

AN ABSTRACT OF THE THESIS OF

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Title: THE INFLUENCE OF APPLIED MATHEMATICS PROBLEMS  
ON THE ACHIEVEMENT AND ATTITUDE OF COMMUNITY  
COLLEGE VOCATIONAL STUDENTS

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Purpose of the Study

The purpose of this study was to analyze, in the mathematics classrooms, career-oriented verbal mathematics problems on the achievement and attitude of the vocational mathematics student. These career-oriented mathematics problems, used as advanced organizers, were contrasted with mathematics word problems of a more abstract and generalized nature to test the effectiveness of a learning paradigm which was built upon the needs and interests of the community college student.

Procedure

One instructor was selected from each of three randomly selected community colleges to teach both a class which utilized career-oriented mathematics word problems and a class which

presented word problems of a more generalized and abstract nature. Both sets of problems were selected through a modified Delphi Technique which utilized a panel of experts. A two-factor nested design coupled with analysis of covariance was used in computing the statistics. The pretest was used as the covariant. Two instruments, the Dutton Attitude Scale and the Guilford-Zimmerman General Reasoning Exam, were used for both the pretest and posttests at each of the schools.

### Conclusions

Career-oriented mathematics verbal problems used as advanced organizers have the potential of improving students' attitudes toward vocational mathematics.

Career-oriented mathematics verbal problems used as advanced organizers have the potential of improving students' achievement in vocational mathematics.

The students at one community college who were sampled during fall term appeared to be equivalent to the winter term students as measured by achievement test means, attitude scale means, and student age means.

### Suggestions for Further Study

1. This study should be replicated using career-oriented mathematics verbal problems aimed at the individual student's career goals.

2. The present study should be replicated using the same design to ascertain if another randomly selected group of community colleges would produce similar conclusions.
3. This study should be replicated at the high school level to determine the effect of career-oriented mathematics verbal problems at that level.
4. A similar study should be conducted with community college students to ascertain if problem density has an effect on their achievement and attitudes toward career-oriented mathematics problems.
5. A learning paradigm should be investigated which utilizes career-oriented verbal mathematics problems as advanced organizers. These problem sets should precede the core mathematics content. In addition, verbal problems of a more generalized and abstract nature should be used to encourage students to generalize their mathematics learning.

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on the Achievement and Attitude of Community  
College Vocational Students

by

Dell L. Swearingen

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# THE INFLUENCE OF APPLIED MATHEMATICS PROBLEMS ON THE ACHIEVEMENT AND ATTITUDE OF COMMUNITY COLLEGE VOCATIONAL STUDENTS

## I. INTRODUCTION

Many studies have been conducted with community college students in hopes of acquiring a profile of their characteristics and needs. Three such studies were produced by Cross (1968), Cross (1971), and Monroe (1973).

According to Cross (1968) these students are attracted to a college for practical reasons--low cost, nearness to home, and job training which would lead to a higher income. These vocationally-oriented students have not been especially successful in their high school studies. Thus, they feel that they are not as well prepared for college as their four-year college counterparts (Cross, 1971).

According to Cross (1971) the community college students tend to feel nervous or shy in the competitive classroom. Yet they are eager for academic help and are more interested in counseling help with personal problems than their four-year counterparts. Previous failures have caused a lack of motivation and interest in academic programs.

Monroe (1973) suggested that community college students, who are as heterogenous as the community they represent, are on the average older than the typical four-year college student, and

the majority come from lower-middle and higher-lower class American communities. He concluded that the community college must adapt its teaching methods and curriculum to meet the needs of this clientele who may require a great deal of instructor patience and understanding.

Learning constructs which capitalize on the needs of the community college student must be investigated. These constructs must utilize students' interests in job training and immediate goals to motivate the students in the classroom.

#### Statement of the Problem

Community college students who are interested in immediate goals and have not been especially successful in their high school studies are often discouraged by the theoretical and abstract nature of the classroom. These students are not motivated by learning for learning's sake, but rather, like to see a practical use for what they learn (Cross, 1968; Monroe, 1973). The literature suggested that community college students are responsive to an instructional strategy which relates a common mathematical core to their interest or occupational area (Evans, 1971; Bell, 1973, Mrachek, 1975).

Therefore, a study was needed to compare community college vocational students' achievement and attitudes toward mathematics verbal problems related to various careers with their achievement

and attitudes toward mathematics verbal problems of a more generalized and abstract nature. The major purpose of this study was to use, in the mathematics classrooms, verbal problems from various businesses and industries to test the effectiveness of a learning paradigm which was built upon the needs of the community college student.

### Rationale for the Study

Many authors have offered suggestions of the most suitable curriculum for the community college students' needs. Cross (1968) cautioned that instead of a watered-down four-year college curriculum, a search must begin for new measures and programs specifically designed for the community college student. Further, Jensen as cited in Cross (1968) pointed out that equality of education does not mean that all students should be subjected to the same curriculum. He used an analogy of a physician giving all of his patients the same prescription. It was indicated that even giving every patient different amounts of the same medication would be a catastrophe. The parallel in education must also be avoided. The teacher must find ways to increase the student's self-confidence and problem-solving abilities, for the future will bring more pragmatic students and also more young students from the lower socioeconomic classes. According to Monroe (1973), the community

colleges will have to develop new curricula and use alternative teaching techniques. Instructional objectives will have to apply to the student's current world and its problems. The cry of relevancy in courses and problems heard on many college campuses will reinforce this need. To the student, a relevant education means a practical, occupationally-oriented education (Monroe, 1973). This same idea was emphasized by Evans (1971) when he indicated:

Every general education course can have occupational value, and awareness of occupational goals leads students to see the relevance of certain content which otherwise might appear highly irrelevant (p. 2).

. . . capitalizing on existing interests of students may be the best way of providing skills which can later lead to the development of additional interests (p. 46).

Evans (1971, p. 50) continued by suggesting:

. . . learning will occur most efficiently when tied to the student's perception of relevance. Moreover, the school will realize that for many students, educational relevance is best perceived when the students see that skills, knowledges, and attitudes are needed for occupational survival, and these are taught in many different school subjects.

The above discussion of relevance and new methods, programs, and curricula designed for vocational students at community colleges suggests that the content of many college courses should thoroughly be examined. More specifically, this study analyzed the relevance of occupationally-oriented word problems in the mathematics curriculum for vocational students.

Johnson (1976) included the following types of problems in a book dedicated to problem solving:

In his motor boat, a man can go downstream in 1 hour less time than he can go upstream the same distance. If the current is 5 mph, how fast can he travel in still water if it takes him 2 hours to travel upstream the given distance? (p. 33)

The perimeter of a triangle is 42 yards. The first side is 5 yards less than the second, and the third side is 2 yards less than the first. What is the length of each side? (p. 124)

A collection of coins has a value of 64¢. There are two more nickels than dimes and three times as many pennies as dimes. How many of each type of coin are there? (p. 70)

A man is four times as old as his son. In 3 years, the father will be three times as old as the son. How old is each now? (p. 82)

The above problems are typical of many verbal mathematics problems found in community college textbooks. While these problems demonstrate the various methods or models used in solving verbal problems, they are not relevant to many community college students.

Evans (1971, p. 55) suggested that:

If a student does love learning for learning's sake, almost any method of instruction is effective. But if he does not, the method of instruction and the context of content become extremely important. The evidence suggests that vocational education as a method of instruction is highly effective with many students, and the evidence is clear that far more students want vocational education than can be accepted in a program of its current size.

Further, Evans (1971) indicated that if the students do not see the need for mathematics they might lack the motivation to learn some of

the concepts they will need the most. Hoyt et al. (1974, p. 26) expanded this idea further when they suggested how mathematics could be made more meaningful to students.

Math teachers can use occupational examples without 'watering down' the concepts, and the principles of physics can be taught while integrating their occupational applications. What better way to drive home the importance of geometry than to show that not only the mechanical engineer and the draftsman but the crane operator determining the safe lifting capacity of his machine depend upon its principles. As an illustration, a carpenter marking and cutting a rafter is applying trigonometry, and conceptually, a youth could be taught to cut a rafter as a way of demonstrating trigonometry's practical applications. If the sales girl cannot operate the cash register without conventional arithmetic where better to learn it?

Hoyt et al. (1974) further indicated that this seemingly simple charge is difficult because many teachers do not know the career implications of their subject area. They are not unwilling to include career-oriented problems, but their experiences outside of formal education are not broad enough for them to do so. Thus, there is a very real need for career-based curriculum materials.

Educational leaders have suggested a need for a more practical mathematics curriculum for vocational community college students. The curriculum should meet the students' needs through the use of relevant application problems. The question remains, which of two learning constructs will produce a higher achievement and/or attitude level in vocational students? One theory is based on the premise that if students understand the structure of mathematics and the basic

problem-solving models, they will transfer this knowledge and later be able to solve the occupational math problems which arise on the job. This conflicts with the premise that students would learn best when given verbal mathematics problems worded as on the job. Many writers, including Evans (1971), Bell (1973), Hoyt et al. (1974), and Mrachek (1975) have strongly indicated that the added interest created by the second strategy makes it a more realistic model to be used in teaching mathematics to vocational community college students. Unfortunately, no scientific research had tried to substantiate that career-oriented verbal problems in the classroom would produce a higher achievement and/or attitude level than the generalized approach which uses abstract model verbal problems.

This research used career-oriented verbal problems chosen from the Oregon Vo-Tech Math Project to test the learning construct which included career-oriented math verbal problems to tie the core mathematics concepts to the real world. According to the project director (Swearingen, 1975), the Oregon Vo-Tech Math Project used the findings of task analysis conducted by the Oregon State Department of Education along with personal interviews with men working on the job in collecting occupational problem sets in 22 occupational areas. The problem sets were designed to create a learning climate which would support and provide positive reinforcement of math concepts relevant to specific occupational areas. These problem sets

have undergone evaluations by students at both the secondary and community college level. They have had three major revisions, the last of which involved vocational instructors rewriting the problem sets focusing on their content validity and also improving their readability. Further, according to Morgan (1975), the problem sets may be used successfully in a variety of ways. For example, problem sets may be handed out as advanced organizers before a module is covered and then collected before the students take the module test. The problems were distributed this way during the study to validate the learning construct which utilizes a career-oriented, problem-solving approach.

In summary, educational leaders are concerned with the relevancy of curriculum materials for the vocational community college student. However, little attention has been given to gaining empirical evidence about the teaching strategies or learning constructs which are being explored with these students at the community college level.

### Need for the Study

The need to analyze the mathematics curricula throughout the United States has been suggested by many educational leaders across the country. Many of these leaders have called for an increased emphasis on mathematical applications. One of the first to voice his

disappointment with modern mathematics was Kline (1973) in a book entitled, Why Johnny Can't Add: The Failure of the New Math. Kline suggested the use of applications as both motivational devices and as goals of mathematical learnings. Some of Kline's thoughts pertaining to increasing the use of applications were echoed by Bell (1973). According to Bell, the reforms of the 1960's developed agreement of terminology and a more valid content, but the school mathematics process failed for a large majority of citizens. Most people readily confessed to incompetence in using even simple mathematical tools. Their dominant attitude toward mathematics was a combination of awe and distaste. Bell felt that to improve this situation, real world links must be implemented in mathematics curricula. This does not mean that we begin with the mathematics and then look for ways to apply it. Rather the process must start with the real world and then seek mathematical models and mathematical procedures to solve those problems.

Both Evans (1971) and Hoyt et al. (1974) proposed using career-oriented problems as an effective method of motivating students in the classroom. Other leaders who supported increased emphasis on mathematical applications include Adler (1972), Wilder (1973), Mizarahi and Sullivan (1973), Fremont (1974), and Mrachek (1975). In addition, Geeslin (1974) called for research now while the move toward more emphasis on applications is still in the stage of

supposition. This would allow educators to accept or reject the implementation of applications in mathematics curricula from an empirical base. Geeslin (1974, p. 66) suggested some systematic studies which needed to be completed. For example, a few of his suggestions included:

A rather simple study could determine whether inclusion of applications promotes student facility with word problems. (One should make certain the included application is not simply a practice element for the set of problems.) A similar study could determine if use of applications increases performance on achievement tests (i.e., reinforces concepts) or retention tests. Attitude scales concerning motivation, interest, and enjoyment could be used to ascertain the effect of application on these variables.

In summary, many educational leaders are concerned with the lack of real life applications in the present mathematics curriculum. However, little attention has been given to gaining empirical evidence about the teaching strategies or learning constructs which use mathematics verbal problems to marry the concrete real life situations to abstract mathematics concepts. Without this evidence, applications may become just another educational fad as the pendulum swings from the theoretical to the practical and then returns (Broudy, 1966).

Thus, this paper investigated one of the research needs suggested by Geeslin (1974). The study focused upon the impact of career-oriented verbal problems on the attitude and achievement of community college vocational students.

### Definition of Terms

The following constitute important terms in this document. Their definitions are offered in the interest of promoting a clear understanding of how they apply to this study.

Achievement Test. A test used to measure the present proficiency, mastery, and understanding of general and specific areas of knowledge (Kerlinger, 1964).

Applied Mathematical Problems. Mathematics problems written in verbal form which utilize mathematics concepts to solve career-oriented verbal problems.

