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Title: THE INFLUENCE OF VOCATIONALLY-ORIENTED APPLICATIONS ON THE ACHIEVEMENT AND ATTITUDE OF COMMUNITY COLLEGE ALGEBRA STUDENTS

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Howard L. Wilson

The purpose of this study was to analyze the effect of the use of vocationally-oriented applications on the achievement and attitude of community college beginning algebra students. The applications were chosen to be representative of problems encountered in a variety of occupations. They were in contrast to the more abstract and generalized applications typically found in beginning (first-year) algebra texts.

Procedure

The study was conducted at four randomly selected Oregon community colleges. At each college the same instructor taught the control and experimental classes. The experimental classes received vocationally-oriented applications while the control classes received applications typical of those traditionally found

in beginning algebra texts. To test the effect of varying the number of vocationally-oriented applications received on student achievement and attitude, two additional experimental groups were established at one of the colleges. Students in all groups were pretested and posttested with Part II (General Reasoning) of the Guilford-Zimmerman Aptitude Survey and with Dutton's Attitude Scale. The differences between the pretest and posttest scores were calculated for each student and analyzed.

Findings

The data from a random sample of 20 students from each school, 10 from the experimental and 10 from the control group, were analyzed. Using analysis of variance, it was found there was no significant difference between the achievement and attitude of the control and experimental groups. At only two of the four schools, the achievement of the experimental group was greater than the achievement of the control group. None of these differences were found to be statistically significant.

Applying regression analysis to a sample of 53 students, it was found that varying the number of vocationally-oriented applications used failed to significantly affect achievement or attitude.

The Influence of Vocationally-Oriented Applications on the Achievement and Attitude of Community College Algebra Students

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Micheal E. Morgan

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Redacted for privacy

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I. INTRODUCTION

The recent growth of the community college represents an American educational phenomenon of impressive proportions. The community college has, in part, become a place of learning for students who in the past would have been excluded from post-secondary education. The emergence of this new population has brought with it a need for changing traditional curricula and developing new curricula which are attuned to the needs, motivations, aspirations and interests of community college students. These new curricula must take into account the community college student's pragmatic point of view and interest in preparation for his /her vocational future. Therefore, learning constructs and classroom procedures which attempt to capitalize on these characteristics merit investigation.

Several studies have been conducted with the purpose of acquiring an understanding of the characteristics of community college students. Monroe (1972) characterized the students attending a given community college as being as heterogeneous as the populace of the community in which the college is located.

Cross (1971) identified many community college students as being uncomfortable in the traditional academic setting, nervous or shy in the competitive classroom, and unable to maintain a learning pace comparable with a traditional academic curriculum. She further described them as being conservative, hard-headed realists many of whom have experienced failure and therefore lack interest in and are unmotivated by a traditional curriculum.

In addition, Monroe (1972) suggested that community college students are typically older than their four-year college counterparts. Both Monroe (1972) and Cross (1971) have identified them as coming primarily from lower-middle and higher-lower social strata. Monroe's and Cross's findings have led them to conclude that community college students are different from their four-year counterparts. These authors are, therefore, insistent that the community college curricula meet the needs of those students it is meant to serve. If it must break from the traditional mold to do so, this break is to be applauded. The recent attention paid by the mathematics education community to the use of applications provides an opportunity for such a break.

For the past six years, the mathematics faculty at Linn-Benton Community College has been involved in an effort to meet the mathematical needs of students who are either in pursuit of or actively employed in a wide variety of occupations. Our efforts have centered on the widespread use of applications in our mathematics courses. In particular, those mathematics courses taught for vocational students are laced with mathematics applications relating to the vocations they are pursuing. Our efforts appear to be fruitful, but, unfortunately have not been subjected to empirical analysis. The study herein being reported represents, in part, such an analysis. It also extends the analysis to other Oregon community colleges.

Statement of the Problem

Cross (1971) pointed out that the typical community college student is not interested in complicated manipulation of abstraction. Learning for learning's sake is therefore an insufficient motivating factor. Community college students are attracted to the practical and what they perceive as being useful. They are attracted to learning which they perceive as relating to their vocational goals. Several authors have suggested the use of an instructional strategy which integrates the teaching of mathematics theory and its application to various occupations (Mrachek, 1975; Zurflieh, 1976; McNeils and Dunn, 1977; Singer, 1977). Such a strategy would attempt to structure the learning situation so that those students to whom "learning mathematics for mathematics' sake" is ludicrous would instead see mathematics as a means to an end, as a useful and meaningful aid in the achievement of their goals. In addition, such a strategy would attempt to capitalize on an intrinsic motivation, thereby producing more effective learning.

Therefore, it would seem useful to conduct a study comparing the achievement and attitude toward mathematics of two groups of community college algebra students: a group who had had the opportunity to apply mathematics in verbal problem form to a variety of occupations and a group who had not. More specifically an answer would be sought to the following question:

> Does the use of vocationally-oriented applications significantly increase the achievement and attitude of community college algebra students?

Rationale for the Study

It is essential that the community college curriculum be built around the needs of students. Cross (1971) stated that schools have done a better job of training youth for continuance in school than for leading useful, productive lives. Further, she indicated that community college students are not likely to perceive traditional course offerings as being relevant.

Monroe (1972) pointed out that the community college students' cry for relevance in instruction and curriculum is loud and compelling. Evans (1971) stated that one of the principle goals of vocational education is the providing of motivation for all types of learning. The cry for validity and variety in post-secondary curriculum is emanating from many sources--educators, students and the general public. In summary, community college students are likely to be attracted by learning that they perceive as relevant. For many of them, vocationally-oriented curricula embody that relevance. It is appropriate, then, that this aspect of relevance, with its accompanying effects on attitude and achievement should be the subject of systematic investigation.

A number of authors have described the importance of relevance in a learning situation. Skemp (1971) stated that the assimilation of information is positively influenced by a student's perception of the meaningfulness of that information. Gagné (1970) felt that learning takes place in an "idiosyncratic" manner thereby lending credence to the notion that information to be learned should be relevant to the learner. Further, Rogers (1969) and Ericksen (1974) supported the contention that perceived relevance promotes learner achievement. In addition, Ericksen (1974) indicated that the best means of insuring transfer of learning is to insure that the learner is made aware of and sees relevance in what he is learning at the time it is being learned.

In summary, the above statements on learning have the following common elements:

1. That the quantity and quality of learning is significantly influenced by learner motivation which is influenced by perceived relevance.
2. That a learning experience should be related to the learner's interests and goals.
3. That the transfer of learning is more likely to occur if classroom learning experiences relate to learner interests and goals.

If one adds to the above the notion that adult learners are best motivated by learning which relates to their out-of-school, real-life experiences (Knowles, 1973), the use of vocationally-oriented applications in the community college mathematics classroom becomes a means of providing relevancy, thereby influencing attitude and achievement.

The cry for applications in the mathematics curriculum is presently reaching a new crescendo. Critics of "new math" have pointed out its lack of applications. As stated by Kinney (1964), its emphasis on structure has led to a deemphasis on applications. The mathematics reform of recent years has led to the definition of a more valid curriculum, but it has not met the needs of all students. Not enough attention has been paid to the application of mathematics to a variety of disciplines (Kinsella, 1971). There is a definite need for a linking of mathematics with the real world

(Bell, 1974). Some of this linking can and should take the form of applications of an occupational or vocational nature. Applications of this type are a means of capitalizing on a motivation inherent in many community college students.

An examination of the history of mathematics education reveals that the notion of including applications in the mathematics curriculum is not original with its present proponents (National Council of Teachers of Mathematics (N.C.T.M.), 1970). Mathematics education is presently witnessing a get-back-to-applications movement. One might ask, however, for what reason should applications, or problem-solving activities in general, be included in mathematics. Polya (1973) indicated that the teaching of problem solving should be the most important goal of a mathematics curriculum. This sentiment is particularly apropos when one considers the rapidity of the present-day knowledge expansion and the accompanying problems it creates. Education, including mathematics education, should be at the forefront of training the problem solvers of the future. As Polya (1973) indicated, one becomes a problem solver through practice. It is appropriate that at least some problem-solving practice come in the form of applications of an occupational or vocational nature. Such applications provide a teaching strategy capitalizing on learner goals and, at the same time, provide the learner with the opportunity to solve problems like those he may encounter in his future.

Thus a case can be made for relevancy in curriculum and instruction. Such relevancy is important for all mathematics curricula, in particular that of the community college. One means of establishing such relevance is the use of vocationally-oriented applications. A number of authors have indicated the soundness of such an approach. Skemp (1971) suggested that:

> Mathematics is also a valuable and general purpose technique for satisfying other needs. It is widely known to be an essential tool for science, technology, and commerce; and for entry into many professions. These are goals which motivate many adults to mathematics (p. 132).
>
> For an adult, an excellent learning situation is one in which short-term and long-term motivation are fused, the short-term one being an enjoyment of the learning and doing of mathematics, an intrinsic motivation, and the long-term one being some personal, practical or academic goal to be achieved with the help of a knowledge of mathematics (p. 134).

In an indictment of present-day mathematics curricula, Freudenthal (1968, p. 8) stated that: "I am convinced that, if we do not succeed in teaching mathematics so as to be useful, users of mathematics will decide that mathematics is too important a teaching matter to be taught by mathematics teachers."

The mathematics curriculum must take into account the social and vocational needs of its students. As pointed out by Rosenbloom (1972), it must provide the opportunity for students to learn the mathematics skills needed in his/her vocation. The mathematics curriculum of the future will be judged on many bases, one of which should be the degree to which it has met the needs of its students by introducing meaningful applications at all levels (Adler, 1972). However, unless meaningful research is undertaken, the introduction and use of applications will likely proceed in a haphazard manner.

Available research (see Chapter II) indicates that the use of applications, particularly those of a vocational nature, has the potential of improving the achievement and attitude of community college mathematics students. Their use, however, by no means represents a panacea. As pointed out by Geeslin (1974) and Hilton (1973), anyone who thinks thusly is sadly mistaken. However, two-year college mathematics instructors who choose to ignore the career implications of their subject matter are failing to capitalize on a strong and important motivation factor among their students--a motivation which once tapped may result in more efficient learning and a more favorable attitude toward mathematics. If it can be demonstrated that the use of vocationally-oriented applications in the community college mathematics classroom results in more efficient learning and better attitude toward mathematics, this contention will be supported. This study aimed at such a demonstration by expanding the empirical base for using applications on two fronts.

