AN ATTITUDINAL AND CORRELATIONAL STUDY OF MATHEMATICS INSTRUCTORS CONCERNING CERTAIN MAA-NCTM RECOMMENDATIONS AND THE TEACHING OF COLLEGE PREPARATORY MATHEMATICS COURSES

DISSERTATION

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The problem of this study is to determine the attitudes of instructors teaching college preparatory mathematics courses from a random sample of Texas 4-A high schools, Texas community/junior colleges, and Texas senior colleges/universities with regard to the teaching of college preparatory mathematics courses and with regard to the document "Recommendations for the Preparation of High School Students for College Mathematics Courses" issued jointly by the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) in December, 1977.

The purpose of the study is to find answers to the following questions.

1. Is there a significant difference in any of the three simple pair-wise comparisons of the attitudes of the three groups of mathematics instructors of college preparatory courses toward teaching those courses?

2. Is there a significant difference in any of the three simple pair-wise comparisons of the attitudes of the three groups of mathematics instructors of college preparatory courses toward the MAA-NCTM recommendations?

3. Is there a significant correlation between the attitudes toward the MAA-NCTM recommendations and the attitudes toward teaching the college preparatory methematics courses held by the mathematics instructors in each of the three groups?

To answer these questions, the nine possible null hypotheses were tested at the 0.05 level using the simple one-way ANOVA, Scheffe's F-Test, and the Pearson correlation coefficient. The instruments used for data gathering were a specially designed questionnaire and a 1960 revision of the Purdue Master Attitude Scale entitled, "A Scale to Measure Attitude Toward Any Vocation."

The respondents to the study were as follows: 73 instructors from a random sample of 42 4-A Texas high schools; a random sample of 43 mathematics instructors teaching in Texas community/junior colleges having enrollments of at least 2,000 students; and a random sample of 33 mathematics instructors teaching Texas senior colleges/universities having enrollments of at least 3,000 and 5,000 students, respectively.

The data led to the conclusion that all three groups held the same favorable attitude toward teaching college preparatory mathematics courses. Also, there were no significant differences among the three groups' attitudes toward the MAA-NCTM recommendations. However, while no significant correlation was found for the high school instructors, there did exist a significant positive correlation between the two attitudes for each of the other two groups studied.

Additional findings included the following.

1. Senior college/university instructors placed more emphasis on regular assignments to be completed outside of class than did the high school mathematics instructors.

2. Senior college/university mathematics instructors felt more strongly than did the community/junior college mathematics instructors that there was a serious problem with grade inflation in education.

3. The high school mathematics instructors were in less agreement than the other two groups that their institutions provided assistance to students with deficiencies in their mathematics courses.

4. Community/junior college mathematics instructors were more willing to allow their students to use calculators and/or computers than were the high school mathematics instructors when teaching classes where arithmetic skill was assumed.

5. The high school mathematics instructors were more convinced that the college preparatory mathematics courses offered by their schools met the needs of their students than were the senior college/university mathematics instructors with respect to college preparatory mathematics courses taught in the senior college/universities.

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CHAPTER I

INTRODUCTION

During the past decade, various study groups have brought about drastic and sudden changes in the curriculum of pre-calculus mathematics. The relative merits of the changes are open to debate. However, in an attempt to provide a stabilizing force to the mathematical educational community, a joint effort by the Mathematical Association of America and the National Council of Teachers of Mathematics produced the document "Recommendations for the Preparation of High School Students for College Mathematics Courses" in early December 1977. Working to make the recommendations widely applicable, they were stated in a general nature, without reference to any specific mode or style of curriculum. To emphasize this fact, they wrote, ". . . any consideration of the relative merits of new vs. traditional school curriculum has been deliberately avoided. A study of this issue would have exceeded both the charge to the committee and its limited resources" (5).

How will the recommendations affect the teaching of college preparatory mathematics courses? If instructors of such courses do not agree with the recommendations, certainly their effect will be minimal, at best. Therefore, what is the attitude of the mathematics educator with respect to these recommendations? It was to this final question that the research problem addressed itself. Because of the mathematical maturity of the target student, that is, a pre-calculus student, the problem was not restricted to just high school instructors, but community/ junior college and senior college/university instructors of pre-calculus mathematics courses were also included in the problem.

Statement of the Problem

The problem of this study was to determine the attitudes of instructors teaching college preparatory mathematics courses at a random sample of Texas 4-A high schools, Texas community/junior college, and Texas senior colleges/universities with regard to the teaching of college preparatory mathematics courses and with regard to certain recommendations dealing with college preparatory mathematics courses issued jointly by the Mathematical Association of America and the National Council of Teachers of Mathematics in December 1977.

Purpose of the Study

The purpose of the study was to find answers to the following questions.

1. Is there a significant difference in any of the three simple pair-wise comparisons of the attitudes of high school, community/junior college, and senior college/university

mathematics instructors of college preparatory courses toward teaching those courses?

2. Is there a significant difference in any of the three simple pair-wise comparisons of the attitudes of high school, community/junior college, and senior college/university mathematics instructors of college preparatory courses toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations?

3. Is there a significant correlation between the attitudes toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations and the attitudes toward teaching the college preparatory mathematics courses held by the mathematics instructors in high schools, community/junior colleges, and senior colleges/universities?

In order to answer these questions, the following hypotheses were tested by standard statistical methods. The instruments used for data gathering were a specially designed questionnaire and a 1960 revision of the Purdue Master Attitude Scale entitled, "A Scale to Measure Attitude Toward Any Vocation."