Attitude. A predisposition to think, feel, perceive, and behave toward a cognitive object (Kerlinger, 1964). In this study the cognitive object will be applied mathematics problems which are related to the various occupational areas.

Community College Vocational Students. For the purpose of this study these students are enrolled in vocational mathematics (Mathematics 4.202) at the community colleges to receive entry level skills in a specific occupation or to up-grade their present skills.

Modern Mathematics. The curricula and curricula changes brought about by government spending patterns after Russia beat the United States into space with the first Sputnik. The curricula emphasized the theory and logic underlying mathematical procedures. The

trend was toward understanding of the underlying structural concepts rather than applying the mathematics toward a concrete situation.

A new vocabulary of technical terms such as "sets," "expanded notation," "functional notation," and "the Commutative property" were introduced to the mathematics students (N.E.A., 1976).

Nested Two-Factor Experiment. A statistical design where comparisons can be made both between schools or between the experimental and control groups within schools. This design is often used in industry when a number of machines are compared, each of which turns out two separate products.

Practical Applications. See applied mathematics problems.

Practical Applied Problems. See applied mathematics problems.

Validity. The instrument measures what its designer intended it to measure.

Vocational Mathematics (Math 4.202). A mathematics course tailored for the community college vocational student covering the following mathematics topics: measurement and conversion; integers; introduction to algebra; equations and formulas; ratio and proportions; and geometry.

## II. REVIEW OF RELATED LITERATURE

The conceptual framework and relevant literature review are presented in this chapter. The first section of this chapter reviews the conceptual foundation for using career-oriented mathematics applications in the mathematics classroom. This conceptual foundation, deeply rooted in learning theory, will serve as a cornerstone for the sections to follow. The second section analyzes the suggestions which have developed out of the Career Education Paradigm envisioned by Evans, Hoyt and others. The last section includes the views of educational leaders, community college and technical school instructors who support an increased emphasis on applied mathematics.

### Conceptual Foundations

A review of the literature will include those topics which are the most important to this study. The three main topics presented are as follows: (1) the learning sequence; (2) the use of advanced organizers; and (3) the transfer of learning.

### The Learning Sequence

Many authors have presented their findings on when learning takes place. The evidence indicated that effective learning requires

an actively-involved student who wants to learn (Ausubel, 1968; Rogers, 1969; Gagné, 1970; Cole, 1972; Schwebel and Raph, 1973; Erickson, 1974). Erickson (1974) credited this principle to Hull. According to Erickson, the principle included two major points. First, in order for learning to take place, there must exist a need or a motive within the learner; and secondly, the learner must perceive what is to be learned as reducing or satisfying this need. In 1968 Ausubel expanded this notion slightly when he suggested that the learner's present attitude structure differentially enhances or inhibits the learning process. Ausubel's contribution also included the concept of anchoring ideas which exist within the learner. According to Ausubel (1968, p. 389):

When their attitudes toward the controversial material are favorable, subjects are highly motivated to learn; they put forth more intense and concentrated effort, and relevant perceptual, cognitive and response thresholds are generally lowered. Furthermore, since the cognitive component of attitudes in question is well-established, the subjects possess clear, stable and relevant anchoring ideas for incorporating the new material. When, however, their attitudes toward the controversial material are unfavorable, all of these factors operate in precisely the opposite direction.

Ausubel also concluded that doing without interest leads to little permanent learning.

Rogers (1969), using his experiences in clinical psychology as a basis, supported the same principle. Further, Rogers supported a concept which holds that when a student

sees relevance in the subject matter and he perceives that it will help him attain his goal, learning will take place at a faster pace. He used an analogy of the speed in which an adolescent learns to drive a car as evidence of this principle. Cole (1972) pointed out that if a student feels that what is to be learned is personally relevant for him, a need will exist and will insure an emotional commitment to the task. This not only aids the learning process but insures that the subject matter will be retained for a longer period of time. Piaget's studies of children provided further evidence. He suggested that in order for a child to be actively involved in the learning process, that child must be interested in exploring the learning environment (Wickens, 1973).

Closely attached to the fact that the student must want to learn if he is to be successful in the learning process is the notion that he must also feel he has the potential to conquer the subject matter presented. Wilson et al. (1974) indicated that even very bright students will not become actively involved in the learning process unless they are convinced they are capable of learning the subject matter. This is especially important for students who do not have a collection of successful experiences to draw upon.

In summary, since, according to Cross (1971), the community college students are vocationally oriented, the above discussion is especially relevant. This view was best summarized by Weber (1974,

p. 153), who suggested that most psychologists agree on the following six points:

1. That motivation is essential; that learners should desire to learn or learning is not likely to occur.
2. That transfer of training is not likely to happen automatically; transfer of training is more likely to occur if experiences are meaningful in terms of goals of the learners.
3. That mere repetition, or exercise, or drill is not necessarily conducive to learning; but they are likely to be when repetition or drill is experienced because learners see that these activities are related to their goals.
4. That learning is not merely a matter of chance; while learning might be variable, it is usually related to goals or purposes of learners rather than to purposes of teachers.
5. That responses are modified by their consequences; plans of action which seem to propel learners toward their goals are more likely to be learned; those which seem to divert learners from their goals are less likely to be learned.
6. That learning is, in part, a process of discriminating one situation or one plan of action from another in meaningful patterns which are related to learners' goals.

### The Use of Advanced Organizers

Since many authors suggested that applied math problems can best be utilized as advanced organizers, this topic will be discussed in the following section.

As mentioned earlier, Ausubel (1968) pointed out that a very important variable affecting the learning and retention of new material is the availability of relevant anchoring ideas. These ideas, an integral part of the cognitive structure, must be at a level which allows the student to match them with new material. If these specifically-relevant anchoring ideas are not available in the cognitive structure, the student is forced to apply rote learning techniques.

Ausubel (1968) studied instructional techniques which may be used to create anchoring ideas. This research led to the development of what Ausubel calls "advanced organizers." These "organizers" are introductory materials written at a high level of generality and presented in advance of the subject content. The organizers are written so that their relevance to the learning task is made explicit. They are intended to aid the learner to assimilate the new material, rather than to rely on the instant availability of appropriate anchoring ideas in the prevailing cognitive structure.

The bridging of the gap between the lack of relevant anchoring ideas and the new material to be learned is very important, for the learning and retention of new materials are functions of the stability and clarity of its anchoring ideas. If these ideas are vague and unstable, they are also often confused with the new material. This further complicates learning (Ausubel, 1968).

Ausubel's research indicated that advanced organizers facilitate the input into memory and the retention of what is learned in three ways. First, they strengthen any anchoring ideas which are present in the prevailing cognitive structure. Second, since they add to the stability and clarity of these ideas, they provide optimal anchorage. Third, the use of advanced organizers reduces the amount of rote learning required of students. This stems from the fact that the students are not required to learn the details of an unfamiliar subject before they have the appropriate anchoring ideas. They also aid the distinguishability of the new materials from the prevailing anchoring ideas.

In summary, the principle purpose of the advanced organizer is to bridge the gap between the learner's experiential base and the prerequisite skills needed before the task at hand can successfully be learned. These skills must be mastered before they can be transferred.

### The Transfer of Learning

According to Evans (1971, p. 2), vocational programs have the following three main objectives: "(1) meeting the manpower needs of society; (2) increasing the options available to each student; and (3) serving as a motivating force to enhance all types of learning." Any program striving to meet these objectives must be concerned with

instructional strategies to provide optimal transfer of learning to the particular needs and interests of students. The following review constitutes an investigation of the transfer of learning.

In 1968, Ausubel indicated that to aid transfer, vocational learning should take place in as realistic a situation as possible. This transfer does not take place automatically. In fact, there must be a deliberate effort on the student's part to appreciate the practice the skills and knowledge which will later be needed in a given situation. Additionally, Ausubel (1968) suggested that transferability depends on the application of a concept, during the original learning, to as many specific contexts as possible. According to Ausubel (1968, p. 161),

Transferability, in other words, is largely a function of the relevance, meaningfulness, clarity, stability, integrativeness, and explanatory power of the originally learned subsumers. Rote learnings have little transfer value. But generalizations manifest transferability only when they are thoroughly grasped and overlearned and take into account the pupil's level of cognitive functioning.

Bruner (1969) broadened the concept of rote learning discussed by Ausubel. Bruner was opposed to a cookbook approach to learning. He warned that it is uneconomical, for a number of reasons, to teach specific topics or skills without making their context clear in the broader structure of the discipline. First, this approach has minimal transfer value. Second, this approach provides little intellectual excitement which would aid the student's intrinsic motivation.

According to Bruner (1969, p. 3), the best way to develop an interest in a subject is to perceive it as worth knowing: ". . . which means to make the knowledge gained usable in one's thinking beyond the situation in which the learning has occurred." Further, Bruner pointed out that facts or knowledge learned without sufficient cognitive structure to secure them becomes rote learning and will not be retained. In this way, Bruner reinforced Ausubel when he suggested that facts which are not tied to relevant anchoring ideas have a very short half-life in the memory.

In 1970, Gagné discussed both vertical and horizontal transfer in his book entitled The Conditions of Learning. In this masterpiece his horizontal transfer sounds much like Ausubel's version of vocational transfer and, therefore, will not be discussed in this paper. However, Gagné's principles which make up his hierarchical description of the conditions of learning are very closely tied to what he called vertical transfer and will be reviewed in depth. Gagné, like Bruner, felt that the best way to insure transfer of learning was to make the learning experience as broad-based as possible. Learners should practice applying their knowledge in as many different situations as possible. He suggested the most important variable to long term retention is the amount of practice and the depth of the learning which originally takes place. More specifically, Gagné (1970, p. 318) indicated the following:

Once an intellectual skill has been acquired, it needs to be put to use. Most statements of educational objectives emphasize the broad applicability of learned capabilities, rather than specific performances. Thus, it is generally considered desirable that the student learn not only to recognize structurally correct English sentences but to apply this knowledge to compositions that he himself generates.

In summary, Gagné supported the concept that the most dependable factor in the instructional situation for insuring transfer of learning is mastery of subject content during its original learning. In addition, for a student to develop competence, Cole (1972, p. 98) quoted Gagné when he suggested that there must be, ". . . many opportunities, through the course of his instruction, for him to encounter, formulate, and solve problems of many varieties in his own chosen field."

Erickson's findings in 1974 agreed with Gagné's and others on the importance of the original learning. He reaffirmed Gagné's comments when he pointed out the best instructional strategy for aiding transfer is to show students the transfer value of the subject content as it is being learned. He then expanded the concept of overlearning mentioned earlier in Ausubel's (1968) research. According to Erickson (1974, p. 60):

Overlearning (going beyond the minimum requirements to recognize, recall, or utilize what is being learned) aids transfer. Overlearning is especially helpful if it gives a student the opportunity to review what he is learning under conditions that approximate the transfer setting; to 'practice under game conditions.' The important increment resulting

from overlearning is the student's clearer perception of the boundaries of a topic and meaning of its intrinsic structure.

Likewise, Erickson suggested that the teacher should direct his students toward the "principles, procedures, and general rules" which help him realize the meaning of "specific, factual, and concrete" events he will encounter. This is very important since meaningfulness is the most effective single counterbalance to the steep forgetting curve. Meaningful material becomes better organized as the student explores ways of applying it in situations outside of the classroom. When Erickson further analyzed the "ideal" retention curve, he mentioned three conditions which must exist at the time of original learning for effective transfer of learning. According to Erickson (1974, p. 46), these conditions were as follows:

1. The substantive information is relevant to the anticipated transfer situations; it has intrinsic carry over value.
2. The teacher defines his course objectives in terms of a limited number of larger "ideas" (principles, generalizations, procedures, attitudes, and values) rather than in terms of a mass of factual information.
3. Information is thoroughly learned and routine procedures of teaching and testing are changed if need be. Each student should have the opportunity to 'package' the course content in his own language so that, over a period of time, he will more readily recognize confirming and nonconfirming recurrences of the generalized principles learned in the classroom.

Erickson (1974, p. 2) concluded:

Other methods of instruction must be found that will improve the conditions for learning without compromising the

flexibility and diversity of education, and this may be the main educational challenge for the rest of this decade.

### Suggestions from Career Education

This section will extract motivational implications from the Career Education Paradigm which directly relate to the mathematics curriculum, for the reader now has a cognitive structure which includes anchoring ideas in the conceptual areas of the learning sequence, the use of advanced organizers, and the transfer of learning. This conceptual foundation provides the footings which logically connect to the structure implied in the Career Education Paradigm.

Parnell (1972), in analyzing the prevailing abstractness and lack of visual imagery available to the students in the Oregon schools, suggested a great need to implement a massive infusion of illustrations from the world of work. He suggested that the vast majority of our students require the academic subject-matter related to what concerns them in real life. He challenged instructors in all subject areas to analyze what they were teaching and systematically replace it with relevant materials. Parnell asked instructors in all discipline areas to marry the abstract concepts, symbols and language of their subject matter to real-life situations or more specifically to careers. While Parnell asked for a change in Oregon, similar

demands were made throughout the United States. As examples of the repercussion of the Career Education movement, Herr (1972) reported on experimental curricula in Quincy, Massachusetts, and Richmond Pretechnical Program, San Francisco. In these curricula, occupational interests served as a foundation for developing both general and academic skills.