It investigated the effect of vocationally-oriented applications on the achievement and attitude of community college algebra students, a population not previously used. It also investigated the effect of varying the number of such applications received on achievement and attitude. A study of this effect was suggested by Geeslin (1974) but heretofore has not been attempted.

It is unlikely that the teaching of mathematics will be made simpler by using applications, but it may well be made better. Hence, instructional strategies incorporating applications merit investigation.

II. REVIEW OF RELATED LITERATURE

An educational framework and relevant review of literature is presented in this chapter. The first section deals with available research findings related to the use of applications in mathematics. The following sections deal with motivation for learning, transfer of learning, some reasons for teaching mathematics, problem solving in the mathematics curriculum, the controversy surrounding "new" mathematics, and the significance and use of applications in the mathematics curriculum.

Research Relating to the Use of Applications

A thorough search for research related to the use of applications in mathematics revealed a near void. Geeslin (1974) indicated the near non-existence of such research and pointed out that it should be done now while the movement toward applications is still in the stage of supposition. Such research is needed now in order to provide an empirical base for the continuation or discontinuation of the applications movement. At present, this empirical base is miniscule.

Bell (1971) reported an informal, non-statistical study conducted with high school algebra students. The applications used were not necessarily of a vocational nature. Further, he reported that the study revealed a potential for improvement of attitude and achievement through the use of applications. Kaufman (1961) conducted a study in which freshman electronics students were introduced to mathematics concepts through the use of applications related to electronics. Students exposed to such applications performed significantly better on a standardized algebra and trigonometry test than did those students who received no such applications. Roetter (1976) conducted a study similar to Kaufman's. He used applications from "the real world and technology" to introduce mathematics concepts to two-year college engineering technology students. The study revealed no statistically significant difference between the posttest and retention test scores of the experimental and control groups. He concluded that the use of applied examples as a means of introducing mathematics concepts to two-year college engineering students produced equivalent if not better achievement and retention as compared to a more traditional method of instruction. Swearingen (1977) conducted a study involving the use of vocationally-oriented applications with community college vocational mathematics students. He concluded that the use of such applications has the potential of improving student achievement and attitude.

The smallness of the number of studies relating to the use of applications in mathematics makes it a largely unexplored instructional strategy. With the present-day lip service being paid to applications comes a need for further study concerning their use.

Motivation for Learning

"Motivated is a description we apply to behavior which is directed towards the satisfaction of some need" (Skemp, 1971, p. 132). An individual's motivation is indirectly discernible from his actions. Typically, if he actively engages in learning, he is said to be motivated. If not, he is said to be unmotivated. Learning theorists typically classify motivation as being of two types: intrinsic and extrinsic. Intrinsic motivation arises from stimuli internal to the learner. Skemp (1971) and Piaget, as pointed out by Wadsworth (1974), stated that intrinsic motivation arises from an organism's innate need to explore and come to know its environment, in short, from its innate need to grow mentally. Further, they stated that such mental growth is self-perpetuating; that is, mental growth fosters further mental growth. Extrinsic motivation arises from stimuli external to an individual. Gagné (1970) identified peer groups, society, and the approval or disapproval of authority figures as sources of extrinsic motivation. Ausubel (1968) added ego-enhancement and vocational aspirations to this list. Holt (1964) stated that fear of failure is the strongest motivating force in the classroom. Further, he noted that fear of failure may be either a positive, fostering learning, or a negative, hindering learning, motivating force. Of the two types of motivation, learning theorists typically identify intrinsic motivation as being the most important. However, as Skemp (1971) pointed out, intrinsic motivation is not well understood and until it is mathematics may remain for the majority of students a subject to be endured not enjoyed.

Motivation is nearly universally accepted as being an important part of the learning process. Gagné (1970) stated that many students of learning think that controlling and utilizing motivation is the most serious issue faced by schools. There is some debate, however, as to whether motivation is indispensible to learning. Ausubel (1968) had the following to say:

> The weight of the evidence indicates that although motivation is a highly significant factor in and greatly facilitates learning, it is by no means indispensible (p. 364).

He continued, however, with the following:

> Even though particular instances of learning may be largely unmotivated, it is undoubtedly true that the subject matter in question must be related to felt needs if significant long-term meaningful learning is to occur (p. 366).

Although not indispensible, motivation greatly facilitates learning. Motivation stemming from felt or perceived needs is a particularly powerful facilitator of learning. Thus, a teaching strategy capitalizing on perceived needs has the potential of capitalizing on and utilizing a strong motivating force.

The relationship between learning and motivation is reciprocal. Motivation enhances learning while successful learning, in turn, enhances motivation. It is essential that educators concern themselves with motivation and use it for learning purposes. Aubusel (1968) offered the following practical suggestions as ways to increase motivation: (1) making explicit the objectives of the learning to take place; (2) making use of existing interests; (3) arousing intellectual curiosity; (4) making the learning task appropriate to the learner; (5) setting realistic goals and measuring progress toward them; and (6) taking into account individual differences. Ausubel (1968) stated that it is unrealistic to expect that school subjects will be effectively learned until students develop a felt need to learn them. This statement, together with his above suggestions for increasing motivation, lends credence to an instructional strategy which capitalizes on the vocational interests and goals of community college students.

Transfer of Learning

Few educators challenge the importance of transfer of learning. However, as pointed out by Ausubel (1968), transfer does not take place easily. Transfer takes on particular significance when something is being learned for delayed utility; that is, when it is being learned so that it will facilitate future learning. Transfer has little chance of taking place, however, unless teachers deliberately present and students deliberately practice skills and knowledge with their transferability in mind.

Gagné (1970) has identified transfer as being of two types: lateral and vertical. Lateral transfer refers to the application of learned skills and knowledge to a broad set of tasks of nearly equal complexity. Vertical transfer occurs with the application of learned capabilities to the learning of new capabilities at a higher level of complexity. Mathematics is often lauded for its usefulness. In this case, it is being lauded for its transferability to situations outside of mathematics per se. Praising mathematics for its transferability is easy. Teaching mathematics for transferability is a considerably more difficult task.

Learning theorists have made a number of suggestions concerning improving the transfer of learning. Ausubel (1968, p. 161) stated that transferability is ". . .largely a function of the relevance, meaningfulness, clarity, stability, integrativeness, and explnatory power. . ." of the originally learned material. Further, he pointed out that transfer is aided by emphasizing the similarity between knowledge being originally learned and the task(s) to which it is to transfer. Gagné (1970), taking a stand similar to Ausubel's, stated that the most important prescription for transfer is to be sure of the possession of subordinate and prerequisite skills and knowledge necessary for the transfer. He added that transfer is facilitated when students are encouraged to generalize their knowledge to a wide variety of situations. Dienes (1963) took this notion one step further by stating that effective original learning can only occur when students are presented with multiple embodiments of the same knowledge. According to Dienes, this removes irrelevancies from what is learned making that learning more enduring and usable. Multiple embodiment of knowledge is for Dienes a key to learning the structure of the knowledge itself. Grasping this structure is for Bruner (1969) the essential ingredient in making knowledge usable; that is, transferable. He stated that:

> In order for a person to be able to recognize the applicability or inapplicability of an idea to a new sutiation and to broaden his knowledge thereby, he must have clearly in mind the general nature of the phenomenon with which he is dealing (1969, p. 18).

For Bruner, learning which does not emphasize structure will be of minimal transfer value.

The goal of teaching for transfer is to make the learner capable of applying what he has learned to a variety of situations, some of which may be problematic. However, as Ausubel (1968) pointed out, it is impossible to expose students in the classroom to every situation they will encounter outside the classroom. This only emphasizes the need for teaching for transfer. He went on to say that the primary goal of transfer for general education subjects is to facilitate future learning. If it can be applied in a practical sense so much the better, but such application is not a primary goal. Given the interests and goals of community college students, it appears essential that general education subjects, mathematics in particular, be taught to them with practical application in mind. Bruner (1969) stated this notion eloquantly with:

> The best way to create interest in a subject is to render it worth knowing, which means to make the knowledge gained usable in one's thinking beyond the situation in which the learning has occurred (p. 31).

In summary, the following statements can be made about transfer of learning:

1. Transfer is necessary but not generally easy.
2. Transfer is influenced by a number of variables, some of which are: (a) the similarity between the situation in which something is learned and the situation to which it is to be transferred; (b) the degree of possession of prerequisite skills necessary to the transfer; and (c) the degree to which the structure of the knowledge to be transferred is grasped.
3. Transfer is facilitated when the situation requiring transfer fits into the existing cognitive structure of the person doing the transferring.
4. Rote or "cook book" learning does not facilitate transfer.

Some Reasons for Teaching Mathematics

Watson (1971) argued that the goals of education are complex and transcend subject matter. The reasons for teaching mathematics are certainly complex and they may be said to transcend mathematics itself. Matthews (1976) stated that its vocational value and the need for a "numeracy" of the general population are reasons for teaching mathematics. Elton (1971) offered a more comprehensive but somewhat less specific list of reasons for teaching mathematics. They were: (1) for its own sake; (2) for its applicability and relevance to other disciplines; and (3) as a part of general education. There is some debate as to which if any of these reasons should take precedence over the others. There appears to be a growing voice which downplays the first reason supplied by Elton and espouses the second; that is, they hold mathematics should be taught as a usable subject and its relevance to other disciplines should be emphasized.

Kline (1973) stated that the inner reason for teaching mathematics is its use or application. He stated that historically mathematics developed out of a need to solve real world problems. Fehr (1968) and McNeils and Dunn (1977) echoed Kline by pointing out that mathematics has historically arisen from social settings and should be taught with this in mind. For these men, an emphasis on the relevance of mathematics to other disciplines is of crucial importance. Watson (1971) pointed out that students of low mathematics ability have a special need to see its relationship with and relevance to the real world. This is likely true in varying degrees of all mathematics students. If one of the reasons for teaching mathematics is its usefulness or applicability, it should be taught with a conscious recognition of this reason. For Fehr (1968), Watson (1971), Kline (1973), Hendrickson (1974), Matthews (1976), and McNeils and Dunn (1977), the use of applications is such a recognition and constitutes a means of introducing an element of relevance in the mathematics curriculum.