Hypotheses

The hypotheses tested in the study were as follows.

1. There is no significant difference between the attitudes of mathematics instructors of college preparatory

courses in Texas 4-A high schools and selected Texas community/junior colleges toward teaching those courses as measured by the _Purdue Scale For Measuring Attitudes Toward Any Vocation_.

2. There is no significant difference between the attitudes of mathematics instructors of college preparatory courses in Texas 4-A high schools and selected Texas senior college/universities toward teaching those courses as measured by the _Purdue Scale For Measuring Attitudes Toward Any Vocation_.

3. There is no significant difference between the attitudes of mathematics instructors of college preparatory courses in selected Texas community/junior colleges and selected Texas senior colleges/universities toward teaching those courses as measured by the _Purdue Scale For Measuring Attitudes Toward Any Vocation_.

4. There is no significant difference between the attitudes of mathematics instructors of college preparatory courses in Texas 4-A high schools and selected Texas community/junior colleges toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations as measured by a special questionnaire.

5. There is no significant difference between the attitudes of mathematics instructors of college preparatory courses in Texas 4-A high schools and selected Texas senior colleges/universities toward the Mathematical Association

of America-National Council of Teachers of Mathematics recommendations as measured by a special questionnaire.

6. There is no significant difference between the attitudes of mathematics instructors of college preparatory courses in selected Texas community/junior colleges and selected Texas senior colleges/universities toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations as measured by a special questionnaire.

7. There is no significant correlation between the attitudes of Texas 4-A high school mathematics instructors toward the teaching of college preparatory courses and the Mathematical Association of America-National Council of Teachers of Mathematics recommendations.

8. There is no significant correlation between the attitudes of mathematics instructors of college preparatory courses in selected Texas community/junior colleges toward the teaching of college preparatory courses and the Mathematical Association of America-National Council of Teachers of Mathematics recommendations.

9. There is no significant correlation between the attitudes of mathematics instructors of college preparatory courses in selected Texas senior colleges/universities toward the teaching of college preparatory courses and the Mathematical Association of America-National Council of Teachers of Mathematics recommendations.

Background and Significance of the Study

The need for improvement in the field of mathematics is certainly nothing new. Since before the time of Euclid mathematicians have been searching for ways to improve the subject , be it in listing basic assumptions, as in the case of Euclid, or the most modern approaches to research into the study of mathematics.

> . . . For example, toward the end of the eighteenth century Lagrange, the leading figure of the era, wrote in a letter to D'Alembert: "Doesn't it seem to you as if our lofty mathematics is beginning to decline?" Again, Hilbert's program of 1900, in which he outlined a course for future research, was specifically designed to cure the _fin de siecle_ jitters of his fellow mathematicians.
>
> A few years ago André Weil wrote a paper bearing the title "The Future of Mathematics." Placing himself _in loco Hilberti_, he specified important unsolved problems and incompletely developed subjects of pure mathematical research. The type of prophecy practiced by Hilbert and Weil is one of the truly rational species of prediction (4, p. 716).

And to the same end, the Mathematical Association of America and the National Council of Teachers of Mathematics issued jointly a list of ten recommendations December 1, 1977, aimed at improving the teaching of college preparatory mathematics courses in high schools. The reason for the action by the two professional groups was the widespread feeling of college mathematics instructors that there has been a decline in the ability of their students over the past few years (1).

> Many of these recommendations should help teachers of mathematics implement what they would have liked to do for some time, but felt they could not do without

appropriate backing. The approval of these recommendations by the two largest organizations of teachers of mathematics on the North American continent should provide the needed support to the high school teachers of mathematics whose sincere efforts and hard work--in the face of many obstacles--deserve our wholehearted backing (1).

The Board of Governors of the Mathematical Association of America and the Board of Directors of the National Council of Teachers of Mathematics made the following recommendations.

1. Proficiency in mathematics cannot be acquired without individual practice. We, therefore, endorse the common practice of making regular assignments to be completed outside the class. We recommend that parents encourage their children to set aside sufficient time each day to complete these assignments and that parents actively support the request of the teachers that homework be turned in. Students should be encouraged to develop good study habits in mathematics courses at all levels and should develop the ability to read mathematics.

2. Homework and drill are very important pedagogical tools used to help the student gain understanding as well as proficiency in the skills of arithmetic and algebra, but students should not be burdened with excessive or meaningless drill. We, therefore, recommend that teachers and authors of textbooks step up their search for interesting problems that provide the opportunity to apply these skills. We realize that this is a difficult task, but we believe that providing problems that reinforce manipulative skills as a by-product should have high priority, especially those that show that mathematics helps solve problems in the real world.

3. We are aware that teachers must struggle to maintain standards of performance in courses at all levels from kindergarten through college and that serious grade inflation has been observed. An apparent growing trend to reward effort or attendance rather than achievement has been making it increasingly difficult for mathematics teachers to maintain standards. We recommend that mathematics departments review evaluation procedures to insure that grades reflect student achievement. Further, we urge administrators to support teachers in this endeavor.

4. In light of 3 above, we also recognize that advancement of students without appropriate achievement

has a detrimental effect on the individual student and on the entire class. We, therefore, recommend that school districts make special provisions to assist students when deficiencies are first noted.

5. We recommend that cumulative evaluations be given throughout each course, as well as at its completion, to all students. We believe that the absence of cumulative evaluation promotes short-term learning. We strongly oppose the practice of exempting students from evaluations.