While Parnell (1972) and Herr (1972) emphasized the need for this approach, Evans et al. (1973) supported the concept from a research basis. Evans et al. (1973) indicated that such motivation should entice all of the students some of the time and some of the students most of the time. They suggested that the students' occupational interests could be added to the motivational techniques an instructor uses for a given topic. The emphasis on career implications holds great potential for helping students explore reasons for learning directly related to the world of work.

Likewise, a teacher can emphasize the career relevancy of mathematics, English and other subject areas to motivate students to learn of the world of work at the same time they are studying the academic subject matter. This instructional strategy, which capitalizes on the students' interests, serves both to motivate and illustrate. Evans et al. (1973, p, 112) made the following point about using career education as an instructional strategy:

Pointing out the career relevance of subject matter can provide double reinforcement: a) motivation through demonstration of usefulness or contributing to an objective the student can relate to and endorse; b) clarification in providing illustrations within the student's range of experience and understanding.

This awareness is critical since many students describe mathematics as boring, time-wasting, dull and uninteresting. The teaching seems to vacillate from abstract theory to specific mundane shop applications with little, if any, concern for the students' interests.

According to Evans et al. (1973), mathematics instruction must reach a balance between the theoretical and applied. Students really need both. Theoretical mathematics may aid in the development of analytical skills and applied mathematics may demonstrate usefulness.

Evans et al. (1973, p. 165) put real-life applications of mathematics in perspective when they suggested: "Except for those few hired as pure mathematicians, math does not exist in the job world separate from science, engineering, marketing, or some other practical application." These authors quickly pointed out that while career education provides motivation by demonstrating the relevance and usefulness of academic subjects, it is not a panacea. Further, they predicted that in the future, math teaching will shift from focusing on the abstract principles to stressing utilitarian applications.

In conclusion, the Career Education Paradigm supported using career-oriented math verbal problems in the mathematical classroom

on the basis that they are a powerful motivational technique. Thus, the Career Education Paradigm reinforced the conceptual foundations reviewed earlier in the discussion of learning theory.

What follows continues to build a theoretical structure based on the relationship between the above considerations and the curriculum.

### Further Considerations

This section will expand upon the first two sections by addressing the question of how they apply to curriculum development. This section is subdivided into the following three parts: (1) suggestions from curriculum development; (2) the call for mathematics applications; and (3) suggestions from technical curricula.

#### Suggestions from Curriculum Development

According to Stratemeyer et al. (1963), learning takes place more efficiently when the students can apply the subject matter to a situation with which they are personally concerned. Of course, efficient learning involves helping students bridge the gap between classroom activities and their personal goals and purposes. In order for this learning to transfer, the student must identify common elements in the two situations. If a student uses a particular mathematics topic, say, ratio and proportion, both in the mathematics classroom and in the woodshop where he is building a bookshelf, he

will more likely be able to apply the math concept in daily life than a student who only works problems in the mathematics classroom.

The more a student generalizes his knowledge, the better the chance he will be able to use it in a new situation. For example, the automobile mechanic who has a thorough knowledge of the principles involved in one motor can readily adapt that knowledge to a new motor. In this process he generalized his knowledge. Such generalizations are developed through a broad range of experiences. These experiences cannot be learned simply through rote memorization.

Stratemeyer et al. (1963) indicated that retention is closely tied to repetition. If facts, skills and generalizations are important in the students' daily lives and they continually use them, very likely retention will be very high. The converse is also true. That is, the less related to life the subject matter, the greater the chance that information will be forgotten. As mentioned earlier, the best way to slow the steep forgetting curve is to learn the subject matter thoroughly during the original learning.

Stratemeyer et al., along with many of the other authors discussed in the first section of this chapter, felt that the needs and purposes of the learners must receive top priority in the development of curriculum. The choice and organization of learning experiences should develop out of examples encountered in the home, school, and community. Cole (1972) agreed when he indicated that if educational

practice was to be relevant, it must be relevant to and built upon the needs of the students.

In discussing curriculum, Erickson (1974) suggested that students will almost automatically transfer those process skills which are taught in a way that stresses their general application beyond the site of original learning. The medium of instruction is less important for improving student performance than is an internal course organization which capitalizes on the unique talents and interests that students bring to the classroom.

In summary, much of what was just presented was discussed in the first section on conceptual foundations. However, it does serve to reinforce the need to develop the curriculum with the needs and interests of the students in mind. In addition, it was again suggested that transfer best occurs when the students thoroughly learn the original material and apply it in as many and varied instances as possible.

### The Call for Mathematics Applications

As early as 1962, Polya indicated that the most important mathematical skill a secondary student could learn is how to set up and solve verbal problems. Bruner (1964) pointed out that the body of research on the factors which affect the learning of mathematics is very sparse. He warned that too often psychologists are invited to

analyze a curriculum development process after it has already been completed. He felt a better approach is to make changes continually in the curriculum from the embryonic stage through the polished curriculum. These changes would be based on sound empirical evidence gathered throughout the development process. This process should be followed when implementing the use of applications in the mathematics classroom.

In 1971, Bell reported on a conference which opened with a summary of why mathematical applications are often neglected in school mathematics courses. Some of the comments made at this conference show the lack of understanding which exists in this area..

A partial list includes (Bell, 1971):

1. Most mathematics teachers are not acquainted with applications. . . (p. 293).
2. Applications require elaborate equipment which . . . mathematics teachers are not equipped to use . . . (p. 293).
3. Young students, by and large, are not interested in applications of the subject . . . (p. 293).
4. Significant applications may require more than one lesson to teach . . . (p. 294).
5. If you want to do it right (whatever that means), it may require a cluster of mathematical skills, only some of which the student may possess at the time the application is presented . . . (p. 294).
6. Applications tend to give students the idea that mathematics has no right to its own existence (p. 294).

Bell (1971) further suggested that very little is really known about how students learn or how they manage to apply what they have learned. He felt the main difficulty stems from the fact that texts have not integrated mathematical models and applications. Bell found that teachers were more than willing to incorporate mathematical applications into the classroom, but they felt ill-prepared by their own training and experience to supply such emphasis. Because of the need for finding out more about implementing applied problems in the mathematics curricula, Bell did a pilot study which focused precisely on the problem of integrating mathematical models and applications in a standard high school course. Unfortunately, the pilot study was not carried out under research conditions and, thus, yielded only "gut level" feelings about the students' positive reactions toward utilizing mathematical models and applications in the mathematical classroom. Bell suggested that these mathematical models could be used to motivate both discussions of theory and structure and specific topics in algebra. Bell also suggested using mathematical models on a long-term basis to develop a single mathematical model. For example, the model involving free falling objects can be used in a spiral approach to marry the theoretical mathematics with the real world over a long period of time.

Adler (1972) pointed out that from the very start, the curriculum reform of the sixties was sharply criticized by instructors who felt

that the reformers misinterpreted the fundamental concepts of learning theory. These instructors, who now appear to be prophets, felt that instead of stressing the internal structure of mathematics, its external connections in applications to the sciences should have been stressed. Unfortunately, according to Adler (1972), despite the efforts of both sides there was still not enough emphasis on scientific applications. He felt the two reasons for this were: (1) mathematics teachers did not know enough about the sciences to be able to show how mathematics was applied in them, and (2) many mathematics instructors had too narrow a view of what constituted an application to the sciences. Adler felt that teachers badly needed a resource book of open-ended discovery problems, classified by topic and grade level. He suggested that if the instructor does not think that students can do applied problems, his belief becomes a self-fulfilling prophecy.

Mizahi and Sullivan (1973), agreeing with Bell, felt that more attention to applications has been long overdue and severely neglected by most mathematical curricula. They suggested that more applications, more usable models, were needed at every educational level. Further, they indicated that applications could enhance mathematics learning, and make it more interesting and enjoyable for both the students and the instructor. These applications or models are often best used as a motivational device for introducing new subject matter (Mizrahi and Sullivan, 1973).

Wilder (1973) also supported more emphasis being placed on applying the mathematics obtained in the classroom. According to Wilder, the student should understand the relationships between mathematics and the rest of his culture. He felt the student should be coached in the process of examining an unfamiliar problem, analyzing its basis, picking out the key concepts, and then translating these concepts into a mathematical model. Wilder (1973, p. 684) indicated:

The so-called story or word problems that we give our students are, of course, an elementary example of this. The student finds them difficult because they require much deeper thought and penetration than is required to perform elementary arithmetic and algebraic computations, many which even an intelligent chimpanzee can probably be taught to simulate.

Wilder felt that the use of mathematical applications would satisfy the needs of the mathematics major, as well as the general student who takes just a little mathematics. Applications can provide students with a view of the mathematics which is used in our industrial society as well as in the science. Failure to recognize the importance of including applications in the curricula can lead to the de-emphasis of mathematics in preparing for various occupations.

Using similar reasoning, Bell (1973) considered the mathematical needs of "Everyman" a solid foundation of mathematics. Such a foundation is necessary if he plans on taking more mathematics or math-related courses or if he later intends to move up the promotional ladder in his occupation. Bell felt that for mathematics to be relevant

an individual must be able to turn problematical situations into mathematical models which can be manipulated. Bell suggested that not only is this a needed skill, but that it also gives students a sense of control over their world that dealing with things abstractly might not. This sense of control builds his self-confidence. In other words, the student who feels successful after performing a task in mathematics has a better view of himself and his ability to do mathematics. Bell (1973) stressed the need to develop real world links between the students and the mathematics being taught. This would instill a more comprehensive view of mathematics for students. They may see that mathematics is not only useful, but also they may find it more fun and intellectually stimulating. In closing, Bell suggested that through the use of real world links the student will develop a feeling of "I can do it." The process of having this positive attitude reinforced in many different situations is the key to learning how to learn.

Fremont (1974) implied that students had difficulty with verbal problems because the mathematical skills were taught in isolation. He stressed that there was very little commonality between the set of problems solved and the set of math skills learned. Fremont emphasized the practice of using advanced organizers to help give the students a need for learning the mathematical skills. A need to learn something increases the students' desire to learn and their ability to

make use of what is learned. By implementing the mathematical applications before the skills are taught, the students have a better chance of seeing the power, and the usefulness of mathematics. When the verbal problems are used only as drill or exercise problems at the end of a mathematical topic area, too many students feel that mathematics is little more than a collection of meaningless exercises, instead of the motivating force for learning the ideas in the first place. According to Fremont (1974, p. 401) even James Watson

. . . who was awarded a Nobel Prize for discovering the structure of DNA, based his work on a physical model made of wooden balls and rods to represent the molecules. Imagine, a Nobel Prize winner needs a physical model to do his creative work! Don't most of us need concrete and visual representations in order to grasp abstract ideas? Don't most of us require a concrete anchor for the mathematical ideas we try to master?

Further, Fremont (1974) suggested that through the use of many applications and the freedom to explore and follow his intuition about ideas, a student is given a sense of what mathematics is all about. In addition, the student can begin to feel the power and the wonder of mathematics and, thus, develop a greater appreciation for it.

Ballew (1974) reported on a group of his students who were playing the game "Stocks and Bonds" (published by the 3M Company) when one student explained that he had some stocks he had inherited from his uncle. This caused a great excitement in the class because the students could see without a doubt that the subject matter they were

learning was relevant to the real world. He felt that the students should immediately be able to value the mathematics applications which are presented rather than study applications that they may need at some future date. Ballew also suggested that the use of math verbal problems linked with various careers provide an excellent source of problems to interest students. Likewise, Sloyer (1976, p. 26) stated:

Applications of mathematics do form a vital force in motivating students to further study and we, as teachers, should be as serious as is reasonably possible, in indicating to students the significance of the integration of mathematics with the real world.

It seems clear that mathematical applications are very important in teaching mathematics. It is also important to note the many different ways that verbal problems can influence students. These were best summarized by Geeslin (1974, p. 65):

1. applications might provide motivation (Bell, 1971);
2. build a student's intuition (Wilder, 1973);
3. reinforce concepts (Mizrahi and Sullivan, 1973);
4. make mathematics more enjoyable (Adler, 1972);
5. make mathematics more interesting (Fremont, 1974);
6. cause more efficient learning (Fremont, 1974);
7. provide anchors for mathematical ideas (Fremont, 1974);
8. aid student reasoning even after the student is in the formal operations stage (Bell, 1971); and
9. contribute to problem solving (Fremont, 1974).

Geeslin (1974, p. 66) pointed out that without a research base we are forced to conclude that: "applications will solve all our teaching problems (just like modern mathematics did)." He further stated that research is needed to test the validity of this conclusion.

The remaining part of this section will review the literature which is aimed more specifically at the community colleges' and trade schools' mathematics curricula.

### Suggestions from Technical Curricula

In a comprehensive study of the technical educational literature, Doversberger (1970, p. 20) found that:

1. Technical mathematics for technology curricula should be taught in separate courses from the mathematics offered for other curricula.
2. Topics selected for inclusion in the technical mathematics courses should be those necessary in the technical specialties.
3. There should be strict avoidance of too theoretical an approach in teaching technical mathematics. The courses should be kept on an applied level, with many illustrations from industry.
4. Careful coordination of the mathematics and the technical specialties is necessary.