Problem Solving in Mathematics

The use of applications is a means of capitalizing on the problem solving potential of mathematics which in turn leads to the development of problem solving capabilities of mathematics students. A good deal of attention has been paid to the need for and difficulties surrounding the teaching of problem solving skills. Krulik (1977) asked what good is it to learn skills if they are not used. Polya (1973) stated that problem solving is the most important ingredient of the mathematics curriculum. Lester (1977) said that problem solving is at the heart of all curriculum. A considerable amount of this attention, as Wickelgren (1974) pointed out, has been lip-service. All of the research on problem solving has led to few significant changes in the classroom. General problem solving methods are seldom taught. Yet the teaching of problem solving, as feeble as our present efforts appear to be, remains a highly important endeavor. If we are to remain a nation of doers and not passive observers, the teaching of problem solving must be conducted with fervor.

The debate among learning theorists has particular relevance to the teaching of problem solving. Gagné (1970) described the learning process as being hierarchical with problem solving stationed at the top of the hierarchy. The ability to solve problems is thus dependent on the possession of prerequisite and subordinate knowledge. Further, he characterized problem solving as follows:

> One might be tempted to conclude, therefore, that problem solving is a set of events in which human beings use rules to achieve some goal. This is quite true, but it is not the whole story. The results of using rules in problem solving are not confined to achieving a goal, satisfying as that may be to the thinker. When problem solving is achieved, something is learned. . . What emerges from problem solving is a higher-order rule, which thereupon becomes part of the learner's repertory. The same class of situation, when encountered again, may be responded to with great facility by means of recall and is no longer looked on as a problem. Problem solving, then, must definitely be considered a form of learning (1970, p. 216).

Bruner (1969) concurs with Gagné that problem solving is a form of learning. For Bruner, however, learning begins with problem solving in the form of discovery. Problem solving, then, is the vehicle by which learning takes place. The curriculum should, thus, be centered on problem solving. Ausubel (1968, 1971) took exception to this stand. He stated that problem solving is important, but that schools have as their central charge the departing of knowledge and thereby the preservation of culture. For Ausubel, problem solving or discovery learning is an inefficient means of fulfilling this mission; that is, over-emphasis on problem solving will create an unbalanced curriculum. These learning theorists do agree, however, along with Polya (1973) and Johnson (1976), that acquiring even a small degree of problem-solving ability requires persistent and consistent practice. This fact reinforces the inclusion of problem solving in the mathematics curriculum. This inclusion, which must not be made at the total expense of the teaching facts and skills, has traditionally taken the form of "story" or "word" problems.

Johnson (1976) pointed out that word problems are widely recognized as the most difficult part of the learning and teaching of algebra. Wickelgren (1974) felt that some of this difficulty arises from our failure to teach general problem-solving methods. Krulik (1977), however, attributed some of the difficulty to the type of story problems traditionally included in algebra textbooks. They fail, he felt, to emotionally engage students in their solution. Without this emotional involvement, the problems become uninteresting, abstract, and difficult. Davidson (1977) echoed Krulik by stating that problem solving is enhanced when students can relate to or become emotionally involved in the situation depicted by the problem. This notion serves as a justification for the use of vocationally-oriented applications in community college mathematics classrooms.

The Controversy Surrounding "New Math"

The mathematics curriculum reform movement of the 1960's produced needed change and, like any reform, it produced controversy. As pointed out by the National Advisory Committee on Mathematical Education (NACOME) (1975), the goal of the reform movement was a major reconstruction of the scope, sequence, and pedagogy of school mathematics. The popular view of this reconstruction has "new math" being an increased emphasis on structure and points to the introduction of set theory and number bases as examples. NACOME (1975) indicated, however, that "new math" was to be more--it was also to encompass a change of teaching methods based on the Socratic model. This change was intended to reduce rote learning and increase understanding. Critics of "new math" contend that it failed and is failing to accomplish this goal.

Kapur (1977) argued that the goals of the "new math" movement were inconsistent. For example, "new math" created an inconsistency with its emphasis on rigor and structure while portraying discovery and intuition as the chief methods for learning mathematics. As indicated by Ausubel (1968), the undisciplined mind of a child is not likely to successfully handle this dicotomy.

Kapur (1977) also stated that the "new math" movement aimed to produce a small number of mathematicians yet prescribed the same curriculum for all students, regardless of whether they were bound for careers in mathematics. In short, it emphasized the mathematical education of the elite at the expense of the masses. Perhaps the most common and most stinging criticism of the "new math" movement is its apparent failure, as indicated by falling national assessment test scores, to teach basic mathematics skills. "New math," its critics argue, has failed to meet the mathematical literacy requirements of a large group of students. Ormell (1972), Kline (1973), and Kapur (1977) attributed this failure to an overemphasis on formalism; that is, structure. They claimed "new math" was initiated by a group of mathematicians and psychologists who had little regard for the pedagogical needs of students. This emphasis on formalism, they also indicated, spawned a teaching of mathematics for its own sake with an accompanying deemphasis on applications. A teaching of a subject, argued Ormell (1972), cannot be justified simply on the grounds that it exists. If this were so, the inclusion of any subject in the curriculum can be justified. "New math," Kline (1973), Lomon (1973), and Kolb and Waters (1974) argued, paid only lip-service to the use of applications thereby removing one of the chief reasons for learning mathematics. Lomon (1973) recognized that "new math" materials included some applications but noted that these applications were often contrived and seldom "real life."

Is or was "new math" a failure? Given the complex nature of "new math," its general misunderstanding, lack of full implementation, and its continuing evolution, it is unlikely that this question will ever be fully and satisfactorily answered. For example, NACOME (1975) stated the "new math" movement should now be called the "present mathematics program," "current school mathematics," or "contemporary mathematics teaching." This change in nomenclature is necessary, it believed, to reduce the controversy surrounding the term "new math." The change also recognizes that "new math," as originally conceived, was never fully implemented and that some of its glaring weaknesses are at present being successfully dealt with by the "present mathematics program." "Current school mathematics," NACOME (1975) felt, is now paying attention to mathematics programs for less able students, minimal competence for effective citizenship, and the interaction of mathematics with other disciplines. These appear to be indicators that "contemporary mathematics teaching" is moving in a positive direction.

The Significance and Use of Applications

The literature indicates that there exists considerable opinion in favor of the use of applications in the mathematics curriculum. This opinion is, however, by no means unanimous. The controversy surrounding applications is spawned by two philosophical points of view, one which holds that education should be pragmatic and one which holds that education should be general. The pragmatists argue that the generalists make education too abstract while the generalists argue that the pragmatists would make education too specific to be useful to students in a rapidly changing world. This controversy is not likely to be resolved easily if at all. There appears, however, to be a growing voice bespeaking compromise and in favor of an eclectic resolution of the issue.

Dienes (1963, 1964) stated that mathematics cannot be taught for purely formal nor for purely practical reasons. Teaching for one at the expense of the other produces an imbalance. Vocational educators are often criticized for having a narrow, overly pragmatic view of education. Evans (1971), however, pointed out that vocational education has among its goals the increasing of student options and the melding of all education. Further, he pointed out that vocational educators wish to strike a compromise between general educators who emphasize the abstract, and employers who would have education become the acquisition of a narrow range of specific skills. The teaching of mathematics from this eclectic point of view would have mathematics presented as both a "tool" subject--exposing its pragmatic side--and as a structured way of thinking--exposing its abstract or formal side. Fehr (1968), Levanti (1974), and Sida (1975) all espoused this compromise point of view. That is, mathematics can exist neither as a purely "tool" subject nor as a purely formal discipline. The teaching of mathematics must go beyond the simple teaching of skills; it must stress mathematical understanding and thinking as well. This point of view was amplified by Watson (1971) when he stated that: "A large fund of mathematical knowledge is less important than the ability to apply mathematics to a situation which is encountered" (p. 113). The application of mathematics requires the possession of mathematical skills as well as an understanding of those skills. There is, as pointed out by Mrachek (1975), a need for the coexistence of practical and theoretical mathematics. According to Newsom (1972) the two cannot exist separately. The teacher of mathematics must be capable of residing on both sides of the mathematical fence. That is, he must be able to survive in the world of pure mathematics, a world of abstraction, and in the real world calling for the application of mathematics. Without this capability, he has no hope of developing among his students the talent to think and solve problems mathematically.

Suggestions for Vocational and Career Education

Vocational and career education, particularly career education, have in recent years undergone a revitalization. Both, at least in their philosophical positions, take a compromise stand concerning the issue of pragmatic versus general education. Both recognize the need for general education. As Evans (1971) and Singer (1977) pointed out, career and vocational education must work in harmony with general education. They also indicated that career and vocational topics can be incorporated in general education subjects thereby providing a source of motivation. Evans (1971), Levanti (1974), Hoyt *et al.* (1974) and Singer (1977) specifically stated that career education topics can be a rich source of motivation in the mathematics classroom. As pointed out by Finn and Brown (1977), ". . .career topics have the attractiveness of 'relevance' for acquiring and expanding skills" (p. 490). The use of a wide variety of applications, some of which may have a career and vocational orientation, has, as pointed out by Mrachek (1975), the potential for broadening the thinking of mathematics students. Many of the so-called applications presently included in mathematics textbooks are contrived and thus lack realism. According to Ballew (1974), this situation can in part be remedied by incorporating in them a thread of practicality. He foresaw the relating of mathematics to career topics as a means of providing this thread.

Although career and vocational educators are in near unanimous agreement as to the importance of incorporating career topics in general education, in particular mathematics, there is some disagreement as to whom should be teaching career and vocational mathematics courses. Should it be the mathematics teacher or the vocational and technical instructor? This issue is of particular concern to community college vocational and mathematics instructors. Research conducted by Doversberger (1970) indicated the existence of a contingent of two-year college technical instructors who feel that mathematics for technical programs should be taught by technical instructors. Zurflieh (1976) expressed this same point of view. Typical mathematics classes, it was felt, are too abstract to be of use. The counter argument suggests that mathematics taught by technical instructors will emphasize skills at the expense of understanding. What is needed is a compromise--a marriage between theory and practicality. A survey conducted by McCuiston and Walker (1976) indicated, however, that two-year college mathematics instructors are ill-prepared to meet this challenge. In short, they have failed to incorporate career education topics in their classrooms. They are thus failing to capitalize on a likely means of motivating their students toward the learning of mathematics.

