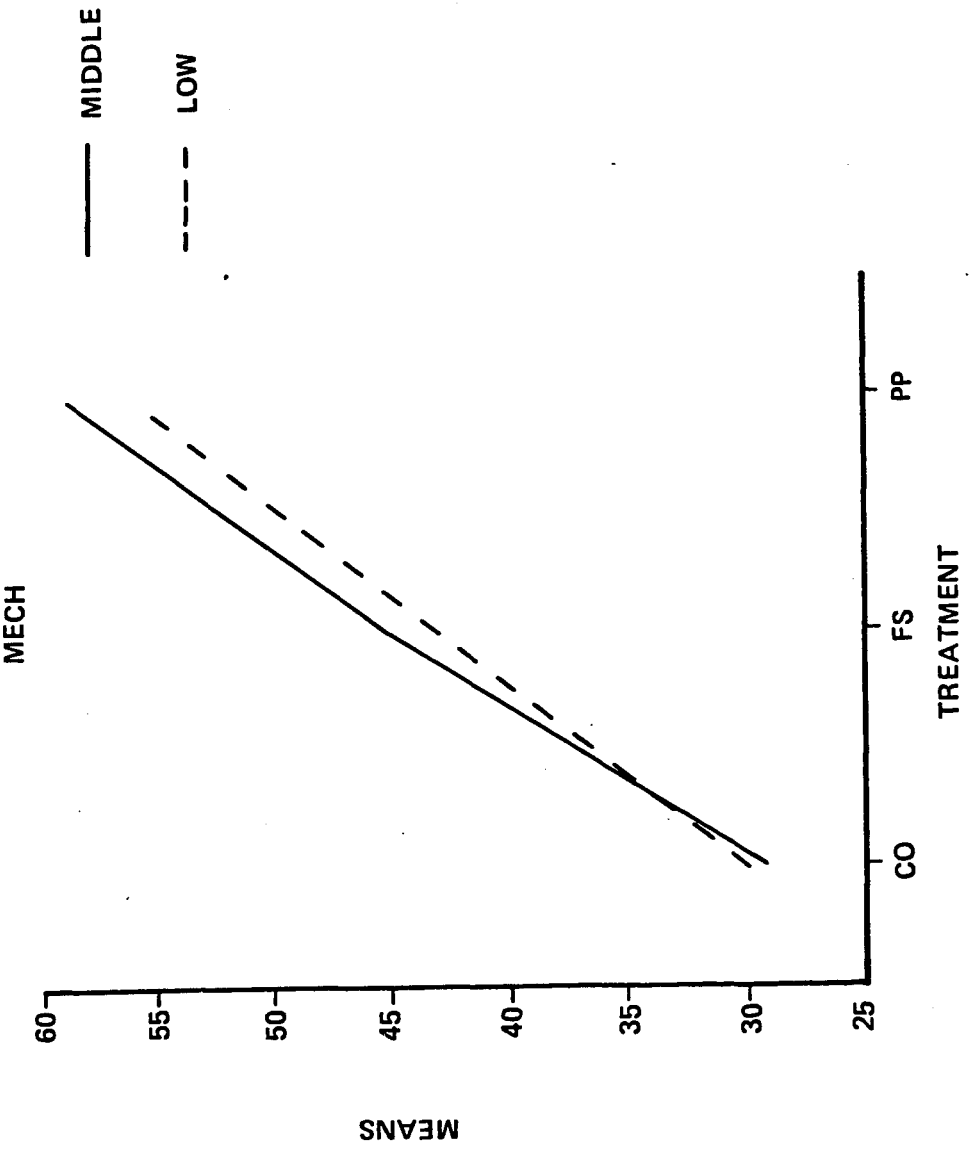



FIGURE 3

ADJUSTED MEAN SCIENCE SUBTEST SCORES FOR MINORITY HIGH SCHOOL STUDENTS FROM FAMILIES IN THE LOW AND MIDDLE SOCIO ECONOMIC LEVELS.

FIGURE 4

ADJUSTED MEAN MECHANICAL COMPREHENSION SCORES FOR MINORITY HIGH SCHOOL STUDENTS FROM FAMILIES IN THE LOW AND MIDDLE SOCIO ECONOMIC LEVELS.



# V I T A

HAROLD E. FISHER
45 Norwood Avenue
Plainfield, New Jersey 07060

Born May 2, 1938; 6' - 185 lbs.
Married - two children
(201 561-1009)

## EDUCATION

| | |
|---|---|
| 1982 | St. John's University, Jamaica, New York<br>Ed.D. (Administrative and Instructional Leadership) |
| 1975 | Awarded Professional Diploma degree in Education<br>(Curriculum and Teaching) |
| 1968 - 1971 | Seton Hall University - Graduate Division<br>South Orange, New Jersey<br>M.A. (Supervision and Administration) |
| 1967 | Newark State College, Union, New Jersey |
| 1965 | Seton Hall University, South Orange, New Jersey |
| 1962 | Kansas State University, Manhattan, Kansas |
| 1958 - 1960 | University of Idaho, Moscow, Idaho<br>B.S. (Ed.) Minor Psychology<br>Honors: Signed as free agent with Pittsburgh Steelers, Pennsylvania (professional football team) |
| 1956 - 1958 | Ventura Junior College, Ventura, California<br>Honors: First Team, All Western Conference; Honorable Mention - All American Junior College; Most Valuable Player Award (1957-1958) |
| 1953 - 1956 | Williamsport High School, Williamsport, Pennsylvania<br>Honors: All Pennsylvania State Football Team; Honorable Mention - All American; Vice President, High Y |