Levanti (1974) at a conference entitled "Perspectives on Applications," pointed out that for the student to relate mathematics to his trade he must first have a good mathematics foundation. He must be a problem solver and have the ability to think effectively. This implies that it is very important that students understand the mathematics in addition to manipulative skills. Levanti indicated that it is obvious that to encourage, stimulate and challenge the student applications of mathematics to trades plays a vital role. These

applications must continually be made evident to the pupils by the instructor. As earlier, Levanti suggested that the applied problems be utilized in advance of a lesson to point out the usefulness of the content area in question. This will help the student visualize the mathematics content as a tool which can be effectively used in his trade. The process of solving these applied problems will aid the student to understand what he is doing. Whereas manipulative skills often focus on the "how" to solve a specific type of problem, he must also learn "where, " "when, " and "why" these general principles are important.

The mathematics curriculum, while placing more emphasis on applied problems, must also include a sound mathematical core to support these problems. Otherwise, the approach brings back memories of what was done 15 to 20 years ago, where the instructor passed out blocks of practical mathematics problems and from then on each student was on his own. This approach was as bad as the other extreme where the instructor took a college preparatory approach. Of course, the vocational-technical curricula must find a happy medium between these two approaches (Levanti, 1974).

Further, Levanti reported on the methods of implementation that he found commonly used. They were as follows (Levanti, 1974, p. 112):

1. The specific trade application made after understanding has been established.

2. Illustrating the principle by using problems taken from a variety of trades.
3. Devoting one period per week to solving specific trade problems.
4. Devoting a marking period to trade problems.
5. Devoting part of the senior year to trade problems.
6. Use of trade problems from a variety of trades and the use of trade problems in the theory program.

Likewise, Mrachek (1975) echoed some of the findings of the previous two authors. According to Mrachek (1975), mathematics instructors often over-emphasize the theory which discourages many students, especially the students who have not been previously successful in mathematics. He further suggested that the vocational student needs a readable textbook which includes definitions, illustrations, practical applications, and practice problems. Mathematics textbooks should not be aimed at one specific vocational area. This approach enables students to use only a few basic formulas which are too restrictive in their application. Students should learn the basic mathematical concepts, practice these concepts, and then be exposed to specialized mathematics for a specific occupational area. Mrachek (1975) also indicated the curriculum emphasis should be one of practical applications and should include mathematics theory only in a subtle way. He felt word problems which most students have difficulty with are probably the best means of insuring that students can, later

on the job, read carefully, reason methodically, and apply the mathematics concepts learned in the classroom. In addition, Mrachek (1975) suggested that the mathematics instructor should choose a curriculum and a text and then develop appropriate teaching strategies. The mathematics curricula should reflect present-day conditions, which, for example, would include problems dealing with the current costs of products, wages, and so on. Zurflieh (1976) pointed out that mathematics texts should take an intuitive, informal approach and they should illustrate practical applications. These texts should be written at the student's reading level and include many examples and illustrations. He further suggested that it is good educational practice to broaden students' horizons with applications pertaining to various occupational areas. With the thoughts of these many authors in mind, it is now time to summarize this chapter.

### Summary

The following inferences have been derived from the review of the related literature:

1. The student must want to learn for effective learning to take place.
2. The learner must be actively involved in the learning process.
3. The learner must have relevant anchoring ideas in his cognitive structure for effective learning to take place.

4. The learners must perceive the subject matter as being relevant to their goals.
5. The use of advanced organizers can supplement anchoring ideas and decrease the lag time between when material is encountered and when it is understood by the learner.
6. The most effective way to insure the transfer of learning is to thoroughly learn the material in the first place.
7. The learners will not think abstractly and generalize results unless they are forced to. This is important because both tend to aid the transfer of learning.
8. The process of overlearning aids transfer.
9. The use of career-oriented math verbal problems aids both transfer of learning and student motivation.
10. Repetition aids retention.
11. Career-oriented math verbal problems should be used as advanced organizers.
12. The mathematics verbal problems must be used in conjunction with a strong core mathematics program.

Implications from the research on learning theory, career education, and more emphasis on applied mathematics problems must be conscientiously translated into curriculum strategies. However, as Bruner (1964) pointed out, this translation must be carried out along with empirical studies which direct the course of development.

Thus, this study compared two curricular strategies. One used career-oriented math verbal problems while the other used abstract verbal problems.

### III. RESEARCH METHOD AND DESIGN

#### The Population

This study involved a student population from three randomly selected community colleges in Oregon. The number three was acquired using a random number table. Then the schools were listed in alphabetical order and every third school was selected for the study. Four schools were eliminated because they did not offer two sections of occupational math during winter term. The participating schools were Blue Mountain Community College (Pendleton), Linn-Benton Community College (Albany), and Portland Community College (Portland). These schools represent a cross-section of the Oregon community colleges both in size and geographic location. The following data were extracted from a report distributed by the Community College Division of the Oregon Department of Education in January 1977.

Blue Mountain Community College is located on a hill overlooking Pendleton in northeastern Oregon. The school provides an excellent view of rolling hills where local farmers and ranchers grow crops and feed cattle. A panoramic view of the Blue Mountains rounds out the setting. The school services the sparsely-populated Umatilla and Morrow counties. The total assessed valuation of the two-county area equals \$1,001,971,601.00. This assessment provided the school

with \$2,505,561.00 for operating expenses during the 1975-76 school year. This money supported a headcount of 4,950 students of which 51.2 percent were reported to the Oregon Department of Education as taking vocational courses. The school's student body represents 2.45 percent of the state's unduplicated headcount. Of the 2,532 students in the school's vocational curricula, 1,209 were male and 1,323 were female.

Linn-Benton Community College is located in the rich grassland of the Willamette Valley. It is just south of Albany and within ten miles of Oregon State University. On a clear day the setting provides a view of both the Cascade and Coastal mountain ranges on the east and west sides respectively. Albany is a highly industrial town which includes lumber mills, a paper plant, and several rare metals plants. The school services Linn and Benton counties which have a total assessed value of \$1,884,188,035.00. During the 1975-76 school year the school had total operating expenditures of \$4,909,055.00. These funds provided courses for a headcount of 13,627 students of which 50.1 percent were enrolled in vocational programs. The school's enrollment represented 6.75 percent of the state's unduplicated headcount. Of the 5,020 students enrolled in vocational courses, 1,537 were male and 2,030 were female. Most of the female vocational students were taking courses in the Business Division with very few attending the traditional male-oriented occupational training programs.

Portland Community College, which includes many campuses, is surrounded by Oregon's largest city. This study utilized the Sylvania campus of Portland Community College which possesses a panoramic view of the fertile Tualatin Valley. Because of its size, Portland is accessible by many major airlines, by boat, and by train. These means of transportation are not available in Albany or Pendleton. Portland Community College is a short drive from a multitude of businesses and industries and is also within commuting distance of many four-year colleges and universities. The total assessed valuation of \$10,043,668,751.00 is derived from Yamhill, Clackamas, Multnomah, Washington, and Columbia counties. During the 1975-76 school year Portland Community College had a total approved operating budget of \$14,904,585.00. These monies provided courses for 62,805 students of which only 27.5 percent were enrolled in Portland Community College's many vocational offerings. The school's student body represented 37.89 percent of the state's unduplicated headcount. Of the 17,293 students enrolled in vocational courses, 10,297 were male and 6,996 were female.

All three schools are comprehensive community colleges which offer a wide variety of courses and programs for the student who is interested in training or retraining as well as courses in adult education, or a two-year, lower-division collegiate program. For the

purposes of this study, the students enrolled in the vocational curricula are of prime concern.

More specifically, the population consisted of those students enrolled in Mathematics 4.202 at each of the three community colleges during the 1975-76 school year. This course is a service course taken along with the vocational curriculum's two-year programs. It is also included in many of the local apprenticeship programs. The course includes the mathematics topics of measurement and conversion, integers, introduction to algebra, equations and formulas, ratio and proportions, and geometry.

Each school provided an instructor who taught both an experimental and a control group. These groups consisted of the students who were signed up for these classes. A coin was flipped to decide which group was the control and which was the experimental. All students in both the control and experimental groups were pretested and posttested. Once the data were collected, the actual samples subjected to statistical analysis were selected by ordering the students in both the experimental and control groups at each school by their student number and selecting every other one. This process was continued until a total of 15 students was selected from each group at each of the three community colleges. This procedure helped to minimize sampling bias.

### The Treatment

Both the experimental and control groups at each of the schools used the same textbook to present the basic core mathematical concepts. Portland Community College used Elementary Algebra Structure and Use by Barnett (1975), while both Blue Mountain Community College and Linn-Benton Community College used Core Mathematics for Occupational Students by Morgan et al. (1976). With these texts as a foundation, the experimental groups were presented with career-oriented verbal problems selected from the materials produced by the Oregon Vo-Tech Math Project. The control groups were given mathematics verbal problems representative of the verbal problems often found in mathematics textbooks. These problems were not career-oriented, but rather consisted of similar models presented in a more general and abstract form.

### Problem Selection

The problem selection process relied on a modified Delphi Technique (Hostrop, 1975) to insure that the problems presented to both groups were at about the same difficulty level, were representative, and were categorized under the proper topic areas. Five math instructors, each having Masters Degrees in Mathematics and at least six years of community college mathematics teaching experience

were used as the panel of experts. Following an inservice session with each of the participating instructors, they were asked to submit problems from various occupational areas for consideration for both the control and experimental groups, under the topic areas of measurement and conversions, introduction to algebra, equations and formulas, ratio and proportions, and geometry. Once assembled these problem sets were mailed to each of the instructors who examined them and eliminated the problems which they felt were not appropriate. Problems rejected by two or more of the instructors were eliminated. The problem sets were again retyped and resubmitted to the same panel of experts for further revision. From these sets, problems were randomly selected in each topic area and a separate teacher set of problems was developed to be used in both the experimental and control classes. This process yielded a complete student set of career-oriented verbal problems and a complete student set of control group problems which were presented to the students in their respective groups.

### Inservice

The instructors met again for a half day inservice to discuss the importance of the project and instructional strategy which was to be tested. Some of the discussion emphasized the importance of:

1. Complying with the law which protects human subjects.

2. Spending the same amount of time solving verbal problems in both the experimental and control groups.
3. Keeping the teacher bias to a minimum.
4. Emphasizing problem-solving techniques.
5. Keeping the control and experimental problem sets separate so they were not given to the wrong groups.
6. Filling out all of the information on both the Dutton's Attitude Scale and the Guilford-Zimmerman Aptitude Test.
7. Working together as a team to reduce the amount of instructor variance involved in the study.

In addition, it was decided that:

1. The problem sets were handed out by topic and collected the day before each individual unit test.
2. The problem sets were each handed out in advance of the presentation of the unit in the class.
3. Students who missed more than three weeks of class were eliminated from the study.
4. It was agreed that the pretest and posttests were to be given on the same day by all three participating instructors.

#### The First Research Instrument

The first selected instrument was the Guilford-Zimmerman Aptitude Survey. The instrument consists of a seven test battery

which is reported as measuring a student's aptitude with greater specificity of application than some of the well-known intelligence tests. The tests have undergone 20 years of uninterrupted research in the Aptitude's Project at the University of Southern California. The tests, originally developed during World War II to predict the success of aircraft personnel, are now distributed by Sheridan Psychological Services. In this study the intent was not to predict students' future success in a given occupation and, therefore, only the General Reasoning Test - Part II was used as a research tool. The authors utilized a factor analysis approach to reduce the intertest overlap.

#### Description

According to Guilford and Zimmerman (1956), the General Reasoning (Part II) measured the most important factor in typical IQ tests, cognition of semantic systems. This factor is important in a variety of problem-solving skills. Form A, which was used in this study, consists of 27 multiple choice arithmetic-reasoning items graded in difficulty. Through a factor analysis approach the numerical computation aspect has been kept to a minimum. Each question consisted of a word problem representative of those models traditionally found in mathematical textbooks. The test has been used with populations of high school age students, college and adults.

The scoring key for the Aptitude Test is based on the average response of freshman and sophomore college students. The authors provided C-scale, percentile, and t-score conversions for the raw scores.

### Standardization

The authors provided little information on the initial standardization. They did report (Guilford and Zimmerman, 1956) that preliminary forms were administered to 400 lower-division students in a university and item analyses were made. The items were rank ordered for difficulty and each item was correlated with the total score of the test. The published test included test items over a large range of difficulty. No item was retained that correlated to a significant degree with the student's numerical computation test.

### Norms

Since its initial development, the General Reasoning exam has been reported on by many authors. The major norm data were based upon approximately 4,000 scores from all entering students in one year at the University of Washington and at Northwestern University, and students in beginning psychology at the University of Southern California. The sample was representative of lower-division college students with emphasis upon the freshman year. The test-retest

reliability was reported to be 0.81 on 2,617-2,728 college men and 0.74 on 1,443-1,495 college women.

The reliability was reported by the authors to be 0.89 computed from the Kuder-Richardson formula 21. According to Guilford and Zimmerman (1956) the reliability was probably higher since the K-R formula 21 often underestimates reliabilities.

The authors reported a factorial-validity of 0.60 on the Part II, General Reasoning, test. However, Razor (1949) found a significant correlation between the test results and students' course grades in literature, language, mathematics, accounting, and the sciences. The authors did not report on content validity.

#### Applicability

It was reported that students taking the Guilford-Zimmerman General Reasoning test should be able to read at approximately the sixth-grade level. The authors did not indicate which of the reading level methods were utilized to compute this level. A Linn-Benton Community College reading specialist computed the following:

(1) Flesch, sixth grade reading level; (2) Dale-Chall as revised in 1958, fifth or sixth grade reading level; and (3) Fry, sixth grade reading level.