Applications in Mathematics Education

Geeslin (1974) indicated that the term application has not been suitably defined. The approach commonly taken is to accept application as an undefined term and then describe rather than define it.

Pollak (1969) stated that application connotes connecting mathematics to something else in a practical way and that it involves mathematization of a real world situation. Klamkin (1968) stated that application involves the intertwining of mathematics and the real world. This intertwining he noted also usually involves the intermingling of many branches of mathematics, e.g., algebra, trigonometry, and geometry. Further, he stated in 1971 that an application of mathematics involves the following steps: (1) recognition of the existence of a problem; (2) formulation of a mathematization of the problem; (3) mathematization of the problem solution; (4) actual computation of the solution; and (5) explanation and interpretation of the solution.

Klamkin's characterization of application is more sophisticated and comprehensive than the typical perception of application. Typically, applications are presented in story or word problem form. Although these situations are to a degree preformulated, hence foregoing steps one and two of Klamkin's application process, they are likely more suited to the mathematical abilities and talents of community college algebra students. As indicated by Ausubel (1968), an unsophisticated mind has difficulty dealing with unorganized and seemingly unrelated data. Story problems, then, may be taken as a lower level application than that proposed by Klamkin. Although other modes are possible and merit investigation, story or word problems represent an effective vehicle for the application of mathematics and they are likely to remain the dominant means of doing so. The typical perception, then, has application being nearly synonymous with story problem.

As pointed out by Kline (1974), the task of applying mathematics is formidable but noble. It requires an ability to co-exist in the worlds of the abstract and real. Hilton (1973) stated that it is easier to teach mathematics for mathematics' sake than for usefulness. The introduction of meaningful applications at all levels of the mathematics curriculum thus becomes a formidable task indeed.

The use of applications has over the past several decades been spotty and has suffered from neglect. Their reintroduction thus becomes subject to suspicion, prejudice, and misunderstanding. Pollak (1968) indicated the following as the most common misunderstandings surrounding the use of applications:

1. That only higher levels of mathematics, e.g., calculus and differential equations, are appropriate for making application of mathematics.
2. That classical physics is the only true source of applications.
3. That teaching applications is different from teaching pure math--it requires an entirely different set of techniques.
4. That applications are necessarily difficult and remote.

Bell (1971) added the following:

1. That applications require elaborate equipment which teachers are not prepared to use.
2. That young students, by and large, are not interested in applications.
3. That applications tend to give students an impression that mathematics has no right to its own existence.

This list, although by no means exhaustive, is illustrative of the prejudices and misconceptions surrounding the use of applications. The general public perceives mathematics as being important because of its usefulness. Therefore, they are likely to support the use of applications. As with all instructional strategies, however, the ultimate success or failure of the use of applications in mathematics lies in the hands of the teacher. Teacher attitude and preparedness, as indicated by Hilton (1973) and Elton (1971), represent the keys to the success or failure of the use of applications.

This section relating to the use of applications can best be summarized by suggesting an answer to the question: "why teach applications?" The literature suggested the following answers:

1. Applications provide motivation (Bruner, 1969; Bell, 1971; Kline, 1973; Ballew, 1974; Flegg, 1974; Fremont, 1974; Hoyt _et al._, 1974; Levanti, 1974; Finn and Brown, 1977).
2. Applications build intuition (Wilder, 1973).
3. Applications reinforce mathematics concepts (Mizrahi and Sullivan, 1973; Fremont, 1974; Finn and Brown, 1977).
4. Applications aid reasoning and understanding (Bell, 1974; Mrachek, 1975).
5. Applications relate mathematics to the real world thus providing an element of relevancy (Engel, 1968; Evans, 1971; Ormell, 1972; Kline, 1973; Davidson, 1977).
6. Applications reinforce the need for learning mathematics (Carrier _et al._, 1962; Kline, 1973; Mrachek, 1975; Matthews, 1976).

III. RESEARCH METHOD AND DESIGN

The purpose of this study was to ascertain the effect of vocationally-oriented applications on the achievement and attitude of community college algebra students. For this purpose, an experimental group receiving vocationally-oriented applications and a control group receiving applications like those traditionally found in algebra textbooks were established at each of four Oregon community colleges. Each group was pretested and posttested with an achievement and an attitude measuring instrument. For each student, posttest scores were subtracted from pretest scores. These differences were subjected to statistical analysis.

The Population

A population from four randomly selected Oregon community colleges participated in this study. The participating community colleges were selected by the following method:

1. The names of Oregon's 13 community colleges were placed in an alphabetized list.
2. The number seven was selected from a random number table.
3. The seventh school in the alphabetical list was contacted and asked to participate in the study.
4. Beginning with the eighth school in the list, seven additional

places were counted off. The school in this position was contacted and asked to participate.

Additionally, a school's participation was predicated on its offering two sections of a beginning algebra class taught by the same instructor during winter term. Also, at least one of the schools had to meet the qualification of having the same instructor teaching two sections of beginning algebra during both fall and winter terms. Once the participation of a school was secured, the assignment of control and experimental status to the classes involved was accomplished by the flip of a coin. The members of the classes were not informed as to whether they were in the control or experimental group. This was to minimize the Hawthorne effect. Based on the above selection procedure, Chemeketa Community College, Linn-Benton Community College, Portland Community College, and Umpqua Community College became the participating schools. These schools represent a cross-section of Oregon community colleges, as the following data extracted from documents produced by the Community College Division of the Oregon Department of Education indicate. These data pertain to the 1976-77 school year--fall through summer term.

Chemeketa Community College is located in Salem, the state's capital. The school serves a diverse student population drawn from primarily rural Marion, Polk, Yamhill, and a portion of Linn counties. Chemeketa had a total operating budget of $9, 317, 030 for the 1976-77 school year. Its student body had an unduplicated head count of 26, 532 students resulting in 4, 103.7 FTE of which 35.2 percent and 41.8 percent were enrolled in lower division collegiate and vocational education programs respectively. Chemeketa's enrollment accounted for 10.52 percent of the state's total community college FTE reimbursement.

Linn-Benton Community College is located near Albany and within 15 miles of Corvallis. Albany, located in Linn County, is an industrialized city having lumber, paper, and rare metals plants. Corvallis, located in Benton County, is the site of Oregon State University. Linn-Benton's student population is drawn from primarily rural Linn and Benton counties. For the 1976-77 school year, Linn-Benton had a total operating budget of $6, 221, 183 with an unduplicated student head count of 16, 193 resulting in 3, 502.7 FTE of which 26.5 percent and 48.9 percent were for lower division collegiate and vocational education respectively. Linn-Benton's enrollment accounted for 7.22 percent of the state's total reimbursement for community colleges.

Portland Community College (P.C.C.) is the state's largest community college having several campuses all of which are located in the Portland metropolitan area. It operates on tax monies coming from Yamhill, Clackamas, Multnomah, Washington, and Columbia counties. For the 1976-77 school year, its total operating budget was $18, 215, 570. Its student body had an unduplicated head count of 55, 540 resulting in 13, 558 FTE of which 33.5 percent and 48.5 percent were for lower division collegiate and vocational education respectively. P.C.C. accounted for 27.95 percent of the state's total community college FTE reimbursement.

Umpqua Community College is located at Roseburg near the southern end of the Willamette Valley. Its student body is derived primarily from Douglas County noted for its production of forest products. For the 1976-77 school year, Umpqua had a total operating budget of $2, 817, 065. It served an unduplicated head count of 7, 990 students producing 1, 628.2 FTE. These FTE were apportioned, 35.3 percent for lower division collegiate courses and 44.1 percent for vocational programs. Umpqua accounted for 3.36 percent of the state's FTE reimbursement for community colleges.

All four of these community colleges are comprehensive--offering courses in lower division transfer, vocational, and adult education. This study concentrated on the portion of the student population enrolled in elements of algebra courses at these schools. Elements of algebra, also identified as beginning algebra, is the equivalent of a first-year high school algebra course. It typically attracts students of several types: those with definitive vocational interests, those with more general education interests, and those seeking algebra remediation.

The Treatment

As stated previously, a control group receiving traditional applications and an experimental group receiving vocationally-oriented applications were established at each of the participating schools. At each school, the same instructor taught both the control and experimental groups using the same textbook in each case. Chemeketa used Beginning Algebra for College Students, Karl J. Smith and Patrick Boyll (1976). Linn-Benton Community College used Beginning Algebra, Ignacio Bello and Jack R. Britton (1976). Portland Community College employed Elementary Algebra--Structure and Use, second edition, Raymond A. Barnett (1975), while Umpqua used Practical Mathematics, R.V. Pearson and V.J. Pearson (1977). The text material represented the core mathematics taught to each group. The control and experimental groups were established by supplementing this material with sets of applications. The experimental groups received vocationally-oriented applications. The applications received by the control groups were of a non-career nature and representative of those traditionally found in first-year algebra texts. In each case, the application sets were distributed to the groups prior to their covering the core mathematics topic to which they related. In addition, the sets were collected and graded prior to testing covering the related core mathematics.

Application Set Construction

All of the sets of applications used in this study were constructed using the same procedure, with only the original source of the traditional and vocationally-oriented applications differing. This procedure was a modified Delphi Technique (Hostrop, 1975). Initially, the researcher prepared two application sets each for the mathematics topics of ratio and proportion, charts and graphs, simple equations, and formulas. One set was of a vocational nature and one was of a non-vocational nature. These initial sets contained from 12 to 15 applications each. The above topics were chosen because of their typical inclusion in beginning algebra courses. The applications included in the vocationally-oriented sets were based primarily on the materials produced by the Oregon Vo-Tech Math Project. These materials represent a collection of mathematics applications relating to a variety of specific vocations (Swearingen, 1975). The applications included in the non-vocational or traditional sets were derived from those found in elements of algebra textbooks. These initial sets were submitted to a panel of community college mathematics instructors all of whom had masters degrees and at least five years community college teaching experience, which included teaching both algebra and vocational mathematics. The members of the panel were asked to rank the problems in each set from best to worst. For each set, the applications receiving the nine highest overall rankings were retained. These reduced sets were resubmitted to the panel and screened for their appropriateness for beginning algebra students and their correct classification by mathematics topic. In addition, the control (traditional) and experimental (vocationally-oriented) application sets were screened to insure that they were mathematically equivalent. That is, an inspection was made to insure a one-to-one correspondence between the problems in the application sets in each mathematics topic area. This inspection was made to insure equivalency of difficulty and mathematical technique needed for solution. For example, each vocationally-oriented application pertaining to ratio and proportion had a mathematically equivalent counterpart among the traditional ratio and proportion applications.