6. We recommend that computers and hand calculators be used in imaginative ways to reinforce learning and to motivate the student as proficiency in mathematics is gained. Calculators should be used to supplement rather than to supplant the study of necessary computational skills.

7. We recommend that colleges and universities administer placement examinations in mathematics prior to final registration to aid students in selecting appropriate college courses.

8. We encourage the continuation or initiation of joint meetings of college and secondary school mathematics instructors and counselors in order to improve communication concerning mathemetics prerequisites for careers, preparation of students for collegiate mathematics courses, joint curriculum coordination, remedial programs in schools and colleges, an exchange of successful instructional strategies, planning of in-service programs, and other related topics.

9. Schools should frequently review their mathematics curricula to see that they meet the needs of their students in preparing them for college mathematics. School districts that have not conducted a curriculum analysis recently should do so now, primarily to identify topics in the curriculum which could be either omitted or de-emphasized, if necessary, in order to provide sufficient time for the topics included in the above statement. We suggest that, for example, the following could be de-emphasized or omitted if now in the curriculum:
(A) logarithmic calculations that can better be handled by calculators or computers,
(B) extensive solving of triangles in trigonometry,
(C) proofs of superfluous or trivial theorems in geometry.

> 10. We recommend that algebraic concepts and skills be incorporated wherever possible into geometry and other courses beyond algebra to help students retain these concepts and skills (5).

Upon reflection, most of the recommendations are not new, but it is important to ascertain the attitudes of the instructors in the various types of institutions toward the recommendations. For example, referring to number 1, will the instructor be willing to take time to suggest ways of improving study habits and techniques to improve the student's reading of mathematics? Professor Horst Taschow wrote, "A language within a language! A language which needs more skill and knowledge in decoding than in computation!"(10) When such a statement is written about the reading of mathematics, it becomes more clear how critical reading instruction is in the mathematics classroom.

To consider another part, number 2, there is an ever-present question in the minds of students. They wonder what the stuff is good for! How can they use this in everyday life? A well-known mathematician, George Polya, wrote,

> Thus, a teacher of mathematics has a great opportunity. If he fills his allotted time with drilling his students in routine operations he kills their interest, hampers their intellectual development, and misuses his opportunity. But if he challenges the curiosity of his students by setting them problems proportionate to their knowledge, and helps them to solve their problems with stimulating questions, he may give them a taste for, and some means of, independent thinking (6, p. v.).

Since the launching of Sputnik, there has been more work in mathematics curriculum and education revision than at any other time in history. Starting with S.M.S.G. in the post-Sputnik boom, many programs have been developed or are in the process of being developed at the present time. This work is being carried on in an effort to improve mathematics education as much as possible. Eight such programs are: (i) Secondary School Mathematics Curriculum Improvement Study--(SSMCIS); (ii) Comprehensive School Mathematics Program--(CSMP); (iii) Statistics by Example; (iv) Source Book on Applications; (v) The Arithmetic Project; (vi) The Madison Project; (vii) Unified Science and Mathematics in the Elementary School--USMES); and (viii) Developing Mathematical Processes--(DMP) (3).

Thus, it can be seen that the work toward improving mathematics curriculum and education is not a singular effort, but is an ongoing job--being accomplished from many different directions. The president of the Mathematical Association of America, Professor Henry Alder, wrote, "The MAA has assumed its responsibility in this, at least in part, by the preparation and wide distribution of the enclosed document" (1). He also calls for members of the mathematical community to bring the recommendations to the attentions of their colleagues and the communities served by those educators (1).

Therefore, it was of great importance to gain an insight into the attitudes of instructors toward these recommendations and whether or not the attitudes differ according to the type of institution involved. This study would also provide information about various practices of instructors that could conceivably be beneficial in the educating of future high school, community/junior college, and senior college/university instructors.

Definition of Terms

1. High School refers to grades 10-12.

2. Course refers to a semester course unless otherwise noted.

3. College preparatory course refers to any mathematics course below calculus and analytic geometry combined, probability and statistics, finite mathematics, and below any higher level mathematics course.

4. MAA refers to the Mathematical Association of America.

5. NCTM refers to the National Council of Teachers of Mathematics.

6. Recommendations refers to the document "Recommendations for the Preparation of High School Students for College Mathematics Courses" issued jointly by the MAA and the NCTM in a letter dated December 1, 1977.

Limitations of the Study

1. This study was limited to high school mathematics teachers of college preparatory courses in 4-A high schools.

2. This study was limited to mathematics instructors who teach college preparatory courses in Texas community/

junior colleges having present enrollments of at least 2,000 students.

3. This study was limited to mathematics instructors who teach college preparatory courses in Texas senior colleges/ universities having present enrollments of at least 3,000 and 5,000 students, respectively.

4. This study was limited to the attitudes toward teaching college preparatory mathematics courses and to the attitudes held toward the recommendations by the three groups of mathematics instructors outlined above.

5. The information obtained was limited to the responses of the three groups of mathematics instructors to a questionnaire prepared relating to the different recommendations and to responses given on the _Purdue Scale For Measuring Attitudes Toward Any Vocation_.

Although the procedure of gathering data had admitted limitations, it was considered the best way to obtain data in an unbiased, consistent manner from the three groups of mathematics instructors.

Basic Assumptions

1. It was assumed that respondents to the instruments would answer according to their true feelings.

2. It was assumed that an instrument could be devised that would allow the subjects to indicate their attitudes toward the recommendations accurately.

3. It was assumed that an instrument had been devised that would allow the subjects to indicate their attitudes toward their job accurately.