### Administration and Scoring

The test administration time is about 40 minutes; however, it is a power test. The test can be given either to a group or to an individual and is designed to be as nearly self-administering as possible. The students read the directions by themselves and are given an opportunity to ask questions.

The General Reasoning (Part II) Test can be scored either by hand or by machine. The scoring sheet consists of two stencils with punched holes. The first provides the scorer with the number right and the second with the number wrong. It was also suggested that the no-responses be tabulated, as a check on the accuracy of scoring of the test. The scoring formula subtracts one-fourth the number wrong from the number of correct responses to obtain the student's raw score.

### The Second Research Instrument

The second research instrument used in the study was Dutton's Attitude Scale, which is an attitudinal rating scale. Like the Guilford-Zimmerman General Reasoning Test, it was used on a pretest-posttest basis (see Appendix C). It was used to assess the students' attitudes toward the subject and the verbal problems which were utilized in the study.

According to Aiken (1970, p. 554): "The scale of attitudes toward arithmetic which has been used more than any other is Dutton's Scale. . . ." Dutton's original instrument had 15 items using Thurstone scaling format which included a variety of positive and negative statements pertaining to arithmetic. It was originally developed and used to measure the attitudes of elementary teachers, but has also been frequently used at the junior high level (Aiken, 1970).

The scale which has withstood many revisions was reported by Dutton (1968) as having a reliability of 0.90 when used on 300 junior high students. Dutton further indicated that the statements are listed in random order and the items have scale values which range from 1.5 lowest to 10.5 highest. The items of neutral range were omitted. The careful construction of this new Likert-type scale was described in detail by Dutton and Blum (1968).

In the development of the revised instrument, its authors started with the strongest items in the old Dutton's Thurstone-type scale and reworded them to make third person statements. Other items were added by having students from junior high school through college list two things they liked and disliked about the new mathematics (arithmetic only). A series of procedures invented by Thurstone were then used to refine the statements. After a lengthy process statements were retained half of which were positive and half

of which were negative. The test was then administered to a trial group, and the Spearman-Brown test-retest method indicated a reliability coefficient of 0.84. Next, the scale was administered to a representative sample of 346 junior high school students. The students were chosen by their teachers to represent four socioeconomic classes. The sample included both average and accelerated classes.

In a personal letter, Dutton (1976) indicated that the content of his attitude scale would be valid at the community college level. He also felt the reliability would stand. In the same letter permission was granted to replace the word arithmetic with the word mathematics. The literature indicated that the words are equivalent. This same substitution was used in a doctoral dissertation at Oregon State University (Henry, 1974).

A reading specialist at Linn-Benton Community College computed the reading level of Dutton's Attitude Scale both with the word arithmetic and with the substitution of the word mathematics. According to the Dale-Chall readability formula (as revised in 1958), Dutton's attitude scale is between the fifth and sixth grade reading level with the word arithmetic included and seventh and eighth with the word mathematics in its place. In addition, the Flesch formula indicated a seventh grade level and the Fry ranged between a sixth and seventh grade reading level.

The Dutton Attitude Scale takes about three minutes to complete and is self-administering. The scale is easy to score (see Appendix C).

### Design of the Study

The study utilized a two-factor nested design to determine if there were significant differences in achievement and/or attitude in the use of career-oriented mathematics verbal problems as opposed to problems found in mathematics textbooks. The participating instructors at Blue Mountain Community College, Linn-Benton Community College, and Portland Community College helped to select the experimental problem sets from the Oregon Vo-Tech Math Project and the control problem sets from textbooks in their reference libraries.

The study utilized one experimental and one control group at each of three randomly selected Oregon community colleges. The study considered the retention or rejection of the following null hypotheses:

1. There is no significant difference in the attitudes of students in the experimental groups as compared to the control groups.
2. There is no significant difference in achievement level among experimental and control groups.
3. There is no significant difference in student characteristics between fall and winter terms.

The following information was collected on each student: (1) age, (2) sex, (3) math history, (4) school, and (5) instructor.

The procedures used in this study were to:

1. Pretest each of the experimental and control groups using Dutton's Attitude Scale.
2. Pretest each of the experimental and control groups using the Guilford-Zimmerman Aptitude Test.
3. Administer the treatments for 11 weeks during winter term 1977.
4. Posttest each of the experimental and control groups using an aptitude reasoning exam (same as pretest).
5. Posttest each of the experimental and control groups using an instrument which has an attitude scale (same as pretest).

The design matrix in Table 1 applied to both the achievement and attitude measures.

Table 1. The Design Matrix.

School		Aptitude and Attitude Measures	
		Pretest	Posttest
1	Experimental group <sup>a</sup>	n = 15	n = 15
	Control group <sup>a</sup>	n = 15	n = 15
2	Experimental group	n = 15	n = 15
	Control group	n = 15	n = 15
3	Experimental group	n = 15	n = 15
	Control group	n = 15	n = 15

<sup>a</sup> Experimental and control treatments, 11 weeks, winter term 1977.

## Methods of Analysis

The basic statistical tool utilized in this study was the two-way analysis of covariance. Courtney and Sedgwick (1972) explained the analysis of covariance as a statistic which combines analysis of variance and regression to handle situations where the researcher cannot completely control all of the variables in a study. It is a procedure for testing the significant differences among means of final experimental data by taking into account and adjusting for initial differences in the data.

The two-way analysis of covariance was used to determine if any significant difference existed between the achievement levels and/or the attitude levels between the experimental and control groups. The pretest was used as the covariant and as the reference for comparison to the posttest.

Table 2. Analysis of Covariance Table.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-ratio
Colleges	2	A	A/2	$MS_A/MS_C$
Groups within colleges <sup>a</sup>	3	B	B/3	$MS_B/MS_C$
Error	83	C	C/83	
Total	88	D		

<sup>a</sup>The F statistic associated with the groups within colleges was  $F_{\alpha=.05, df=2, 83} \geq 3.11$ . The critical F for groups within colleges was  $F_{\alpha=.05, d.f.=3, 83} \geq 2.72$ .

In order to determine if these existed a significant difference in student characteristics between fall and winter terms, a comparison was made between the means of the students completing the two research instruments fall and winter terms at Linn-Benton Community College. In addition, the mean ages of the two groups were compared. An F-test was used to test for homoscedasticity followed by a pooled-variance t-test to see if a significant difference existed between the means at  $\alpha = .05$  with  $n = 45$ .

#### Assumptions

The assumptions in this study can be categorized into two major areas: internal assumptions and generalizations of the study. The internal assumptions deal with the internal strength of the design and include the following:

1. The control groups encountered only a minimal set of career-oriented verbal math problems during the course of this study.
2. The differences in effectiveness in which individual instructors incorporated the career-oriented verbal math problems into the educational process of the experimental groups was counter-balanced by the fact that each instructor taught both an experimental and control group.
3. Instructor bias was reduced through inservice. It is assumed that instructor bias toward the experimental group was

counterbalanced by the fact that the participating instructors received their indoctrination in using verbal problems in modern mathematics at four-year colleges and universities. These schools teach verbal problems through the use of the same abstract models which were used with the control groups.

4. The textbooks did not bias the study, since both the control group and the experimental group at an individual school used the same text.
5. The same amount of in-class time was spent by both the experimental and control groups on solving verbal problems. Both groups were given the same number of problems; however, the amount of time spent in-class on verbal problems was probably a function of the student's comprehension rate. The instructors tried to balance the time as best they could.
6. It was assumed that the analysis of covariance controlled for initial differences in the independent variables.
7. The Hawthorne effect was minimized by not informing the students as to whether they were members of a control or experimental group.
8. Since the participating schools were randomly selected, the study was generalizable to all Oregon community colleges where at least two sections of vocational mathematics (Mathematics 4.202) was offered during winter term.

#### IV. PRESENTATION AND ANALYSIS OF DATA

This chapter presents the results of the statistical analysis which were utilized in testing the null hypotheses. These results have been analyzed and presented in five sections. The first section consists of information which was common to each of the null hypotheses. The next three sections provide a discussion of each of the three null hypotheses. The final section summarizes the highlights of each of the hypotheses as to the major findings.

##### Introduction

The student sample utilized in this study consisted of a random selection of vocational math (Mathematics 4.202) students from each of three randomly selected community colleges (Blue Mountain Community College, Linn-Benton Community College, and Portland Community College). The selection of experimental and control groups was decided at each school by the flip of a coin. The original sample consisted of 123 students enrolled in Mathematics 4.202 at the selected schools. The final random selection of students from these classes consisted of 90 students. These 90 students were used as the source of data. In addition, 15 students were randomly chosen from the pilot study conducted during fall term at Linn-Benton Community College. These students were used along with a random

selection of the winter term Linn-Benton Community College students to test the third null hypothesis.

The treatment consisted of presenting students in each of the Mathematics 4.202 experimental classes with career-oriented verbal mathematics problems in the form of advanced organizers. In other words, the problems were distributed before the mathematical concepts and drill problems were encountered by the students. The control groups received verbal mathematics problems of a more generalized and abstract nature. A panel of experts selected problems representative of the verbal problems which are commonly found in mathematics textbooks; these constituted the control problems. This instructional strategy was contrasted with an approach which utilized career-oriented mathematics verbal problems. These career-oriented mathematics verbal problems constituted the experimental problems. The above-mentioned verbal problems were presented to the control and experimental groups, respectively.

Each of the null hypotheses were examined using an  $\alpha = .05$  level of significance. The first two hypotheses were tested using a two-factor nested design which was adjusted through the use of the analysis of covariance with the pretest scores serving as the covariant. The third hypothesis was resolved through the use of a series of Student's t-tests to determine if a significant difference existed between the pretest scores during fall and winter terms. The data

utilized to analyze the hypotheses consisted of pretest and posttest scores on the Dutton Attitude Scale and the Guilford-Zimmerman General Reasoning Exam.

### Hypothesis One ( $H_1$ )

$H_1$  : There is no significant difference in the attitudes of the students in the experimental groups as compared to the control groups.

The analysis used a two-factor nested design using analysis of covariance. The pretest score was used as the covariant. The statistical model was as follows:

$$Y_{ijk} = \mu + \alpha_i + \beta_{j(i)} + \epsilon_{k(ij)}$$

where the terms are described as follows:

$Y_{ijk}$  = an individual's adjusted posttest score

$\mu$  = the general adjusted mean

$\alpha_i$  = the adjusted effect of an individual school

$\beta_{j(i)}$  = the j level of adjusted B within the  $i^{\text{th}}$  level of adjusted A

$\epsilon_{k(ij)}$  = the adjusted error term  
( $i = 1, 2, 3$ ;  $j = 1, 2$ ;  $k = k, 2, \dots, 15$ )

In other words, i indicated which of the three schools was being considered; j indicated whether the score came from an experimental or control group; and k indicated from which of the replications the score

was obtained. The model assumes that the  $\epsilon_{k(ij)}$  terms are distributed independently  $N(0, \sigma^2)$ , and that  $i$  and  $j(i)$  are fixed effects with

$$\sum_i \alpha_i = 0, \quad \sum_{j(i)} \beta_{j(i)} = 0 \quad (\text{Peng, 1967}).$$

The statistical analyses were conducted by an Oregon State University computer expert through the use of the CYBER SYSTEM and the Statistical Package for the Social Sciences (SPSS), a program developed at Northwestern University.

Table 3 includes the results of the two-factor nested design using analysis of covariance.

Table 3. Analysis of Covariance on Attitude Scores.

Source of Variation	Adjusted			Computed F
	Degrees of Freedom	Sum of Squares	Mean Square	
Schools	2	2.182	1.091	0.69
Groups within schools	3	21.866	7.289	4.63*
Error	83	130.592	1.573	
Total	88	154.640		

\* Significant at the .05 level.

Since the a priori alpha level was  $\alpha = .05$  the null hypothesis was rejected. The experimental groups' attitudes were significantly greater than those of the control groups.

However, because the nested design did not isolate the school by group interaction term, supplemental analysis was performed to

ascertain if the interaction was significant. This further analysis is summarized in the tables which are included in the following paragraphs.

Table 4 includes an expanded analysis of variance which displays the interaction term. This analysis indicated that some school(s) were more effective in applying the experimental treatment; or, in other words, the interaction term was significant. The interested reader will find plots of the interaction on the post-test (attitudes) data in Appendix D. Continued investigation led to the data in Table 5. The experimental groups did as well as the control groups at two schools, whereas the experimental group at the other school had attitude scores significantly higher than the control group students.

An analysis of the mean attitude gains of the control groups versus the experimental groups provided similar results. The Student's *t* was utilized after a series of *F*-tests at each individual school was found to be nonsignificant (d.f. = 14, 14). The mean gain *t* values are summarized in Table 6.

#### Hypothesis Two ( $H_2$ )

$H_2$  : There is no significant difference in achievement level among experimental and control groups.

Table 4. Analysis of Covariance on Attitude Scores.

Source of Variation	Adjusted			Computed F
	Degrees of Freedom	Sum of Squares	Mean Square	
Schools	2	2.182	1.091	0.693
Groups within schools	1	5.407	5.407	3.436
School x Group interaction	2	16.459	8.230	5.231*
Error	83	130.592	1.573	
Total	88	282.027		

\* Significant at the .05 level.