This study required the creation of application sets containing varying numbers of vocationally-oriented applications (see Design of Study, p. 42). The control groups received problem sets containing nine problems, none of which were vocationally-oriented. That is, the control groups received only applications like those traditionally found in beginning algebra textbooks (see Appendix B). Experimental groups, depending on their location by school and term, received varying numbers of vocational applications. As did the control groups, the experimental groups received application sets containing nine problems each. However, among the nine problems were randomly dispersed either three, six or nine vocationally-oriented applications (see Appendix B). For example, one of the experimental groups received problem sets containing six vocationally-oriented applications. The sets actually contained nine applications with six of them being vocationally-oriented and three being traditional. To construct this set, its six vocationally-oriented applications were randomly selected from the nine-problem vocationally-oriented application set discussed above. The remaining three applications came from the nine-problem traditional application set discussed above. The three traditional applications used were those three which corresponded to the three vocationally-oriented applications not selected. The experimental problem set containing three vocationally-oriented applications was constructed in a similar manner. This procedure maintained the mathematical equivalency of the application sets. The application sets used are summarized in the following table (see also Design Matrix, p. 43).

Table 1. Application Sets Used.

	Vocationally-oriented Applications	Traditional Applications	Total Applications
Control	0	9	9
3 Vocationally-oriented applications	3	6	9
6 Vocationally-oriented applications	6	3	9
9 Vocationally-oriented applications	9	0	9

Design of the Study

This study utilized a non-equivalent control group design (Campbell and Stanley, 1963) to test the following major hypotheses ($\alpha = 0.05$):

H_1: There is no significant difference in achievement between the control and experimental groups.

H_2: There is no significant difference in attitude between the control and experimental groups.

H_3: There is no significant linear relationship between a student's achievement and the number of vocationally-oriented applications he receives.

H_4: There is no significant linear relationship between a student's attitude and the number of vocationally-oriented applications he receives.

For this purpose, a control and an experimental group were established during winter term at each of four community colleges. The control groups received nine-problem application sets containing no vocationally-oriented applications. The experimental groups also received nine-problem application sets. However, their sets contained six vocationally-oriented applications and three traditional applications each. Also, at one of the schools, two additional experimental groups were established during fall term. One of these groups received nine-problem application sets containing three vocationally-oriented and six traditional applications each. The other group received problem sets containing nine vocationally-oriented applications each. The overall design may be depicted as shown in Table 2.

Table 2. The Design Matrix.

	School			
	A	B	C	D
Fall term	3[a] 9[a]			
Winter term	0[b] 6[a]	0 6	0 6	0 6

[a]Indicates the number of vocationally-oriented applications included in the problem sets administered to the experimental groups.

[b]Indicates the control group.

All experimental and control groups were pretested and posttested with an attitude, an achievement, and an arithmetic skills measuring instrument. Attitude was assessed by Dutton's Attitude Scale (see Appendix A). Achievement and arithmetic skills were assessed by Part II (General Reasoning) and Part III (Numerical Operations) of the Guilford-Zimmerman Aptitude Survey, respectively. The students' pretest scores on Part III (Numerical Operations) were used to establish initial similarity of the control and experimental groups through the use of a Student's t-test on group means. Achievement and attitude gains, computed by subtracting pretest scores from posttest scores, were subjected to statistical analysis employing the services of Oregon State University's Computer Center.

Analysis of Data

H_1 and H_2 were tested through the use of analysis of variance. Their testing constitutes a testing of the notion that the use of vocationally-oriented applications with community college algebra students will improve their achievement level and attitude toward mathematics. H_3 and H_4 ~~apply only to school A.~~ They were tested by regression analysis in an attempt to establish a functional relationship between the number of vocationally-oriented applications received and achievement and attitude gains.

Inservice

Prior to the beginning of the study, the researcher met individually with each participating instructor. These meetings took place prior to fall term at school A and during fall term for schools B, C, and D. At the first meeting in each case the following items were discussed:

1. The implications and importance of guaranteeing student anonymity.

2. The proper administration of the data gathering instruments. In this regard, it was decided that:

   a) care was to be taken to insure the proper completion of the needed background information on each test, e.g., name, age and sex;

   b) the pretests would be given in the order of Dutton's Attitude Scale, Part II, and Part III during a single class period during the first week of the term;

   c) students registering late or absent on the original test day could be pretested individually no later than the end of the second week;

   d) the posttests were to be administered in the same order as the pretests during a single class period during the last week of the term;

   e) students were to be encouraged to do as well as possible on the tests.

3. The proper use of the problem sets; that is, they were to be handed out in advance of covering the topic to which they pertain and collected and graded before testing covering that topic.

4. The importance of keeping the control and experimental classes separate.

5. The importance of using the called for problem sets with the appropriate group.

6. The importance of treating both experimental and control classes the same except for the use of the appropriate problem sets.

7. The importance of minimizing instructor bias.

It was also decided that any student missing more than three weeks of class would be eliminated from the study. A second meeting was held with each instructor prior to beginning of the study. This meeting concentrated on a discussion of the experimental materials and dealt with questions concerning their use.

Research Instruments

Guilford-Zimmerman Aptitude Survey

Two of the research instruments used in this study were taken from the Guilford-Zimmerman Aptitude Survey. This survey consists of a battery of seven tests measuring aptitude factors which predict future success in a variety of occupations. Guilford and Zimmerman (1956) reported that these tests have undergone some 20 years of refinement with norming and validation being done at the University of Southern California and at the University of Washington. Further, its authors reported that the survey is designed to be self-administering with a sixth grade reading level and particularly suitable for use with adults. The survey's reading level was confirmed by Swearingen (1977). Because this study did not intend to predict future occupational success, only Part II (General Reasoning) and Part III (Numerical Operations) were employed.

Part II is reported (Guilford and Zimmerman, 1956) to measure reasoning ability with a reliability of 0.90. It is a 27-item, multiple-choice power test containing problems requiring the utilization of general reasoning abilities. The recommended time limit for Part II is 35 minutes. Part III is reported to measure facility with numerical operations with a reliability of 0.92. It is a 132-item, multiple-choice speed test containing problems requiring the addition, subtraction or multiplication of whole numbers. The recommended time limit for the test is five minutes. Part II is scored number right minus one-fourth number wrong. Part III is scored number right minus number wrong.

Dutton's Attitude Scale

The third research instrument used in this study was Dutton's Attitude Scale (see Appendix A). It was employed as a means of assessing student attitude toward mathematics. According to Aiken (1970), Dutton's Attitude Scale is the most widely used of all such instruments. Its original formulation is chronicled by Dutton and Blum (1968). Also, it was reported by Dutton (1968) as having a reliability of 0.90. In its original form, the scale uses the word arithmetic. In personal correspondence with Dutton (1977), permission was received to replace arithmetic with mathematics. This same substitution was made in studies by Henry (1974) and Swearingen (1977). In this same correspondence, Dutton stated that the scale is applicable to measuring the attitudes of community college students toward mathematics. With the word mathematics substituted for the word arithmetic, a Linn-Benton Community College reading specialist calculated the scale's reading level to be at seventh grade. The scale is self-administering, requiring approximately three minutes for completion.

Assumptions

The assumptions on which this study is based are that:

1. The control groups encountered a nonsignificant number of vocationally-oriented applications during the course of the study.
2. Each instructor's teaching both a control and an experimental group minimized possible differences in instructor and textbook effectiveness.
3. The participating instructors treated the control and experimental groups equivalently except for the application sets used with each group.

Limitations

This study was limited:

1. By the accuracy of the attitude and achievement inventories employed.
2. To a population of Oregon community colleges.
3. To elements of algebra (beginning algebra) students.

Definition of Terms

Achievement - the mastery of or proficiency in a specific area of knowledge. Achievement was measured as a gain from pretest to posttest scores on Part II (General Reasoning) of the Guilford-Zimmerman Aptitude Survey.

Algebra students - same as elements of algebra students (see elements of algebra).

Attitude - a predisposition to think, feel, and behave toward a cognitive object. In this study, the cognitive object is a mathematical application. Attitude was measured as a gain from pretest to posttest scores on Dutton's Attitude Scale.

Control groups - those algebra classes not receiving vocationally-oriented applications.

Elements of algebra - an algebra course typically offered at Oregon community colleges. It is the equivalent of a first-year high school algebra course.

Experimental groups - those classes receiving vocationally-oriented applications.

Vocationally-oriented applications - mathematics word problems derived from and relating to mathematics utilized in a variety of specific occupations.

IV. PRESENTATION AND ANALYSIS OF DATA

The results of the statistical analysis relating to the testing of this study's major hypotheses are presented in this chapter. It begins with a brief description of the study, proceeds to the testing of each of four major hypotheses, then to findings not related to original hypotheses, and concludes with a summary of findings.

Description of Study

This study was undertaken to determine the effect of using vocationally-oriented applications on the achievement and attitude toward mathematics of community college algebra students. A randomly selected, four-college sample of beginning (first year) algebra students was utilized. During winter term, a control group receiving only traditional applications and an experimental group receiving vocationally-oriented applications were established at each school. Also, two additional fall term experimental groups receiving different numbers of vocationally-oriented applications than did the winter term experimental group was established at one of the schools. At each school, the same instructor taught both the control and experimental groups. Both the traditional applications presented to the control groups and the vocationally-oriented applications presented to the experimental groups were selected by a panel of community college mathematics instructors.

Achievement was measured with Part II (General Reasoning) of the Guilford-Zimmerman Aptitude Survey. Attitude was measured with Dutton's Attitude Scale. Each student was pretested and posttested with these instruments. Achievement and attitude gains computed as the difference between pretest and posttest scores were subjected to statistical analysis. Initial similarity of the groups being compared was established by testing the equality of their mean pretest scores on Part III (Numerical Operations) of the Guilford-Zimmerman Aptitude Survey with the Student's t statistic. The first two null hypotheses comparing the achievement and attitude of the winter term control and experimental groups were tested with analysis of variance. The second two null hypotheses compare the achievement and attitude of groups receiving different numbers of vocationally-oriented applications. They were tested with regression analysis. All hypotheses were tested at the $\alpha = 0.05$ level.