4. It was assumed that the researched attitudes of the subjects willing to participate in this study were not significantly different from the attitudes of those unwilling to participate in the study.

5. It was assumed that since the recommendations were a result of efforts by two of the three largest associations of mathematicians--the American Mathematical Society being the third--the subjects would be conscientious in their replies to the questionnaire and Purdue Scale For Measuring Attitudes Toward Any Vocation.

6. It was assumed that the criterion scores would be from a normally distributed population.

7. It was assumed that the criterion scores would be from populations having the same variance.

Instruments

The initial step in the study was the construction of a questionnaire to measure the attitudes of the subjects toward the recommendations. The items for the questionnaire were derived by making a sentence-by-sentence analysis of the recommendations. The items in the questionnaire reflected in a positive way the content of the recommendations. The same questionnaire was used for obtaining data from all three groups.

The next step was the selection of a group of five reading-English experts who judged how well the items on the questionnaire corresponded to the different aspects of the recommendations. A simple majority was used as a criterion for retaining the question, or statement. Suggestions and improvements were solicited from these judges and incorporated into the revised questionnaire.

After content validity of the questionnaire had been established, a sample of 15 community college mathematics instructors were chosen to assist in a test-re-test reliability study of the questionnaire. Borg (2, p.201) suggested that a reliability coefficient be computed for a survey, and the coefficient for this questionnaire was found to be .69.

The 1960 revision of the Purdue Master Attitude Scale entitled, "A Scale to Measure Attitude Toward Any Vocation," was utilized to measure the attitudes toward teaching college preparatory mathematics courses. Validity and reliability for the instrument employed had been established. According to Remmers:

> Beyond their face validity, these scales have demonstrated validity both against Thurstone's specific scales with which they show typically almost perfect correlations and in differentiating among attitudes known to differ among various groups (7, p. 2).

The scoring procedure generally utilized with the Purdue Master Attitude Scale had been extensively validated by Sigerfoos (9). The same scoring procedure was used in the present study. All three groups were sent this instrument, also.

Procedures for Collecting Data

Once the questionnaire had been revised for the final time, it and the Purdue Scale For Measuring Attitudes Toward Any Vocation were sent to a random sample of 42 Texas 4-A high schools, a random sample of 56 mathematics instructors in Texas community/junior colleges with over 2,000 students, and a random sample of 53 mathematics instructors teaching in Texas senior colleges/universities having enrollments of at least 3,000 and 5,000 students, respectively.

In the high schools, the instruments were sent to the principal with a request to select two instructors to complete the instruments. The letter of transmittal to the principal is given in Appendix A, and the instructor's letter of transmittal is given in Appendix B. A postcard was enclosed for the principal to return indicating the names of the teachers selected, so that any follow-up correspondence could be sent directly to the participating instructors. Twenty-seven of the forty-two principals returned the postcards. Sixty of eighty-one instructors (one school indicated the existence of only one qualified mathematics instructor) returned the instruments in the self-addressed, stamped envelopes that were included with the materials. Further correspondence led to a total of 73 high school mathematics instructors returning the completed instruments.

The names of qualifying mathematics instructors in the community/junior colleges and senior colleges/universities were obtained from catalogues of the community/junior colleges and the senior colleges/universities. Of the 56 mathematics instructors contacted in the community/junior colleges, 43 replies were received. Of the 53 mathematics instructors contacted in the senior colleges/universities, 33 replies were received. These totals accounted for percentages of replies of 77 percent and 62 percent, respectively. Because of the low reply rate of the instructors in the senior colleges and universities, additional communications had to be made to comply with the 60 percent response rate previously set.

To respond to the questionnaire, the subject selected the response from a four-point Likert scale, where 1 indicated strongly agree, 2 indicated agree with reservations, 3 indicated disagree with reservations and 4 indicated strongly disagree. The _Purdue Scale For Measuring Attitudes Toward Any Vocation_ was utilized by checking the statements that the respondent found agreeable. The median of the checked items was used as the score for the instrument.

Procedures for Treating Data

A one-way analysis of variance was used to test the hypothesis of equal group means by item for the questionnaire. If a significant difference was indicated, then the Scheffé test was used to test for all possible comparisons. The groups' means were computed for the _Purdue Scale For Measuring Attitudes Toward Any Vocation_ and a one-way analysis of variance was used to test the hypothesis of equal group means. If a significant difference was indicated, then the Scheffé test was used to test for all possible comparisons. To check for a significant correlation between the attitudes of each group on the two instruments, the mean of the item scores was computed for each questionnaire, and for each group this mean and the score for the Purdue Scale For Measuring Attitudes Toward Any Vocation was used for each subject's pair of scores. The group pairs were correlated using the Pearson correlation coefficient and the critical values were found in Roscoe (8, p. 438). All tests were run at the 0.05 level of significance.

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CHAPTER II

SURVEY OF THE LITERATURE

The literature reviewed was divided into nine sections: (1) studies related to previous recommendations and surveys, (2) literature related to assignments and homework (3) research regarding the reading of mathematical materials, (4) literature related to relevant problems, applications, and continued practice, (5) literature concerning evaluation and grade inflation, (6) literature regarding placement examinations, and the assistance of deficiencies in mathematics, (7) literature related to the computer and hand-held calculator, (8) literature related to joint meetings of faculty and the review of mathematics curriculum, and (9) literature considering teacher attitudes.