Table 5. Pretest and Posttest Comparison of Control Versus Experimental Means for Students' Attitudes by School.

School	Pretest	Posttest
1	t = 0.6317	t = 3.3221*
2	t = 0.9007	t = 0.8954
3	t = 0.6133	t = 0.2860

\* Significant at the .05 level, d.f. = 28.

Table 6. Student's t on Mean Attitude Gains by School.

School 1	School 2	School 3
t = 2.7876*	t = 0.1363	t = 0.4099

\* Significant at the .05 level, d.f. = 28.

A standardized achievement test, the Guilford-Zimmerman General Reasoning Exam, was administered both as a pretest and posttest to establish a data base for testing this null hypothesis. The statistical design and the analysis of covariance followed the same procedures as were discussed in the previous section. Table 7 includes the two-factor nested analysis of variance which was adjusted through the use of covariance analysis.

The a priori alpha level was  $\alpha = .05$ ; hence, the null hypothesis was rejected. There was a significant difference between the experimental and control groups. In other words, the experimental group's achievement was significantly higher than the control group's overall achievement.

As in the previous section since the nested design did not isolate the school by group interaction term, a supplemental analysis was performed to ascertain if the interaction was significant at the  $\alpha = .05$  level. This analysis, which is included in Table 8, indicated that some schools were more effective in applying the experimental problems or, in other words, the interaction term was significant. Plots of this interaction will be found in Appendix D. Continued investigation led to the results shown in Table 9. On the average, the achievement of the experimental groups was as great as the control groups at two schools. The experimental group at the other school did significantly better ( $\alpha = .05$ ) than the control group students. It

Table 7. Analysis of Covariance on Achievement Scores.

Source of Variation	Adjusted			Computed F
	Degrees of Freedom	Sum of Squares	Mean Square	
Schools	2	32.848	16.424	1.34
Groups within schools	3	148.373	49.458	4.04*
Error	83	1017.338	12.257	
Total	88	1198.559		

\*Significant at the .05 level.

Table 8. Analysis of Covariance on Achievement Scores.

Source of Variation	Adjusted			Computed F
	Degrees of Freedom	Sum of Squares	Mean Square	
Schools	2	32.848	16.424	1.340
Groups within schools	1	23.476	23.476	1.915
School x Group interaction	2	124.897	62.449	5.095*
Error	83	1017.338	12.257	
Total	88	2016.778		

\*Significant at the .05 level.

Table 9. Pretest and Posttest Comparison of Control Versus Experimental Means for Students' Achievement by School.

School	Pretest	Posttest
1	t = 0.0717	t = 3.7277*
2	t = 0.6717	t = 0.8338
3	t = 0.0191	t = 0.4841

\*Significant at the .05 level.

should be noted that the positive change in attitude and significant difference in achievement took place at the same school.

An analysis of the mean achievement gains of the control groups versus the experimental groups provided similar results. The Student's  $t$  was selected after a series of  $F$ -tests indicated that homoscedasticity existed in the mean gains at each individual school. Table 10 indicates the results of this analysis.

Table 10. Student's  $t$  on Mean Achievement Gains by School.

School 1	School 2	School 3
$t = 4.8624^*$	$t = 0.3056$	$t = 0.1965$

\*Significant at the .05 level, d.f. = 28.

### Hypothesis Three ( $H_3$ )

$H_3$  : There is no significant difference in student characteristics between fall and winter terms.

The sample data utilized in testing this hypothesis consisted of a random selection of students in the pilot study fall term (Linn-Benton Community College) with a random selection of students from winter term (Linn-Benton Community College). The variables used to test  $H_3$  were student attitude, as measured by the Dutton Attitude Scale, achievement as measured by the Guilford-Zimmerman General

Reasoning Exam, and student age. These data were collected from a random sample of 15 students selected from the pilot study and 30 vocational mathematics (Mathematics 4.202) students from Linn-Benton Community College during winter term 1977.

A Student's  $t$  was used to assess the significance level ( $\alpha = .05$ ) of the means between the fall and winter group of students. The first comparison consisted of an analysis of the mean scores on the Dutton Attitude Scale. The results of this analysis are compiled in Table 11. There were no significant differences between the mean attitude scores of fall and winter terms (pooled-variance  $t = 0.13$ , d.f. = 43,  $\alpha = .05$ ). Thus, the null hypothesis was retained.

The second comparison considered the mean scores of the Guilford-Zimmerman General Reasoning Exam between fall and winter terms at Linn-Benton Community College. The results are tabulated in Table 12. There were no significant differences found between the mean achievement scores fall and winter terms (pooled-variance  $t = -0.13$ , d.f. = 43,  $\alpha = .05$ ). Thus, the null hypothesis was retained.

The last variable compared between the fall and winter term students was age. The following table contains the computations derived from this variable (Table 13). There were no significant differences found between the mean student ages of the fall and winter term students (pooled-variance  $t = 0.08$ , d.f. = 43,  $\alpha = .05$ ).

Table 11. Student's t on Attitude Means Comparing Fall and Winter Term Students.

Term	No. of Cases	Mean	Standard Deviation	Standard Error	Pooled t*
Fall	15	5.6660	2.259	0.583	0.13
Winter	30	5.5783	1.958	0.357	

\* A separate variance estimate indicated a computed t value of 0.13.

Table 12. Student's t on Achievement Means Comparing Fall and Winter Term Students.

Term	No. of Cases	Mean	Standard Deviation	Standard Error	Pooled t*
Fall	15	8.4667	4.136	1.068	-0.13
Winter	30	8.6417	4.375	0.799	

\* A separate variance estimate indicated a computed t value of -0.13.

Table 13. Student's t on Student Age Means.

Term	No. of Cases	Mean	Standard Deviation	Standard Error	Pooled t*
Fall	15	24.3333	9.170	2.368	0.08
Winter	30	24.1000	8.580	1.566	

\* A separate variance estimate indicated a computed t value of 0.08.

The assimilation of the above three variables led to the conclusion that the null hypothesis should be retained. Hence, the conclusion was reached that there were no significant differences in student characteristics between fall and winter terms at Linn-Benton Community College.

#### Summary of Data

The statistical data for the first two null hypotheses were assessed using a two-factor nested design. These data were adjusted through the use of an analysis of covariance with the pretest scores serving as the covariant. The F-statistic for both the attitude and achievement scores indicated the covariant was highly significant at the .01 level of significance. The alpha level was set a priori at the .05 level of significance.

The analysis of the first hypothesis indicated that the students who were presented career-oriented verbal math problems as advanced organizers had significantly better attitudes than those students exposed to verbal problems of a more generalized nature. However, a supplementary analysis indicated that there was significant interaction between schools and groups. This interaction was caused by the superior attitude improvement in the experimental students in one school in comparison to the smaller gains at the two other schools.

The analysis of the second hypothesis indicated that those students given career-oriented verbal problems as advanced organizers had significantly higher achievement than those students in the control groups. However, again supplementary research indicated that the school by group interaction was significant. This interaction was caused by the great experimental achievement gain at one school in comparison with the smaller gains at the other two schools.

Three separate t-tests were used to compare the students taking Mathematics 4.202 fall term with the winter term students. The variables analyzed consisted of attitude means, achievement means, and age means which were obtained from the pretest scores during the two terms. No significant differences were found between the fall and winter term students who were enrolled at Linn-Benton Community College.

Further comparisons, as well as conclusions and implications drawn from the study, are presented in Chapter V.

## V. SUMMARY, CONCLUSIONS, AND IMPLICATIONS

### Statement of the Problem

This study was designed to compare community college vocational students' achievement and attitudes toward career-oriented verbal problems with their achievement and attitudes toward mathematics verbal problems of a more generalized and abstract nature. The major purpose of this study was to analyze, in the mathematics classrooms, representative verbal problems from various businesses and industries to test the effectiveness of a learning paradigm which was built upon the needs and interests of community college students.

More specifically, the null hypotheses which were considered in this study were as follows:

1. There is no significant difference in the attitudes of students in the experimental groups as compared to the control groups.
2. There is no significant difference in achievement level among experimental and control groups.
3. There is no significant difference in student characteristics between fall and winter term.

### Procedures and Sample

The study's samples were collected from students taking Mathematics 4.202 during fall term (at Linn-Benton Community College), and three randomly selected community colleges during winter term 1977; namely, Blue Mountain Community College, Linn-Benton Community College, and Portland Community College.

The experimental treatment consisted of presenting students with career-oriented math verbal problems in advance of the curricular content. A modified Delphi Technique was utilized to insure that the problem sets were representative, in the proper topical categories, and at a difficulty level compatible with the vocational mathematics students. The same process was utilized in the selection of the control group's problem sets. The control and experimental problems were also examined by the panel to insure that they were approximately equivalent in difficulty. Both groups of problems covered the same mathematics topics.

The interface between mathematics and the students' needs and interests is an obvious one. The instructional paradigm is supported by educational leaders in learning theory, career education, curriculum development, and community college mathematics instructors.

A review of the literature indicated that for effective learning to take place the students must want to learn, have mastered the

prerequisite skills, and be actively involved in the learning process. The most important variable to insure that the mathematics learned in the classroom will transfer to the job situation is to learn the content well the first time. This means the students must have a cognitive structure which contains anchoring ideas to serve as a foundation for building the mathematical skills. The literature suggested that a learning paradigm which utilized career-oriented math problems as advanced organizers would aid the learning process through an increase in students' interests and thus improve the students' motivation.

Two instruments were chosen for this study. The Dutton Attitude Scale was used to test the students' attitudes toward the career-oriented verbal problems. The Guilford-Zimmerman General Reasoning Exam was administered to assess the achievement gain of the students involved in the study. The exams were administered as pretest and posttest instruments for both the experimental and control group classes. A random selection provided three community colleges with one instructor at each school to teach both an experimental and control class. The decision as to which class was experimental and which was control was based on the flip of a coin. The control groups solved only verbal problems of a more generalized and abstract nature, whereas the experimental groups solved the career-oriented verbal mathematics problems.

The first two null hypotheses were tested through the use of a two-factor nested design with a two-way analysis of covariance. In addition, the third null hypothesis was analyzed by comparing the pretest means, for both attitudes and student achievement, and ages of a random selection of Mathematics 4.202 students during fall and winter terms at Linn-Benton Community College. A Student's *t* was used in the analysis with an alpha level of .05.

### Major Findings

Community college students who were given career-oriented verbal mathematics problems as advanced organizers had overall significantly better attitudes ( $\alpha = .05$ ) than those vocational mathematics students (control) who were given verbal problems of a more abstract and generalized nature. Further investigation indicated that a significant interaction term existed between school and group levels. Supplemental analysis determined that the experimental students did as well as the control students at two community colleges. The significant interaction existed because of the extreme superior attitude gain of the experimental students at one school as compared with the control group at the same school.

Likewise, the experimental community college students had an overall significantly better achievement gain ( $\alpha = .05$ ) than those vocational mathematics students in the control groups. Further

investigation indicated a significant interaction term existed between school and groups within the schools. It was found that the experimental groups at two community colleges did as well as the control groups at the two schools. The significant interaction existed because of the extreme superior achievement gain of the experimental students at the other school as compared with the control group at the same school.

Based on the achievement means, attitude means, and mean ages there was no significant difference ( $\alpha = .05$ ) between the fall and winter term students at Linn-Benton Community College.

### Conclusions

Career-oriented mathematics verbal problems used as advanced organizers have the potential of improving students' attitudes toward vocational mathematics.

Career-oriented mathematics verbal problems used as advanced organizers have the potential of improving students' achievement in vocational mathematics.

The students at one community college who were sampled during fall term appear to be equivalent to the winter term students as measured by achievement test means, attitude scale means, and average age.

## Implications

This section is organized into two sections; namely speculations, and additional comments.

### Speculations

The process utilized in selection of the experimental problem sets to ascertain reliability and content validity made it essential that all experimental students work the same set of career-oriented mathematics verbal problems. This could have had a dampening affect on the students' attitudes and achievements. If students were given career-oriented verbal problems from their interest area or in line with their career goals, their attitude and achievement gains might have been far greater. Likewise, mathematics verbal problems which are not in a student's interest area might serve to interfere with the content to be learned.

### Additional Comments

A learning paradigm which incorporates career-oriented mathematics verbal problems as advanced organizers is an effective way of presenting vocational mathematics to the community college students. The problem sets should be individualized to the students' interest areas or occupational goals. These problem sets serve to

reinforce the anchoring ideas which are in the students' cognitive structure. The problems must be supplemental to a core mathematics textbook which provides the student with the building blocks necessary to progress up the mathematical ladder. The instructor should tie the mathematics content to the career-oriented mathematics problems which the student receives as advanced organizers. This continual recycling reinforces the importance of the mathematics and at the same time reinforces the mathematics content. After the drill exercises of a specific section have been completed, additional verbal problems of a more abstract nature should be used to help the student generalize his knowledge. This technique will aid the vertical transfer process.

The textbook market is gradually catching up with the demand for a career-oriented approach to mathematics instruction. A recent article by Singer (1977, p. 2) suggested:

Instead of being asked to work standard '2 + 2' type problems, math students can be presented with problems dealing with common situations in different occupational areas. Job-related terminology can be fully explained in the textual material so that, in working the problems, students can see what is involved in performing various jobs. The thrust is to fully integrate career exploration information with mathematics instruction.