Hypotheses One and Two (H_1 and H_2)

H_1: There is no significant difference in achievement between the control and experimental groups.

H_2: There is no significant difference in attitude between the control and experimental groups.

The data for testing these hypotheses were gathered during winter term at all four participating schools. The data from a random sample of 20 students, 10 from the control group and 10 from the experimental group, from each school were analyzed. The sampled raw data appear in Appendix C.

The calculated t-value of 0.882 is nonsignificant in a two-tailed ($\alpha = 0.05$) test of the nonequality of the control and experimental means (Table 3). This indicates that the mean Part III pretest scores for the control and experimental groups were not significantly different, thus allowing a comparison of their achievement and attitude gains.

Table 3. Comparison of Control and Experimental Group Means for Part III of the Guilford-Zimmerman Aptitude Survey.

Group	Mean	Standard Deviation	n	Calculated t
Control	46.33	24.42	40	0.882
Experimental	50.93	22.15	40	

Neither 0.329 or 0.378 are significant at the $\alpha = 0.05$ level (Table 4). This indicates that H_1 could not be rejected; that is, there was no significant difference between the achievement of the control and experimental groups. The mean achievement for the control and experimental groups was 2.031 and 1.631 respectively. The

F-ratio, 5.454, is significant. This significance is discussed on p. 58.

Table 4. Analysis of Variance on Achievement.

Source	Degrees of Freedom	Mean Square	F-ratio
Total	79		
School	3	46.143	5.454
~~Experimental vs Control~~	1	3.200	0.378
~~Treatment~~ x ~~School~~	3	2.781	0.329
~~Students~~	72	8.460	

Neither 0.596 nor 0.555 are significant at the $\alpha = 0.05$ level (Table 5). Hence, H_2 could not be rejected; that is, there was no significant difference between the attitude gain of the control and experimental groups. The mean attitude gains for the control and experimental groups were 0.319 and 0.525 respectively.

Table 5. Analysis of Variance on Attitude.

ATTENTION!!

Source	Degrees of Freedom	Mean Square	F-ratio
Total	79		
School	3	0.355	0.231
~~Experimental vs Control~~ TREATMENT	1	0.853	0.555
~~Treatment x School~~ INTERACTION	3	0.916	0.596
~~Students~~ ERROR	72	1.536	

<u>Hypotheses Three and Four (H_3 and H_4)</u>

H_3: There is no significant linear relationship between a student's achievement and the number of vocationally-oriented applications he receives.

H_4: There is no significant linear relationship between a student's attitude and the number of vocationally-oriented applications he receives.

The data for testing these hypotheses were collected during both fall and winter terms at school A (see Design Matrix, p. 43).

None of the calculated Student's t-values are significant for a two-tailed ($\alpha = 0.05$) test of nonequality of means, indicating that none of the mean Part III scores for school A groups were significantly different (Tables 6 and 7). This provides a basis for comparing their achievement and attitude.

Table 6. School A Group Mean Scores for Part III of the Guilford-Zimmerman Aptitude Survey.

Group	Number of Applications[a]	Mean	Standard Deviation	n
1	0	55.461	33.208	13
2	3	51.000	17.292	19
3	6	43.200	18.311	10
4	9	43.636	21.924	11

[a]Number of vocationally-oriented applications in problem sets received.

Table 7. Comparison of School A Group Mean Scores for Part III of the Guilford-Zimmerman Aptitude Survey.

Comparison	Calculated t
0 vs 3	0.445
0 vs 6	1.127
0 vs 9	1.043
3 vs 6	1.111
3 vs 9	0.955
6 vs 9	0.050

The F-ratio 0.317 is not significant at the $\alpha = 0.05$ level (Table 8). Hence H_3 cannot be rejected indicating that the linear regression line for achievement for school A has a slope which is not significantly different from zero. In effect, varying the number of vocationally-oriented applications received had no statistically significant effect on achievement.

Table 8. Regression Analysis, Comparison of Achievement, Linear Model.

Source	Degrees of Freedom	Mean Square	F-ratio
Total	52	7.052	
Regression (Treatment)	1	2.263	0.317
Error	51	7.146	

The F-ratio 0.056 is not significant at the $\alpha = 0.05$ level (Table 9). Hence H_4 cannot be rejected indicating that the linear regression line for attitude gains for school A has a slope which is not significantly different from zero. In effect, varying the number of vocationally-oriented applications received had no statistically significant influence on attitude gain.

Table 9. Regression Analysis Comparison of Attitude, Linear Model.

Source	Degrees of Freedom	Mean Square	F-ratio
Total	52	2.557	
Regression	1	0.146	0.056
Error	51	2.605	

Findings Unrelated to Original Hypotheses

In the preceding analysis it was shown that the linear regression lines fitted to school A data with achievement and attitude as the dependent and treatment level (number of vocationally-oriented applications received) as the independent variable had slopes which were not significantly different from zero. Accordingly, an attempt was made to fit a quadratic curve to the data. The results obtained are shown in Tables 10 and 11.

Neither 0.722 nor 0.038 are significant at the $\alpha = 0.05$ level (Tables 10 and 11). This indicates that varying the number of vocationally-oriented applications received did not produce enough variance in achievement or attitude to be explained by a quadratic curve.

Table 10. Regression Analysis Comparison of Achievement, Quadratic Model.

Source	Degrees of Freedom	Mean Square	F-ratio
Total	52	7.052	
Regression	2	5.148	0.722
Residual	50	7.128	

Table 11. Regression Analysis Comparison of Attitude, Quadratic Model.

	Degrees of Freedom	Mean Square	F-ratio
Total	52	2.557	
Regression	2	0.101	0.038
Residual	50	2.656	

In Table 4, it should be noted that the F-ratio for school effect is significant at the $\alpha = 0.05$ level. This indicates that the school which a student attended affected his/her achievement. Accordingly, a comparison was made between the mean achievement of the winter term control and experimental groups at each school (Table 12). It should be noted that at schools B and C mean

Table 12. Comparison of Control and Experimental Group Achievement by School.

School	Group	Mean Achievement	Standard Deviation	n	Calculated t
A	Control	3.650	3.114	10	0.942
	Experimental	2.450	2.557	10	
B	Control	2.225	2.673	10	0.261
	Experimental	2.600	3.669	10	
C	Control	-0.425	3.663	10	0.056
	Experimental	-0.350	2.142	10	
D	Control	2.675	3.064	10	0.750
	Experimental	1.825	1.856	10	

achievement was greater in the experimental group than in the control group. The opposite was true at schools A and D. However, none of the calculated Student's t values were significant in a two-tailed ($\alpha = 0.05$) test for nonequality of means. A similar comparison was made of the attitude of the experimental and control groups at each school.

At schools A and B the mean attitude gain was greater in the experimental group than in the control group. The opposite was true for schools C and D. However, none of the calculated Student's t values were significant in a two-tailed ($\alpha = 0.05$) test for nonequality of means (Table 13).

Table 13. Comparison of Control and Experimental Group Attitude by School.

School	Group	Mean Attitude	Standard Deviation	n	Calculated t
A	Control	0.296	1.126	10	0.658
	Experimental	0.611	1.011	10	
B	Control	-0.154	0.743	10	1.698
	Experimental	0.612	1.218	10	
C	Control	0.548	1.065	10	0.237
	Experimental	0.392	1.787	10	
D	Control	0.584	1.536	10	0.164
	Experimental	0.485	1.129	10	

In addition to data on achievement and attitude, the percentage of students completing each course was calculated. The formula

$$\frac{\text{no. students receiving grades}}{\text{no. students registered}} \times 100$$

was used. The following data were obtained (Table 14).

Table 14. Percentage of Students Completing Each Class.

School	Class (treatment)	No. Students Registered	No. Students Receiving Grades	Completion Percentage
A	0	34	21	62
	3	30	20	67
	6	38	28	74
	9	40	30	75
B	0	36	29	81
	6	42	34	81
C	0	23	14	61
	6	31	19	61
D	0	17	14	82
	6	35	32	91

It should be noted that at all schools the experimental classes had as high or higher percentage of students completing as did the control groups. Also, at school A, as the number of vocationally-oriented applications received increased, so did the percentage of students completing each class.

Summary of Findings

Statistical analysis resulted in a failure to reject this study's major null hypotheses. There was no significant difference between the achievement and attitude of control groups receiving traditional applications and experimental groups receiving vocationally-oriented applications. Furthermore, varying the number of vocationally-oriented applications received did not produce significant differences in achievement and attitude. The analysis revealed that the school effect on achievement and attitude was significant. At some schools, the experimental group had greater achievement and attitude than did the control group. At other schools, the reverse was true. Further analysis revealed, however, that none of these within-school differences in achievement or attitude were significant. The only statistic appearing to favor the experimental groups was the percentage of students completing the class. All experimental classes had as high or higher percentage of students completing them as did the control classes. In addition, increasing the number of vocationally-oriented applications received appeared to increase the completion percentage.

V. SUMMARY, CONCLUSIONS, SPECULATIONS AND RECOMMENDATIONS

Summary

This study investigated the effect of using vocationally-oriented applications in the community college mathematics classroom. More specifically, it compared the achievement and attitude of two sets of beginning algebra students--a set which received vocationally-oriented applications and a set which did not. Achievement and attitude were measured by Part II of the Guilford-Zimmerman Aptitude Survey and Dutton's Attitude Scale, respectively. Differences between pretest and posttest scores were statistically analyzed to test four major hypotheses:

H_1: There is no significant difference in achievement between the control and experimental groups.

H_2: There is no significant difference in attitude between the control and experimental groups.

H_3: There is no significant linear relationship between a student's achievement and the number of vocationally-oriented applications he receives.

H_4: There is no significant linear relationship between a student's attitude and the number of vocationally-oriented applications he receives.