## U.S. MILITARY

| | |
|---|---|
| 1961 - 1963 | U.S. Army<br>Honors: Athletics - All Physical Fitness Champ of Fifth Army Area. Football and Track Teams |

HAROLD E. FISHER

EXPERIENCE

| | |
|---|---|
| 1980-Present | Administrator, Graduate Study Program Budget Coordinator ($1,000,000) for Local Univ. Part-Time Program |
| 1978 - 1980 | Program Administrator, University and Technical Institute Relations, Bell Telephone Laboratories, Murray Hill, New Jersey. Administer two programs in higher education designed to increase the number of minorities and women in the field of engineering and the applied sciences. The undergraduate program, (BLESP) Bell Laboratories Engineering Scholarship Program's budget is currently $240,000. (CRFP) Cooperative Research Fellowship Program, the graduate program's budget is currently $260,000. |
| 1977 | Consultant, Community Action Planning Committee, Plainfield, New Jersey |
| 1972 - 1976 | Assistant to Dean of Students, Queens College, Flushing, New York (City University) Student enrollment 30,000 |
| 1970 - 1972 | Union College, Urban Campus, Plainfield, New Jersey Director/Counselor (Two-year community college) |
| 1970 - 1972 | Newark College of Engineering, Newark, New Jersey Evening Division. Technology Program for Minorities. Taught English and Counseled Minority Students |
| 1971 - 1972 | City University, New York, Kingsborough Community College. Summer Program for Paraprofessionals Taught Sociology |
| 1969 - 1970 | Union College, Cranford, New Jersey - Evening Division. Taught Contemporary Problems and Sociology |
| 1965 - 1970 | Elizabeth Board of Education, Elizabeth, New Jersey Taught English |
| 1963 - 1965 | East Orange Board of Education, East Orange, New Jersey. Taught Social Studies and Remedial Reading |

OTHER INVOLVEMENT

| | |
|---|---|
| 1965 - 1966 | Project Reach (Remedial), Board of Education Elizabeth, New Jersey |
| 1967 - 1968 | Neighborhood Youth Corps (Drop Outs) Elizabeth, New Jersey |

HAROLD E. FISHER

OTHER INVOLVEMENT (Cont'd)

| | |
|---|---|
| 1968 - 1970 | Supervisor, Summer Youth Program for Deprived Students Humble Oil and Refining Co. (Exxon), Linden, New Jersey |
| 1968 | Employment Consultant, Solvents Recovery Co. Stiles Street, Linden, New Jersey |
| 1968 - 1969 | Minority Consultant, Humble Oil and Refining Co. (Exxon) Pelham, New York |
| 1971 - 1972 | Athletic Director, Union College, Cranford, New Jersey |
| 1971 | Nominated for Outstanding Young Men of America Award, United States Chamber of Commerce |
| 1969 | Assisted in Planning Urban Campuses in Elizabeth and Plainfield for 1970 (Union College - Cranford extensions) |
| 1970 | Counselor to Youth, Roseville Presbyterian Church Newark, New Jersey |
| 1965 - 1970 | Football and Track Coach, Thomas Jefferson High School, Elizabeth, New Jersey |
| 1971 | President of MECCA (Medgar Evers Community College Association). Union College was the sponsoring college in a fund-raising drive to build a two-year college in Fayette, Mississippi. |
| 1965 - 1971 | I wrote several programs for Humble Oil (Exxon), Neighborhood Youth Corps, Model Cities, and Public Service Careers pertaining to social and economic problems. |
| 1973 - 1974 | Consultant, Urban Education, Inc., New York, New York |
| 1976 | I have written a comprehensive program on race relations for middle management employees for American Telephone and Telegraph Company (AT&T), Piscataway, New Jersey |
| 1975 | Director of the weekend programs, Washington Heights-Inwood-West Harlem Mental Health Clinic, 158th Street, West, New York, New York |

HAROLD E. FISHER

OTHER INVOLVEMENT (Cont'd)

| | |
|---|---|
| 1976 | Phi Delta Kappa, St. John's University Chapter, Jamaica, New York |
| 1972-Present | Chief Consultant, Educational Master Skills Consultants, 45 Norwood Avenue, Plainfield, New Jersey. Coordinated the training of Black parents in Newark on various subjects (cultural awareness, proposal writing, intra-/inter-group relations, negotiations, preventive dentistry, drug abuse, public relations, nutrition, etc. |
| 1978 - 1979 | Supervisor, Plainfield Adult Learning Center, Plainfield Board of Education, Plainfield, New Jersey |
| 1978 | Consultant/Trainer, St. Elizabeth College, Convent Station, New Jersey, Workshop "Women Returning to School in Pursuit of a G.E.D. Diploma" |
| 1979 | Appointed to the Union County Coordinating Agency for Higher Education. The agency Contracts on behalf of the county, utilizing state and county funds for Union College and Union County Technical Institute |
| | Presented paper at the Executive Board meeting of the National Society of Black Engineers held at the National Academy of Science, in Washington, D.C., July 12, 13. Title: "Defining Organizational Stability for NSBE." |
| 1980-Present | Appointed Member of the Advisory Board of the National Society of Black Engineers (NSBE) |
| 1982 | Paper selected for presentation at the National Technical Association (NTA) Annual Conference, in Baltimore, Md., August 7, 8. Title: "The Relative Effectiveness of Performance Practice and Formal Study on Acquisition of Aptitude in Engineering in Precollege Engineering Programs for Minorities" (Doctoral Dissertation) |