While this article is very supportive of using a career-oriented approach to teach mathematics, it does have the ring of the bandwagon psychology which was mentioned by Tyler when he was interviewed by

Ryan et al. (1977). According to Ryan et al. (1977, p. 546) in the March issue of The Kappan, entitled "The Back-to-Basics Movement and Its Meanings":

People hear about something that looks new and exciting and becomes popular; without necessarily understanding it they want to climb on the bandwagon. This reaction is unfortunately common in education. . . .

In addition, Hill (1975, p. 80) pointed out that each student, ". . . has the right to be taught significant mathematics in a method consonant with his or her learning style by a well prepared, caring teacher."

In summary, mathematics education in the United States today is being led by two strong forces. The first is the back-to-basics movement, and the second is the trend toward mathematical applications. Rather than blindly jumping on the bandwagon, community college mathematics instructors should build a sound empirical base before they join the bandwagon. The learning paradigm which uses career-oriented mathematics verbal problems is an effective learning technique. However, it is not a panacea--there is none. Effective learning, about which very little is known, depends on the versatility and expertise of the instructor in meeting the needs of the individual student. Only through the continued effort of researchers to examine the classroom activities, instructional techniques and unite their research with sound evaluation techniques will mathematics education really be advanced.

### Suggestions for Further Study

The following suggestions for further study are presented for purposes of providing directions for future research.

This study should be replicated using career-oriented mathematics verbal problems aimed at the individual student's career goals.

The present study should be replicated using the same design to ascertain if another randomly-selected group of community colleges would produce similar conclusions.

This study should be replicated at the high school level to determine the affect of career-oriented mathematics verbal problems at that level.

A similar study should be conducted with community college students to ascertain if problem density has an affect on their achievement and attitudes toward career-oriented mathematics problems.

A learning paradigm should be investigated which utilizes career-oriented verbal mathematics problems as advanced organizers. These problem sets should precede the core mathematics content. In addition, verbal problems of a more generalized and abstract nature should be used to encourage the students to generalize their mathematics learning.

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## APPENDICES

APPENDIX A

EXAMPLES OF EXPERIMENTAL AND CONTROL

PROBLEM SETS

Experimental Problem SetsStudents' Problems

1. The first shift on a forest fire builds 40 chains of fire line in 8 hours. If the second shift works at the same rate how long will it take them to build an additional 34 chains of fire line?
2. By the end of the fifth month of the fiscal year the Deschutes National Forest will have sold 74,3 million board feet of timber. At the same rate, how much timber can we project that they will sell in the remaining seven months of the fiscal year?
3. The Forest Service collected \$23,585 for slash disposal on 320 acres. At the same rate what would the amount be for slash disposal on a 295 acre plot?
4. A stream has an average width of 3.6 mm on an aerial photo with a scale of 1 to 12,000. How many inches wide would the stream appear on a print which has a scale of 1 inch = 300 feet?
5. Aerial application of DDT mixed with diesel fuel has been used to control past infestations of the tussock moth. Each gallon of the mixture contains  $11/16$  pounds of DDT and weighs 7 lbs 15 oz. Determine the number of pounds of DDT in a 20,000 pound load of the solution.
6. A 15 inch shaft is found to have a taper of 0.147 inches in 4 inches. Find the taper in the entire length of the shaft.
7. It is known that 4 machinists can finish a certain job in 7 days. This is a rush order and must be finished in 3 days. How many machinists must be put on the job to finish in the required time?
8. A salesman was paid a commission of \$20 for selling \$250 worth of goods. What should be his commission on \$350 of sales at the same rate of commission?
9. If 6 yards of cloth cost \$5.25, what will 10 yards cost at the same rate?
10. A logging truck which requires 23 gallons of diesel to travel 175 miles will be able to travel how far on 35 gallons of diesel?

11. A fuel pump delivers 25 ml of fuel in 400 strokes. How many strokes are required to get 40 ml of fuel?
12. The driving gear has 12 teeth and has a diameter of 3 inches. What will the diameter of the driven gear be if it has 16 teeth?
13. A building assessed at \$15,000 is billed \$475.50 for property taxes. A similar building next door, assessed at \$21,000, should be billed how much for taxes?
14. If 50 gallons of oil flowed through a feeder pipe in 20 minutes, how long will it take to fill a tank of 1,250 gallon capacity?
15. The electric current, in amperes, in a circuit varies as the voltage. When 12 volts are applied the current is 4 amperes. What is the current when 15 volts are applied?

#### Instructors' Problems

1. Find the large diameter of a piece of tapered work  $4 \frac{1}{8}$  " long, having a taper of  $\frac{5}{8}$ " per foot and a small diameter of 0.572".
2. The driving gear has 24 teeth and has a diameter of 6 inches. What will the diameter of the driven gear be if it has 32 teeth?
3. If a 20 acre forest service campground can accommodate 35 campsites, how many additional acres will be required to expand to handle a total of 53 campsites?
4. If 2 yards of polyester cloth costs \$5.96, what will 5 yards cost at the same rate?
5. The electric current, in amperes, in a circuit varies as the voltage. When 6 volts are applied the current is 2 amperes. What is the current when 7.5 volts are applied?
6. A lathe operator turns 9 brass bushings in 2 hours and 15 min. At the same rate, how many can be finished in an 8 hour day?
7. The tax on a property assessed at \$12,000 is \$800. What is the assessed value of a property taxed at \$1,100?

Control Problem SetsStudents' Problems

1. In a rectangle the ratio of width to length is  $\frac{5}{7}$ . The length is 8 ft. greater than the width. Find the length and width.  
Hint: let  $w$  = width and  $w + 8$  = length.
2. In a post office a machine can cancel stamps at a rate of 300 in 30 minutes. How many can it cancel in 45 minutes?
3. Analysis of carbon dioxide shows that for every 12 grams of carbon there is present 32 grams of oxygen. How many grams of carbon are combined with 100 grams of oxygen in a sample of carbon dioxide?
4. A stake 10 feet high casts a shadow 8 feet long at the same time that a tree casts a shadow 60 feet long. What is the height of the tree?
5. An airplane travels 550 miles in 1 hour 50 minutes. At the same speed, what distance would the plane cover in 2 hours 10 minutes?
6. If 10 men can complete a project in 12 days, how many days will it take 15 to complete it?
7. Hydrogen used for inflation of balloons may be made by passing steam over red-hot scrap iron. If 8.5 lb of iron will make 78 cu ft of hydrogen, how much iron would be needed to make 500 cu ft of hydrogen?
8. Divide \$60 between two men in the ratio of 3 to 2.
9. If you earn \$100 a week for 3 weeks, how long will you have to work at \$80 a week to make the same amount?
10. If in a school the ratio of boys to girls is 5:7 and there are 840 girls, how many boys are there?
11. The ratio of the weight of lead to the weight of an equal volume of aluminum is 21:5. If an aluminum bar weighs 150 pounds, what would a lead bar of the same size weigh?

12. The ratio of woman's weight on Earth compared to her weight on the moon is 6:1. How much would a 150-pound woman weigh on the moon?
13. A person drives 600 miles in  $1\frac{1}{2}$  days. How long would it take to drive 3,000 miles?
14. The scale in an architectural drawing is 1 inch equals 8 feet. What are the dimensions of a room that measures  $2\frac{1}{2}$  by 3 inches on the drawing?
15. A store has a bargain price of 85¢ for three jars of grape jelly. How many jars could someone buy for \$5.95?

#### Instructors' Problems

1. If 5 men can complete a project in 10 days, how many days will it take 13 men to complete it?
2. The ratio of a man's weight on Mars compared to his weight on Earth is 2:5. How much would a 196-pound man weigh on Mars?
3. Analysis of carbon disulfide shows that for every 3 g of carbon 16 g of sulfur is present. How much carbon disulfide contains 96 g of sulfur?
4. If you earn \$75 a week for 2 weeks, how long will you have to work at \$90 a week to earn the same amount?
5. Three cans of pop cost 45¢. How many cans could you buy for \$4.00?
6. Hydrogen used for inflation of balloons may be made by passing steam over red-hot scrap iron. If 9 lbs of iron will make 82.6 cu ft of hydrogen, how much iron would be needed to make 400 cu ft of hydrogen?
7. A person drives 400 miles in 1 day. How long would it take to drive 3,500 miles at the same rate?

**APPENDIX B****PILOT TEST DATA (Fall Term)****WINTER STUDY DATA (Winter Term)**

Student Data from Pilot Study School 2.

Number	Math History	Age	YSCH	Sex	Pretest		Posttest	
					D	G-Z	D	G-Z
1	GM., MI	28	12	M	1.75	4.75	7.35	13.25
2	AI, Geo.	20	13	M	7.70	8.00	8.05	15.75
3	GM, AI	22	12	M	2.73	8.75	4.00	15.75
4	GM, AI, Geo.	18	12	M	7.98	14.00	7.77	15.75
5	GM, AI, BM	24	12	M	6.62	5.75	6.20	5.75
6	GM, AI	25	12	M	7.35	9.00	5.70	12.00
7	GM	18	12	M	6.10	5.50	6.62	3.25
8	AI, Geo.	18	12	M	5.43	18.25	7.42	15.75
9	AI, MI	19	14	M	8.20	5.00	8.33	8.25
10	GM, AI, 1/2Geo.	19	13	M	3.30	8.25	3.30	14.50
11	GM, AI	41	12	M	8.47	2.75	8.76	7.25
12	GM, MI	19	13	M	4.88	5.00	3.93	8.25
13	None	49	8	M	7.42	13.00	7.42	22.00
14	GM, AI, Geo.	18	12	M	4.33	10.75	6.80	17.00
15	AI, Geo.	27	17	M	2.73	8.25	6.60	14.50

GM = General Math; AI = Algebra I; MI = Math I; Geo. = Geometry; BM = Business Math

YSCH = Year in school; D = Dutton; G-Z = Guilford-Zimmerman

Student Data from School 1.

Number	Math History	Age	YSCH	Sex	Pretest		Posttest	
					D	G-Z	D	G-Z
1E	GM, MI	24	12	M	2.00	7.00	4.97	14.50
2E	GM, AI	25	12	M	6.13	9.50	6.77	17.00
3E	AI, MI	19	12	M	7.10	14.50	7.60	17.00
4E	GM, MI	17	11	M	6.90	10.75	8.07	17.00
5E	GM, MI	18	12	M	2.23	4.50	3.13	9.50
6E	GM, MI, AI, Geo.	18	12	M	6.63	11.00	6.77	15.75
7E	GM, MI	18	12	M	8.63	-0.25	7.33	7.00
8E	GM, MI	26	12	M	4.15	7.00	5.05	14.50
9E	AI	26	12	M	7.82	7.00	8.75	12.00
10E	GM, Geo., MI	19	12	M	6.30	4.50	8.17	10.75
11E	GM, MI	19	12	M	5.10	11.25	5.10	13.25
12E	GM, AI, Geo.	20	12	M	10.15	9.50	7.93	15.75
13E	GM, AI, MI, Geo.	18	12	M	6.77	14.50	5.70	15.75
14E	GM, MI	27	11	M	2.85	0.00	5.67	8.25
15E	GM, MI	20	12	M	7.95	3.25	9.00	12.00
1C	GM, AI, MI	19	12	M	7.60	6.75	6.27	8.25
2C	GM, MI	25	12	M	5.60	4.50	4.20	8.25
3C	GM, MI	20	12	M	5.35	4.00	4.23	5.75
4C	GM	22	12	M	6.45	4.50	5.37	8.25
5C	GM, AI, MI	20	12	M	5.20	19.25	3.30	15.75
6C	None	19	12	M	3.13	2.00	3.32	5.75
7C	GM	27	12	M	3.72	8.25	3.65	8.25

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School 1. (Continued)

Number	Math History	Age	YSCH	Sex	Pretest		Posttest	
					D	G-Z	D	G-Z
8C	GM, AI, Geo., Trig.	20	12	M	7.13	16.75	7.47	14.50
9C	GM, AI, MI, Geo.	19	12	M	7.42	2.00	7.35	5.75
10C	None	20	12	M	2.40	5.00	3.13	8.25
11C	GM, MI	19	12	M	5.43	-0.50	3.77	5.75
12C	GM, MI	20	12	M	1.90	10.75	2.63	12.00
13C	GM, MI	20	12	M	7.35	7.00	3.77	7.00
14C	GM, MI	18	12	M	5.60	8.50	7.10	8.25
15C	GM, MI	23	12	M	8.80	13.25	4.33	12.00

GM = General Math; AI = Algebra I; MI = Math I; Geo. = Geometry; Trig. = Trigonometry

Ysch = Year in school; D = Dutton; G-Z = Guilford-Zimmerman

Student Data from School 2.