The first two hypotheses were tested with analysis of variance, the second two with regression analysis. The analysis resulted in a failure to reject any of the above hypotheses. Further analysis of within-school differences between the achievement and attitude of the control and experimental groups indicated the existence of no significant differences as well. Analysis attempting to establish a quadratic relationship between a student's achievement or attitude and the number of vocationally-oriented applications he/she receives also failed to yield significant results.

Conclusions

Based on the results of the statistical analysis, it can be concluded that, under the conditions of this experiment, the use of vocationally-oriented applications as opposed to their non use will likely ($\alpha = 0.05$) produce:

1. No significant differences in achievement.
2. No significant differences in attitude.
3. No significant linear or quadratic relationship between achievement and number of vocationally-oriented applications received.
4. No significant linear or quadratic relationship between attitude and number of vocationally-oriented applications received.

The findings of this study indicate no superiority of the use of vocationally-oriented applications over their non use. It must be pointed out that, while their use was not found to be superior, it was not found to be inferior. At some schools, the experimental group receiving vocationally-oriented applications had greater achievement and attitude than did the control group (see Tables 12 and 13). At some schools, the reverse was true. The use or non use of vocationally-oriented applications thus becomes a matter to be decided by the individual classroom instructor.

Speculations

Speculation about the reason(s) for the outcome of this study may provide a basis for refinement of further investigation concerning the use of applications. In this study, each student in each experimental group was given the same vocationally-oriented applications. This was done for the sake of consistency, simplicity and because beginning algebra classes are not usually homogeneously grouped by occupation or taught with the students' occupational choice in mind. In other words, no special attempt was made to provide a student with vocationally-oriented applications in an area of interest he/she declared. The review of literature (see Kaufman, 1961 and Roetter, 1976) indicated the potential of such an approach. The literature (Cross, 1971 and Monroe, 1972) also indicated that many community college students are oriented toward tactility. Tactility was a variable this study did not consider and if included might produce significant differences in achievement and attitude.

Recommendations for Further Study

The following recommendations for further study are presented in hopes of providing direction for future research.

This study should be replicated or similar studies conducted using vocationally-oriented applications aimed at individual student's specific career goals.

This study should be replicated or similar studies conducted at different levels of mathematics and in different mathematics courses.

A similar study should be conducted on a more longitudinal basis; for example, in a sequence course running for at least three terms.

A study incorporating the use of tactile applications should be conducted.

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APPENDICES

APPENDIX A

THE DUTTON ATTITUDE SCALE

DUTTON'S ATTITUDE SCALE

Read the statements below. Choose statements which show your feelings toward mathematics. Let your experiences with this subject in school determine the marking of items.

Place a check (✓) before those statements which tell how you feel about math. Select only the items which express your true feelings--probably not more than five items.

1.	(3.2)[a]	I avoid math because I am not very good with figures.
2.	(8.1)	Math is very interesting.
3.	(2.0)	I am afraid of doing word problems.
4.	(2.5)	I have always been afraid of mathematics.
5.	(8.7)	Working with numbers is fun.
6.	(1.0)	I would rather do anything else than do math.
7.	(7.7)	I like math because it is practical.
8.	(1.5)	I have never liked math.
9.	(3.7)	I don't feel sure of myself in mathematics.
10.	(7.0)	Sometimes I enjoy the challenge presented by a math problem.
11.	(5.2)	I am completely indifferent to math.
12.	(9.5)	I think about math problems outside of school and like to work them out.
13.	(10.5)	Math thrills me and I like it better than any other subject.
14.	(5.6)	I like mathematics but I like other subjects just as well.
15.	(9.8)	I never get tired of working with numbers.

[a]Weighted item values used to score the test have been added in parentheses. These values were not included in the copies administered in the study.

APPENDIX B

EXAMPLES OF EXPERIMENTAL AND CONTROL PROBLEMS

Ratio and Proportion

Experimental Problems

1. A nurse is to administer 40 mg of a drug from a bottle containing a solution of the drug marked 250 mg/10 cc. How many cc of the bottle's contents must be administered?

2. A common concrete mixture requires 1 part cement, 2 parts sand, and 4 parts gravel. Approximately how many sacks of cement are needed to pour 10 cubic yards of concrete? (1 sack of cement = 1 cubic foot, 27 cubic feet = 1 cubic yard)

3. A spur road in a logging area is 500 ft long and leads to a landing which is approximately circular in shape with a diameter of 300 ft. On a Forest Service aerial photograph with a scale of 1:20,000, what would be the size of the image of the length of the spur road?

Control Problems

1. A dozen oranges costs 89 cents. How much will 20 oranges cost?

2. A football team won 3 of its first 5 games. At this rate of winning, how many of its 15 scheduled games can the team expect to win?

3. A 5" wide and 7" long photograph is enlarged to have a width of 12". What is the length of the enlargement?

Simple Equations

Experimental Problems

1. At a pulp mill, sawdust is blown into a hopper through an opening which is 20" in height and 18" wide. In order to increase production, the area of the opening must be increased 15% with the width remaining unchanged. What must the new height of the opening be?

2. Argyrol solution is a mild solution of protein and silver sometimes used as an antiseptic. A hospital pharmacist is asked to fill a prescription calling for 8 oz of a 10% argyrol solution. He has 8 oz of a 12% solution and 10 oz of a 5% solution. Can he fill the prescription? If so, how?

3. The octane rating of gasoline is related to its capacity to produce knock free engine performance. For good performance, certain engine types require higher octane gasoline than others. However, using too high an octane rating may cause engine damage. An engine requires 90 octane gasoline but only 80 and 95 octane gasoline are available. How many gallons of each are required to produce 300 gallons of gasoline with a 90 octane rating?

Control Problems

1. Two cars start from the same place and travel in opposite directions. The first car averages 40 mph and the second averages 50 mph. How many hours will it take for them to be 550 miles apart?

2. How many gallons of water must be added to 3 1/2 gallons of a 10% solution of salt in order to make a 7% salt solution?

3. A total of $10,000 was invested in two financial ventures. Both ventures were successful with the first returning a profit of 8.5% while the second returned 5%. If the total profit was $657.50, how much of the $10,000 was invested in each venture.

Formulas

Experimental Problems

1. In sewage treatment, the amount of time the sewage actually spends in the treatment process is directly related to the amount of purification it undergoes. The amount of time sewage spends in any particular stage of treatment is called the "detention time" for that stage. The following formula is used to calculate detention time:

$$D = \frac{24V}{Q}$$

where D = detention time in hours, V = volume (in gallons) of sewage detained, Q = flow of sewage in gallons per day, and 24 is a conversion factor converting days to hours.

a) If a sewage treatment plant has a clarifier that contains 3,640 gallons and a flow of 0.015 MGD, what is its detention time? (MGD = million gallons per day)
b) Solve this formula for Q.
c) Find Q when D = 5 1/2 hr for a 2,950 gallon tank.

2. Lumber is commonly sold by the "board foot." The formula commonly used for calculating board feet is

$$B = \frac{TWL}{12}$$

where B = board feet, T = thickness in inches, W = width in inches, and L = length in feet.

a) Determine the total volume in board feet and the total cost for the following items of lumber.

No. of pieces		Cost per TBF*
110	2" x 8" x 20'	$185.00
55	2" x 4" x 12'	170.00
36	2" x 6" x 14'	175.00

*TBF = thousand board feet

b) Solve this formula for L.
c) What is L when T = 1 5/8", W = 3 5/8", and B = 4.91 board feet?

3. The total piston displacement of an internal combustion engine can be found with the following formula:

$$P = 0.7854\ D^2LN$$

where P = piston displacement in cubic inches, D = diameter or bore of cylinders in inches, L = length of stroke of pistons in inches, and N = number of cylinders.

a) What is the total piston displacement for a 6-cylinder engine with a 3 13/16" stroke and a 3.500" bore?
b) Solve this formula for D.
c) What must the diameter of each cylinder of an 8-cylinder engine be if their stroke is 3 5/8" and the total displacement is to be 283 cu in?

Control Problems

1. The circumference of a circle is given by:

$$C = 2\pi r$$

where C = circumference, r = radius of the circle, and $\pi = 3.14$.

a) Find C if r = 3 1/8".
b) Solve this formula for r.
c) Find r if C = 84.93".

2. The following formula is used to convert between Fahrenheit and centigrade temperatures:

$$C = \frac{5}{9}(F - 32)$$

where C = centigrade temperature and F = Fahrenheit temperature.

a) Find C if $F = 89^{o}$.
b) Solve this formula for F.
c) Find F when $C = 100^{o}$.

3. The area of a triangle is given by:

$$A = \frac{bh}{2}$$

where A = area of the triangle, b = length of the base of the triangle, and h = length of the height of the triangle.

a) Find A when b = 6 1/4" and h = 10 3/8".
b) Solve this formula for h.
c) What is h when A = 140.38 sq in and b = 14 1/8"?

Charts and Graphs

Experimental Problems

1. "Huber's Formula" for finding the volume of a log is

$$V = LC$$

where V = volume in cubic feet, L = length of log in feet, and C = basal area of log, that is, the cross-sectional area of the log at breast height.

Plot V vs. C for a 16 ft log where C varies from 5 to 20 sq ft. From your graph, estimate the volume of a 16 ft log having a basal area of 8.25 sq ft.

2. The number of cattle of different weights that may be shipped in a railroad car 48 ft long is:

Average Wt. (lbs)	300	400	500	600	700	800	900	1000
No. of Head	80	67	56	49	44	40	36	33

Graph this information then estimate how many 450 lb calves could be shipped in a 48 ft railroad livestock car.

3. A feed lot has an average of 8,400 steers and 5,600 lambs. The steers average 950 lbs and the lambs 85 lbs. Using the table below, calculate how many tons of nitrogen, phosphorus, and potassium would be produced by these animals in a year's time.

Average Composition of a Ton of Manure

Animal	Nitrogen (lbs)	Phosphorus (lbs)	Potassium (lbs)	Tons produced/ yr/1,000 lbs of animal weight
Dairy cow	10.7	2.1	9.4	15.0
Steer	14.6	4.2	9.2	8.5
Sheep	21.5	6.3	22.0	7.5
Horse	14.0	2.2	12.8	9.0
Pig	9.8	3.0	7.8	18.0
Hen	22.6	7.6	7.6	4.3

Control Problems

1. The distance (D) that a car travels in time (T) at a constant rate (R) is given by

$$D = RT$$

Suppose R = 15 mi/hr. Graph the relationship between D and T as T varies from 0 to 15 hr.