Studies Related to Previous Recommendations and Surveys

Since the late 1800's, there have been many sets of recommendations issued by various professional and governmental organizations related to the teaching of mathematics. "Probably the most important efforts of that kind prior to 1950 were the Committee of Ten report (1894) and the report of the National Committee on Mathematical Requirements (1923) (110, p. 767).

In 1902, Eliakim Hastings Moore presented a presidential address before the American Mathematical Society and asked, "Would it not be possible to organize the algebra, geometry and physics of the secondary school into a thoroughly coherent four years' course, comparable in strength and closeness of structure with the four years' course in Latin?" (10, p. 248) That general question was to be heard continually for years to come, also. The International Commission on the Teaching of Mathematics, formed by the United States Bureau of Education in 1911 stated that the aim of high school education, as far as mathematics is concerned, is general culture, and at the same time is preparation for college. "There is a slight preponderance of popularity in favor of the former reply, but. . . general culture seems to need the sort of mathematics that is prescribed for admission to college" (10, p. 346).

From the early 1900's to the late 1950's, there was a gradual shift from Thorndike's stimulus-response, or bond, approach to teaching computational skills to the Gestalt approach of considering the meaning and understanding of the mathematical concepts (110, pp. 767-768). The National Council of Teachers of Mathematics published <u>The Place of Mathematics in Secondary Education</u> in 1940 and stated that the following considerations were important.

> (a) Early in each year the mathematical maturity of each pupil should be determined. In case the required information is not available from reports, inventory tests may be needed to determine the amount of ground that may be covered during the semester, as well as the necessary amount of reteaching.

(b) Since mathematics is a cumulative subject, pupils should be made to realize that each day's work counts toward success or failure.

(c) An understanding of the concepts and principles of mathematics is the key to its successful study. To teach in such a way that the concepts become clear is the hardest and the most significant task confronting the teacher of mathematics. By way of illustration, a definition should usually be the outgrowth, not the beginning of a learning process.

(d) "Overviews" and motivating discussions are valuable as directing guides, while summaries and organic reviews are effective means of creating perspective and confidence. A properly constructed curriculum will give adequate attention to such considerations.

(e) In the past, much dependence was placed on mere drill. Recent psychological investigations suggest that all techniques should be based on insight. This implies that adequate practice is to be provided, not mere drill, to lead the pupil to proper assimilation and mastery.

(f) Modern psychology has proved the effectiveness of "spaced learning." That is, "bunched learning" is not so productive of lasting values as "spaced learning." With slow pupils, especially, the idea of a periodic return to the same topic, providing for its growing mastery and enlarged application, is of the utmost importance. Experience shows that we cannot expect "one hundred per cent mastery" after a single, brief exposure.

(g) The slow learner profits by at least the same degree of motivation, of cultural enrichment and interest, as do other pupils. But interest is primarily a means of stimulating effort, not a substitute for effort.

Principles of Arrangement. The following principles refer primarily to the sequence of the topics to be included in the curriculum.

(1) The sequence in the curriculum should be such that each topic will contribute definitely toward an ever-growing and more significant organization of the basic concepts, principles, skills, facts, relationships, types of appreciation, and fields of application, resulting in the development of a unified mathematical picture.

(2) Even in a reduced program, the study should emphasize problem solving and modes of thinking, and should not become a mere sequence of formal and relatively abstract drills.

(3) If a unit organization is followed, it is not always advisable to attempt in each of the units a complete or exhaustive treatment of the central theme or topic under discussion. On the other hand a unit should not include unrelated "odds and ends."

(4) In general, a new topic should not be introduced unless there is a sufficient background of prerequisite concepts and skills to permit unhindered concentration upon the new elements.

(5) A new idea of principle should not, as a rule, be introduced prior to the time at which it is needed or may be effectively applied (10, pp. 605-606).

The National Council of Teachers of Mathematics also created The Commission on Post-War Plans and it issued a couple of reports in the mid-40's (10, p. 618). However, the "first of the projects that is clearly a modern mathematics project was the University of Illinois Committee on School Mathematics (UICSM), which began near the end of 1951" (110, p. 768). In 1959, the Commission on Mathematics formed by the College Entrance Examination Board (CEEB) issued a document entitled, Program for College Preparatory Mathematics, which set forth the following nine proposals:

1. Strong preparation, both in concepts and in skills, for college mathematics at the level of calculus and analytic geometry

2. Understanding of the nature and role of deductive reasoning--in algebra, as well as in geometry

3. Appreciation of mathematical structure ("patterns")--for example, properties of natural, rational, real, and complex numbers

4. Judicious use of unifying ideas--sets, variables, functions, and relations

5. Treatment of inequalities along with equations

6. Incorporation with plane geometry of some coordinate geometry, and essentials of solid geometry and space perception

7. Introduction in grade 11 of fundamental trigonometry--centered on coordinates, vectors, and complex numbers

8. Emphasis in grade 12 on elementary functions (polynomial, exponential, circular)

9. Recommendation of additional alternative units for grade 12: <u>either</u> introductory probability with statistical applications <u>or</u> an introduction to modern algebra (109, p. 1).

In the early sixties there was more work done in the area of curriculum reforms--some of which was openly criticized!

> In 1963, the Cambridge Conference on School Mathematics produced the recommendations of 29 mathematicians for future curricular reforms in mathematics. The views expressed were meant to cause discussion and thought for the future, and have done so (110, p. 768).

Stone (96) accused the CCSM report of being both unrealistic and unimaginative. Other reactions have been too numerous to list.