Number	Math History	Age	Ysch	Sex	Pretest		Posttest	
					D	G-Z	D	G-Z
1E	AI	21	12	F	7.10	7.50	6.77	7.00
2E	GM, AI, Geo.	56	15	M	6.13	13.25	7.04	9.50
3E	GM, MI	25	12	M	2.68	7.00	2.35	4.50
4E	AI	18	12	M	7.42	2.25	7.42	6.00
5E	GM, AI, Geo., AII	19	12	M	7.45	10.25	5.20	17.00
6E	GM	20	10	M	2.58	5.75	2.58	12.00
7E	GM	35	11	M	4.66	8.25	6.70	14.50
8E	GM, AI, Geo.	18	12	M	2.60	11.00	3.50	7.00
9E	GM	22	12	M	8.12	8.25	7.73	10.75
10E	AI, AII, Geo.	21	14	M	4.25	10.50	4.25	20.75
11E	GM, MI	27	12	M	2.00	7.25	6.10	5.25
12E	AI	28	12	M	5.70	15.75	6.97	15.75
13E	GM	24	12	M	6.88	9.50	7.85	22.00
14E	None	46	15	M	5.82	0.00	2.68	7.50
15E	AI, MI	19	12	M	5.44	5.00	5.43	0.75
1C	GM, AI, Geo., 1.110	22	12	M	7.53	17.00	7.22	15.75
2C	GM	29	12	M	5.20	10.25	5.30	7.00
3C	GM	22	12	M	7.08	7.50	6.82	14.50
4C	GM, AI	21	12	M	5.35	12.00	5.35	13.25
5C	GM	20	12	M	5.73	5.75	5.35	5.75
6C	GM, AI, Geo.	24	13	M	6.77	8.25	7.60	9.50
7C	GM, MI	30	12	M	7.53	14.75	7.35	19.50
8C	AI	16	12	M	1.25	2.00	2.07	10.00

(Continued on next page)

School 2. (Continued)

Number	Math History	Age	Ysch	Sex	Pretest		Posttest	
					D	G-Z	D	G-Z
9C	GM, AI, MI	19	13	M	5.53	3.00	6.85	10.75
10C	GM, AI	18	12	M	8.20	18.25	5.50	22.00
11C	GM, AI	19	12	M	5.43	9.50	8.07	17.00
12C	GM, AI, MI	25	12	M	2.97	5.00	5.73	5.75
13C	AI	23	11	M	7.77	5.50	7.30	12.00
14C	GM, MI, AI, Geo.	17	11	M	7.20	8.25	5.53	12.00
15C	GM, AI, Geo.	19	13	M	4.98	10.75	5.10	10.75

GM = General Math; AI = Algebra I; MI = Math I; Geo. = Geometry; AII = Algebra II; 1.110 = Elements of Algebra

Ysch = Year in school; D = Dutton; G-Z = Guilford-Zimmerman

Student Data from School 3.

Number	Math History	Age	Ysch	Sex	Pretest		Posttest	
					D	G-Z	D	G-Z
1E	GM, AI, Geo.	20	12	M	6.05	15.50	6.22	21.50
2E	AI, Geo.	23	12	M	4.08	10.50	5.23	11.25
3E	AI, Geo.	23	13	F	2.73	4.74	2.97	4.75
4E	GM, AI, MI	18	9	M	8.33	9.00	8.06	17.50
5E	GM, AI, MI	22	12	M	6.94	5.00	8.17	5.25
6E	GM, AI	18	13	M	6.70	7.00	5.73	5.00
7E	GM, AI, Geo., BM	20	12	M	7.37	13.50	6.30	18.00
8E	GM, MI	25	12	F	8.33	3.75	4.23	8.00
9E	GM, AI, MI, CM	18	12	F	5.35	11.50	4.65	8.50
10E	GM, AI, Geo.	31	16	F	3.70	4.75	3.80	5.25
11E	GM, AI, Geo.	34	12	F	5.52	9.50	4.54	12.75
12E	AI, Geo., AII	22	12	M	5.93	13.00	5.05	10.75
13E	GM	18	11	F	5.28	8.00	6.42	8.50
14E	GM, MI	28	10	F	4.80	3.75	6.62	5.50
15E	GM, AI, Geo.	29	12	F	3.98	6.50	4.23	9.50
1C	AI, MIV, MI	20	12	M	8.12	7.75	7.77	10.25
2C	GM, AI	21	10	F	6.13	19.25	8.33	20.75
3C	MI	24	10	M	3.65	14.75	4.60	4.00
4C	AI, MI	21	12	F	3.77	14.00	2.85	14.25
5C	GM	18	12	M	4.50	0.50	5.35	7.00
6C	AI, Geo.	31	12	F	3.13	5.25	2.97	13.25
7C	GM, AI, Geo.	25	14	F	5.35	5.25	6.50	12.00

(Continued on next page)

School 3. (Continued)

Number	Math History	Age	Ysch	Sex	Pretest		Posttest	
					D	G-Z	D	G-Z
8C	AI, Geo.	36	11	F	7.85	12.00	6.45	11.50
9C	GM, AI, Geo.	19	12	M	5.00	8.25	4.23	7.00
10C	GM, MI	25	12	F	2.28	4.75	2.58	7.25
11C	GM, AI, AII, Geo., MI	31	12	F	6.50	11.00	7.78	12.00
12C	GM	20	14	M	7.10	9.25	7.42	8.25
13C	AI	23	13	M	4.70	9.00	4.65	9.50
14C	GM	29	15	M	6.77	8.50	3.80	15.75
15C	AI, MI	19	13	F	5.35	-3.00	4.23	4.00

GM = General Math; AI = Algebra I; MI = Math I; MIV = Math 4; Geo. = Geometry; BM = Business Math; CM = Consumer Math; AII = Algebra II

Ysch = Year in school; D = Dutton; G-Z = Guilford-Zimmerman

APPENDIX C

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.

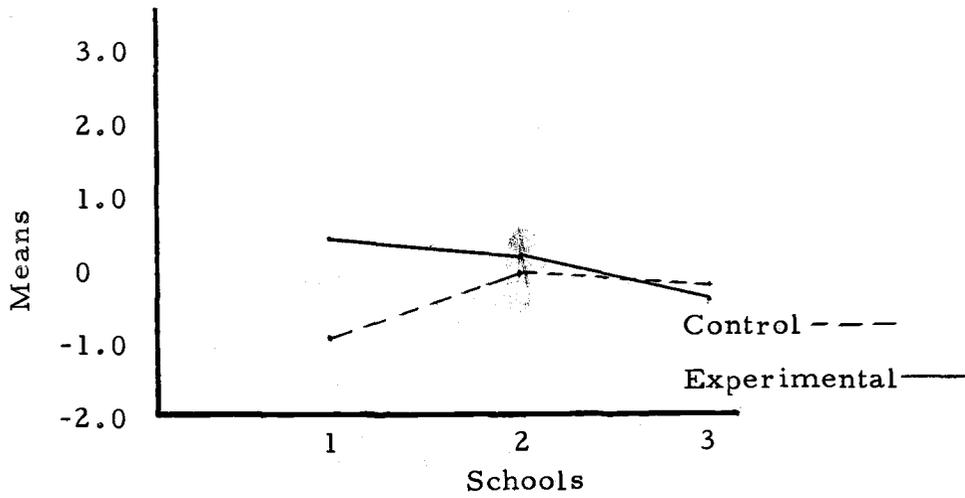
1. (3.2)<sup>a</sup> I avoid math because I am not very good with figures.
2. (8.1) Math is very interesting.
3. (2.0) I am afraid of doing word problems.
4. (2.5) I have always been afraid of mathematics.
5. (8.7) Working with numbers is fun.
6. (1.0) I would rather do anything else than do math.
7. (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.

<sup>a</sup>Weighted item values used to score the test have been added in parentheses.

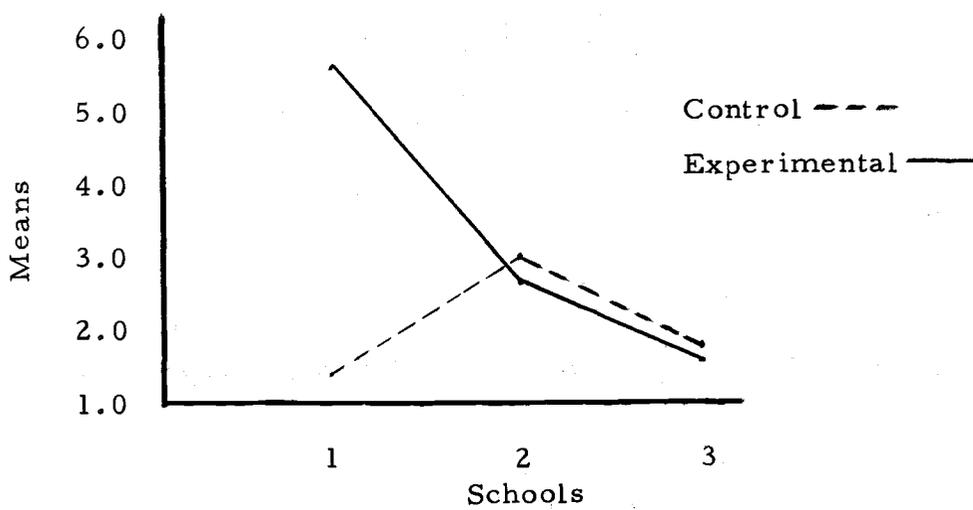
Note: The actual instrument had blanks in place of the weighted scores. The weighted scores were used to determine the numerical value of each response.

## APPENDIX D

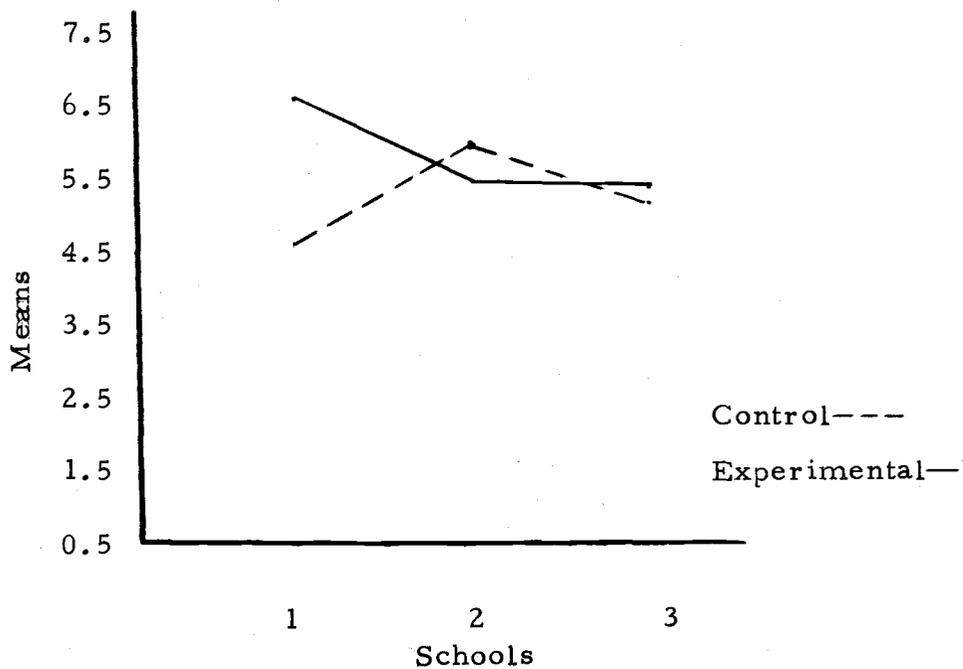
## INTERACTION PLOTS



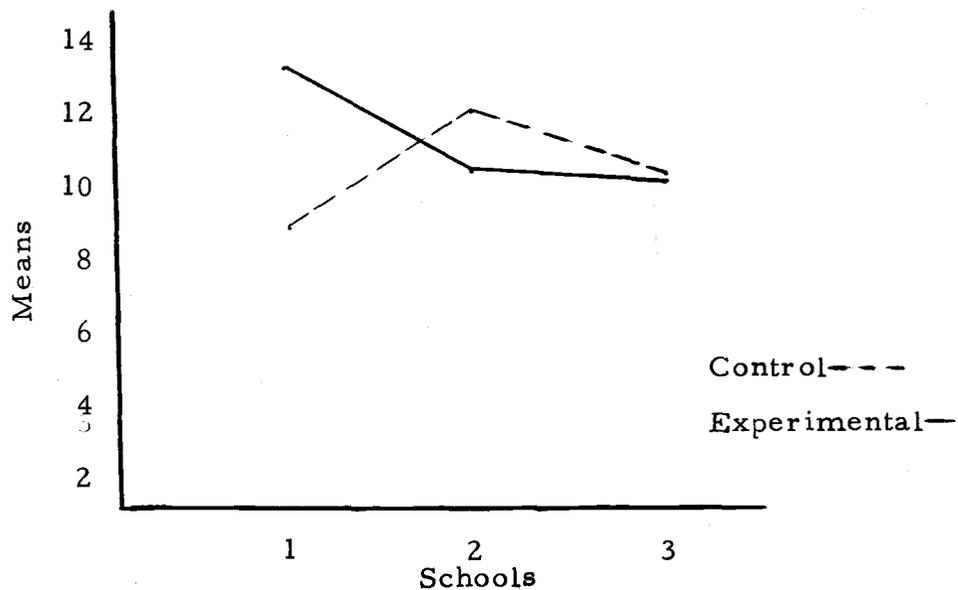
Posttest-Pretest Means on Attitudes toward Mathematics by School (Interaction Plot).



Post-Pretest Means on Mathematical Achievement by School (Interaction Plot).



Posttest Means on Attitudes toward Mathematics by School (Interaction Plot).



Posttest Means on Mathematical Achievement by School (Interaction Plot).