2. Graph the following data.

x	2	10	17	30	32
7	8	40	51	95	96

a) Is the relationship between x and y a linear one? Justify your answer.

b) Estimate the y-values associated with x-values of 8 and 25.

3.

Unit Type	Weight (lbs)	Unit Type	Weight (lbs)
A	12.8	E	41.6
B	18.6	F	52.4
C	21.0	G	25.6
D	38.4	H	37.2

a) What is the total weight of 20 type A units?

b) If Type D units are made of material weighing 0.14 lb/sq in, how many sq in of material are used in a Type D unit?

c) What is the combined average weight of 10 Type C, 15 Type G, and 12 Type H units?

APPENDIX C

DATA SUBJECTED TO ANALYSIS OF VARIANCE

Student Data from School A.

Treatment[a]	Pretest Part III GZAS[b]	Pretest Part II GZAS	Posttest Part II GZAS	Pretest Dutton's[c]	Posttest Dutton's	Age	Sex
0	55	2.00	7.25	2.58	2.99	25	F
0	58	2.50	7.00	6.06	5.86	25	M
0	29	9.00	9.50	2.35	5.20	19	F
0	83	-0.75	4.50	6.78	5.40	19	F
0	79	5.75	15.75	7.88	7.06	27	F
0	36	0.00	4.50	2.73	2.85	44	F
0	71	5.75	7.50	6.27	6.73	19	F
0	27	0.75	4.75	4.70	5.43	18	M
0	91	0.25	2.25	2.40	2.40	31	F
0	123	5.75	4.50	6.11	6.90	35	F
6	34	7.00	12.00	8.53	8.40	34	M
6	22	-1.75	3.50	4.10	4.63	19	F
6	63	0.75	-0.25	2.80	2.85	22	F
6	38	3.50	9.25	3.70	5.70	25	F
6	34	11.50	13.00	2.60	4.64	36	F
6	27	-0.75	0.50	4.58	4.16	46	F
6	39	9.50	8.25	7.25	7.10	18	M
6	66	10.25	11.50	6.13	7.53	31	M
6	76	0.50	5.00	2.43	1.83	34	F
6	33	8.50	10.75	4.65	6.03	34	F

[a]Denotes the number of vocationally-oriented applications received in each problem set; for example, 0 denotes the control group.

[b]Denotes Guilford-Zimmerman Aptitude Survey.

[c]Denotes Dutton's Attitude Scale.

Student Data from School B.

Treatment	Pretest Part III GZAS	Pretest Part II GZAS	Posttest Part II GZAS	Pretest Dutton's	Posttest Dutton's	Age	Sex
0	29	3.25	2.00	5.22	5.80	29	F
0	19	10.50	14.50	7.35	7.35	21	M
0	28	0.00	3.25	2.07	2.58	18	F
0	13	-1.50	1.50	4.00	2.80	19	M
0	25	13.00	12.00	7.35	6.00	26	M
0	51	13.25	18.50	7.42	7.10	25	M
0	42	5.00	5.25	7.35	6.77	22	M
0	28	11.00	12.50	6.96	7.84	20	M
0	23	1.25	8.00	3.45	3.68	25	M
0	97	12.25	12.75	9.05	8.76	32	F
6	35	2.25	6.00	7.91	7.64	24	M
6	22	1.00	9.00	4.50	3.38	32	M
6	44	1.50	6.75	8.76	8.58	17	F
6	73	8.00	9.00	5.43	7.47	21	F
6	74	11.00	16.00	5.10	7.78	27	F
6	40	10.75	8.50	1.25	2.90	21	M
6	43	13.25	10.25	3.63	4.27	18	M
6	16	-0.25	6.00	6.80	6.42	31	M
6	66	6.25	8.25	8.76	8.76	51	M
6	42	2.00	2.00	7.90	8.96	29	M

Student Data for School C.

Treatment	Pretest Part III GZAS	Pretest Part II GZAS	Posttest Part II GZAS	Pretest Dutton's	Posttest Dutton's	Age	Sex
0	44	6.50	8.50	4.07	4.55	27	F
0	36	-0.75	4.25	4.07	3.83	24	F
0	28	6.50	4.25	2.99	3.68	18	F
0	12	-1.25	0.00	3.34	3.34	21	M
0	39	4.00	8.25	3.30	3.33	19	M
0	33	5.75	6.50	5.68	8.58	18	M
0	19	4.50	2.00	8.06	6.94	20	M
0	66	8.25	2.50	2.58	3.55	36	F
0	70	13.25	8.25	6.45	6.97	23	M
0	37	6.25	4.25	3.15	4.40	22	F
6	84	11.00	12.00	5.43	7.47	36	F
6	41	5.25	3.25	3.70	5.35	24	F
6	57	5.75	6.75	5.33	7.10	22	M
6	36	13.25	14.25	7.58	6.42	36	F
6	42	11.25	10.25	5.20	5.43	18	M
6	52	13.00	13.25	6.27	6.28	19	F
6	60	9.50	10.75	8.07	5.58	29	F
6	0	5.75	1.25	2.85	4.23	22	M
6	47	0.00	2.25	2.80	5.35	19	F
6	22	1.25	-1.50	6.23	4.17	21	M

Student Data for School D.

Treatment	Pretest Part III GZAS	Pretest Part II GZAS	Posttest Part II GZAS	Pretest Dutton's	Posttest Dutton's	Age	Sex
0	37	-0.50	6.50	4.45	6.25	24	M
0	44	13.50	15.25	9.47	8.10	31	M
0	51	11.75	12.00	3.90	6.83	30	M
0	34	-1.25	1.50	5.48	7.82	27	M
0	71	9.25	8.50	6.27	5.80	19	M
0	53	4.25	5.75	7.76	7.76	25	F
0	34	-1.25	7.00	3.24	2.58	19	M
0	56	5.50	9.00	6.00	7.77	19	M
0	47	2.00	1.00	5.57	6.20	18	F
0	35	5.25	8.75	2.38	1.25	22	M
6	88	10.00	11.75	6.27	8.82	18	F
6	75	-2.00	-0.50	8.82	9.32	31	F
6	87	2.00	2.50	3.04	4.89	28	F
6	35	2.00	4.75	4.92	3.80	19	F
6	74	6.75	7.50	5.66	6.28	26	M
6	58	7.25	8.00	6.11	6.52	18	F
6	68	7.25	8.50	7.42	7.88	37	M
6	59	10.25	16.25	7.25	6.80	20	F
6	74	8.75	8.25	7.77	6.94	45	M
6	91	9.25	12.75	6.69	7.55	27	M

APPENDIX D

SCHOOL A DATA SUBJECTED TO REGRESSION ANALYSIS

Student Data from School A.

Treatment	Pretest Part III GZAS	Pretest Part II GZAS	Posttest Part II GZAS	Pretest Dutton's	Posttest Dutton's	Age	Sex
0	55	2.00	7.25	2.58	2.99	25	F
0	58	2.50	7.00	6.06	5.86	25	M
0	29	9.00	9.50	2.35	5.20	19	F
0	0	9.75	15.00	6.00	7.45	18	M
0	83	-0.75	4.50	6.78	5.40	19	F
0	79	5.75	15.75	7.88	7.06	27	F
0	33	-0.50	0.75	3.68	4.30	29	F
0	36	0.00	4.50	2.73	2.85	44	F
0	71	5.75	7.50	6.27	6.73	19	M
0	27	0.75	4.75	4.70	5.43	18	M
0	91	0.25	2.25	2.40	2.40	31	F
0	36	3.25	4.50	3.45	4.07	18	M
0	123	5.75	4.50	6.11	6.90	35	F
3	14	8.50	8.50	6.42	6.69	32	M
3	52	2.75	9.50	6.10	3.55	18	F
3	57	15.75	16.75	7.10	7.77	38	F
3	52	8.75	10.50	5.20	3.60	19	M
3	93	7.25	10.00	6.10	6.90	27	M
3	70	3.25	1.50	5.43	5.57	21	M
3	36	3.50	6.00	5.62	5.62	26	F
3	46	5.00	9.50	6.28	5.40	25	F
3	46	-2.25	3.50	4.23	7.78	26	F
3	50	4.25	10.75	4.27	5.90	18	F
3	65	9.25	10.75	7.35	5.62	38	F
3	30	8.25	10.75	4.23	5.35	28	M
3	44	12.75	17.75	6.98	4.55	43	M
3	60	6.25	5.75	6.03	7.25	29	M

(Continued on next page)

Student Data from School A.

Treatment	Pretest Part III GZAS	Pretest Part II GZAS	Posttest Part II GZAS	Pretest Dutton's	Posttest Dutton's	Age	Sex
3	74	7.00	7.00	4.87	6.90	26	F
3	51	11.00	10.75	5.43	5.35	28	F
3	49	6.25	7.00	2.60	2.40	24	M
3	44	4.25	3.25	4.40	6.53	20	M
3	36	8.25	12.00	4.23	5.20	36	M
6	34	7.00	12.00	8.53	8.40	23	M
6	22	-1.75	3.50	4.10	4.63	19	F
6	63	0.75	-0.25	2.80	2.85	22	F
6	38	3.50	9.25	3.70	5.70	25	F
6	34	11.50	13.00	2.60	4.65	36	F
6	27	-0.75	0.50	4.58	4.16	27	M
6	39	9.50	8.25	7.25	7.10	18	M
6	66	10.25	11.50	6.13	7.53	31	M
6	76	0.50	5.00	2.43	1.83	34	F
6	33	8.50	10.75	4.65	6.03	34	F
9	65	10.75	10.75	7.60	7.10	24	M
9	48	7.25	7.00	4.50	7.35	19	M
9	23	1.50	3.00	2.60	4.10	19	F
9	82	11.50	15.50	4.63	5.70	36	F
9	50	4.50	8.50	3.70	2.60	30	M
9	40	4.25	11.25	4.03	7.35	18	F
9	54	-0.50	3.75	7.55	3.70	22	M
9	7	4.00	10.75	6.03	5.08	27	M
9	20	0.75	0.75	7.88	5.54	18	F
9	32	17.50	19.50	7.35	7.98	21	M
9	59	14.25	14.00	3.93	8.50	37	M