There has been a number of surveys of different aspects of mathematics. In 1970, Miller (74) surveyed high schools in the North Central Texas area and found among other things that the preparation of the teachers employed by the large schools was more extensive with respect to breadth and depth of courses taken, number of hours in mathematics, graduate work, and more recent work in mathematics institutes and workshops. In 1956, Dyer, et al, (34, p. ii) conducted a survey of 14 college mathematics teachers, 13 educationists, 11 teachers of mathematical education, 7 high school teachers, 8 psychologists, 5 high school administrators, 2 engineers, and 2 social scientists. The questionnaire dealt with everyday problems in mathematics education and instruction. In the October 1974 issue of The Mathematics Teacher, (107) the results of a survey of a sample of teachers, mathematicians, and laymen were published. The survey had considered various questions with respect to computational skills. Sixty-eight percent of the respondents agreed that facility with arithmetic computation is the major goal of elementary and junior high school mathematics teaching today. Eighty-four percent agreed that speed and accuracy in arithmetic was still essential for a large segment of the public.

The study also showed that 61 percent felt that lack of proficiency in computation skill was a barrier to the learning of mathematical theory and applications. While 72 percent disagreed that all seventh-grade mathematics students should be provided with electronic calculators for their personal use throughout secondary school, 96 percent agreed that the availability of calculators would permit treatment of more realistic applications of mathematics which would increase the motivation of the student.

Sterret (95) distributed a questionnaire to the chairmen of 67 four-year colleges and universities in the Midwest.

> In response to a question about the preparation of students, sixteen chairmen reported that students are less well-prepared now than they were ten years ago, ten thought students are better prepared, and nine thought there is no appreciable change (95, p. 21).

In a survey of the teaching of mathematics, Williams (109, p. 2) sent questionnaires to 2,718 selected high school seniors, and received replies from 1,910 seniors, two thirds of which were men. The student responses were with regard to courses taken over a four-to-five year period. Williams stated that this survey was one of the first instruments developed for studying the recommendations made by the CEEB Commission which has been previously discussed.

In 1971, Gilbert (43) made a study of the transition from twelfth-year mathematics to the calculus as viewed by students and instructors. The following objectives were established:

1. Mastering algebraic manipulation and computation
2. Investigating, thoroughly, the concept of function
3. Studying in depth the elementary functions including the graphing of such functions
4. Mastering manipulation of and computation with inequalities
5. Introducing the concepts of limit and continuity and investigating such concepts
6. Equipping students through the inclusion of meaningful mathematics in high school for the calculus

The course outline consisted of the following major categories:

1. Functions
2. Relations

3. Series
4. Sequences and limits
5. Continuity
6. Differentiation

The pedagogical practices advised are as follows:

1. Give students more responsibility for doing their work
2. Encourage independent study
3. Encourage student self-enrichment (43, p. 2504-A)

The author believed that the utilization of such a course by students in high school would not be detrimental, and the need for the course had been pointed out by those college freshmen who had found the calculus to be a difficult subject.

From these studies and recommendations from the various sources, it seems evident that the recommendations under question are fairly consistent with what had been said in the past, except for some relatively new problem areas, such as grade inflation and computer/calculator technology. It is also apparent that the survey that was done has its counterparts in past similar studies.

Literature Related to Assignments and Homework

There are probably as many ways to assignments and homework as there are students and teachers combined. Laing and Peterson (64) describe three organizational patterns that appear to be better than the vertical organizational pattern of assigning homework. The vertical organization pattern is that in which new topics and assignments are made after it appears that a majority of the students understand the previous assignment.

The three new patterns outlined by the authors are: (1) the distributive pattern, (2) the semioblique pattern, and (3) the oblique pattern. The distributive pattern extends work over a topic as follows:

1. Assign problems from initial problem sets on two consecutive days

2. Assign problems from the review section after forgetting intervals have occurred

In essence, the student is given work on two or more topics at the same time, after each has been introduced.

> . . .Only the research by Laing (1970) has studied the effect of the distributive organizational pattern in a mathematics classroom situation. His results indicated that students given assignments via the distributive pattern were significantly superior in solving mathematical applications to those whose assignments were designed using the vertical pattern. The group differences in the areas of skill and concept learning were in favor of the distributive organization but did not reach statistical significance (64, p. 512).

The semioblique pattern is one in which students start exploring a topic before the work on the previous topic has been finished. The implementation of this pattern is perhaps best accomplished through assignments. A few introductory questions may be asked of a new concept or new concepts planned for two or three days in the future. The assignments should be handled like other assignments over previously discussed concepts. The teacher should not wait until the day the concept is explained to discuss assignment difficulties.

> Can the use of the semioblique pattern increase student learning? Until now there has been only one research study conducted that has investigated this technique. This study, by Peterson. . .found that the use of the semioblique organizational pattern did increase student achievement and retention of mathematical concepts (64, p. 512).

The oblique pattern includes the concepts of yesterday, today, and tomorrow in the same assignment. It seems that not only with work on concepts under discussion, today's, the repeated work on yesterday's topics and introductory work on tomorrow's topics will provide the student with homework assignments that are more interesting and beneficial.

> Theoretically, the oblique organizational pattern should be superior to the other three patterns. Putting the theory into practice could be difficult. Assuming that most teachers have the time to write the exploratory exercises and to consolidate the reinforcement exercises, there is still one possible major problem--time: specifically--student time (64, p. 513).

Three excellent examples of the use of what Laing and Peterson termed the distributive pattern are presented by Saxon (87; 88; 89). The exercise sets of all three texts are cumulative from the first of each book, and provide the student with practice on every concept that has been studied since the first of the course. The texts (87) and (88) have been tested at Mountain View College in Dallas, Texas, in 1976 and 1977-78, and the instructors have been most pleased with results from the use of these texts. The more important concepts of each course are introduced early, and constant practice is afforded the student in mastering the concepts.

Assignment and grading schedules are an important consideration in teaching mathematics. Skinner (54) has found that a variable-ratio schedule after an initial steady or fixed schedule is most successful in building good homework attitudes in students. Small and others (92) found evidence that suggested that careful grading of homework may be a waste of the teacher's time.

With regard to working assignments, Polya pointed out the following:

> The intelligent reader of a mathematical book desires two things:
>
> First, to see that the present step of the argument is correct.
>
> Second, to see the purpose of the present step.
>
> The intelligent teacher and the intelligent author of textbooks should bear these points in mind. To write and speak correctly is certainly necessary; but it is not sufficient. A derivation correctly presented in the book or on the blackboard may be inaccessible and uninstructive, if the purpose of the successive steps is incomprehensible, if the reader or listener cannot understand how it was humanly possible to find such an argument, if he is not able to derive any suggestion from the presentation as to how he could find such an argument by himself (81, pp. 207-208).

The famous French mathematician René Descartes (1596-1650) concluded his book La Geometrie with this comment: "I hope that posterity will judge me kindly, not only as to the things which I have explained, but also as to those which I have intentionally omitted so as to leave to others the pleasure of discovery" (93, p. 4). As can be seen, the so-called "discovery" method in mathematics is nothing new.

The technique of discovery can effectively be used to stimulate and maintain interest in the study of mathematics. Also, this approach helps develop the type of creativity and originality that is so important for the future success of the student in mathematics (93, p. 4). In utilizing the discovery technique, an interesting question can often serve as a most effective way to start or end a class. A question is posed and the students are given a chance to debate and guess an answer to the question. Then, the class moves through to a solution or attempted solution to the problem, with the help of the teacher. It must be remembered that care must be exercised to choose questions that are appropriate for the student to solve (93, p. 3).

Toward this same aim of interesting students in mathematics so that they might do a better job on homework assignments, Polya stated:

> In individual projects, or in class discussion. . . introduce young people to scientific method, to inductive research, to the fascination of analogy. What is "scientific method"? Philosophers and non-philosophers have discussed this question and have not yet finished discussing it. Yet as a first introduction it can be described in three syllables:
>
> GUESS AND TEST.
>
> Mathematicians too follow this advice in their research although they sometimes refuse to confess it. They have, however, something which the other scientists cannot really have. For mathematicians the advice is
>
> FIRST GUESS, THEN PROVE (80, p. 27).

By learning to guess intelligently and then follow up on the guess with proofs, no matter how simple, students will experience the real joy of working mathematics.

Regarding The Reading Of Mathematical Materials

It is well known that difficulty in reading is one of the major causes of failure in mathematics. As to the writing of texts, Begle stated:

> . . .we found that the style in which a textbook is written is not very important. We cannot find any evidence that careful editorial polishing of a manuscript has much effect on student learning. However, in a slightly different direction, we did find that among the texts that seemed to be less effective that others were most of those that I would classify as being overly formal. Again, however, the differences were not large (7, p. 210).

A long time critic of "modern mathematics" (60, p. 768), Morris Kline pointed out that while the curriculum and teachers are the most important factors in the teaching of mathematics, texts need to be improved to provide more aid to the student in his studies. He also stated that

> . . .The secondary and elementary school texts are often supposedly cooperative efforts between knowledgeable professors and experienced teachers, but the professors, "obviously" the authorities, dominate the projects. . . Many professors are indifferent to pedagogy and others are totally ignorant of it. They receive no training in writing--even of research papers, let alone texts. On the basis of their backgrounds and major concerns one should no more expect effective writing from mathematics professors than good mathematics in mathematical research papers were they written by English professors (61, pp. 208-209).

Kline went on to write that

> Much poor mathematical writing is due to sheer laziness. There are mathematicians who fail to clarify

> their own thinking and attempt to conceal their vagueness by such remarks as, "it is obvious that. . .," "Clearly it follows that. . .," and the like. If a conclusion is really evident, it is rarely necessary to say so; and when most authors do say so, it is surely not evident. Often what is asserted as obvious is not quite correct, and the unfortunate reader is obliged to spend endless time trying to establish what does truly follow.
>
> In some cases the difficulty is the writers' sheer ignorance. Even matters that are well understood by reasonably good mathematicians are not understood by numerous authors of high school and college texts. They put out books mainly by assembling passages and chapters from other books, and where the sources are inadequate so is the pirated material. In their books one finds inaccurate statements of theorems, assertions that are not at all true, incomplete proofs, failure to consider all cases of a proof, the use of concepts that are not proved or are proved only subsequently, the use of hypotheses that are not stated, two nonequivalent definitions of the same concept, extraneous definitions, assertions of a theorem and its converse with proof of only one part, and actual errors of logical reasoning (61, p. 211).

It may sound that Kline was waiting to retire to air his opinion but what he said can be seen in almost every mathematics book on any shelf. Many lower-level algebra texts make the mistake of defining "two equal sets", when it is obviously impossible to have such a concept. The word "two" indicates different, but this is often overlooked by textbook authors.

Mac Nerney made the following statement:

> We shall endeavor to preserve the essentials of the English language, and, to this end, we make certain observations. A plural form of a noun or of a verb is not used unless it is applicable. In particular, since it is inconceivable that "two objects may be the same object," the statement that A and B are objects means that A denotes an object and B denotes an object and the object denoted by A is not the object denoted by B. On the other hand, if each of A and B denotes

> an object then the statement that A is B means that the object denoted by A is the object denoted by B. The statement that there is only one object having the property P means that there is an object having the property P and that there are not two such objects. The statement that the proposition A is true only in case the proposition B is true means that A is true in case B is true and in no other case, i.e., that A is equivalent to B. Finally, the statement that either A is true or B is true means that if A is not true then B is true (69, p. 3).

In a study of the terms "necessary conditions"and "sufficient conditions", Brockman (14, p. 194) tested 187 people who were either experienced teachers of mathematics or undergraduate teacher trainees and found that a large percentage of those tested were unsure of the use of the two terms. More of them were able to tell when conditions were sufficient than could tell when they were necessary. Brockman suggested that experience with the two terms be started in the elementary grades and gradually increased.

Dyer, et al (34, p. 26) pointed out that ". . .more first rate mathematicians should be speaking directly to the public in terms that can be understood." And it is also for the teacher to speak to the students in terms that can be understood. It must be considered that part of this "speaking" is through the text and teacher-prepared materials.

Kulm found in his research that

> . . .First, the study shows conclusively that the variables that make mathematical material difficult to read are different from those affecting the reading difficulty of ordinary English. The percentage of difficult words, which is the best predictor of the

readability of ordinary English, is not even among the best five predictors of the readability of elementary algebra material.

> Second, the reading difficulty in mathematics has always been attributed primarily to the difficulty of the vocabulary of mathematics. This study showed that vocabulary is important but is far out-weighed by the difficulty of the symbolism of mathematics. This result may be due, in some part, to the grade level of the textbooks from which passages were sampled. Elementary algebra is the topic in which many students are first confronted with a large amount of symbolic written material. . . . .
>
> It takes conscious study and practice to develop the facility with symbolism that we expect of students. We do not assume that students learn to read prose by "picking it up along the way," and we cannot assume that they will learn to read symbolic material that way either. It is the responsibility of the mathematics teacher to teach students this skill (63, pp. 651-652).

Although they may begin to learn to read mathematics, they may not at the same time be able to verbalize their thoughts. Hendrix has written many articles suggesting that students in mathematics may be able to discover and understand a fact before they are able to verbalize it. Another contention of hers is that early verbalization may slow down understanding of concepts (110, p. 772). From a slightly different angle, Polya said that "one of the ugliest outgrowths of the 'new math' is the premature introduction of technical terms" (80, p. 22).

Taschow made the following observations:

> While the student may be competent to read both words and formula, he is also expected to develop concepts from verbal as well as from mathematical symbols. However, the latter represent meanings which are much more complex than the meaning of a single word. To synthesize the meanings of any mathematical symbolization, the student needs to recognize, attach

> meaning from background experience, evaluate critically, and interpret each mathematical sign in its relationship to and it interrelationship within the whole symbolization. Without mastering this complex reading process, the student is vexed even if he retreats to memorization. While he may have memorized the rule that a division by a fraction is equivalent to multiplication by the fraction inverted, he may find it difficult if not impossible to apply this rule (100, p. 312).

Uprichard (103) reported that although there are varied opinions as to how students learn mathematics, most authorities agree that there is a high correlation between the mathematical development and the reading ability of the student. He stated:

> the relationship between a learner's mathematical development and his or her ability to read mathematics is such that it is necessary for successful mathematics teachers also to be teachers of the reading of mathematics. The importance of this relationship is evidenced by the number of states that now require both preservice and inservice to take coursework in "reading mathematics" (103).

Watkins (106, p. 5975-A) studied the effects of rewriting mathematical statements in ordinary English without symbols. She found that the more experienced mathematics students did better with the mathematical English and symbols, whereas the less experienced mathematics students did better with the ordinary English transcriptions of the materials. She concluded with the observation that the treatments in her experiment may have been too short for the expected effects to emerge significantly.

In another effort to improve the notation of mathematics to alleviate some problems in reading, Caravella suggested that since minicalculators can easily convert symbolic terms into their numerical equivalents, the reading difficulties attributed to the number of symbols used in mathematics may be reduced. It is much easier to cope with terms like $3\pi\sqrt{7}$, or $5\sqrt{17}$ as decimals, since it is easier to understand something when you have a feel for its size (19, p. 24).

With respect to the reading of symbolic notation and storing of such information, Dienes said:

> Those of us who are (i) quickly aware of new structure, and (ii) able to store information in symbolic form, are the ones liable to become mathematicians. It is possible, as we have seen, to increase the number of people who are sensitive to structure in the environment. . .It is still an open question whether our scarcity of mathematicians is due to the scarcity of people who can apprehend structures, or of people who can store such structures in symbolized forms (30, p. 133).

How this directly affects the secondary school student and the pre-calculus student is pointed out by Dolgin when she stated:

> Teachers should not assume that if students are left alone, they will manage to read their textbook efficiently. Content area teachers must recognize their responsibility to teach those necessary reading skills specifically related to their subject area.
>
> Secondary classes in mathematics are textbook-oriented. Because subject area teachers know the nature of textbook materials and the concise style of writing, they are the most competent to systematically teach word meanings related to general language usage, technical words which have special meaning in mathematics, and symbols, formulas, and abbreviations which are associated with concept development (31, p. 68).

However, as difficult as mathematics is to read at present, much progress has been made over the years to improve its notation and readability. One only needs to contrast the usual definitions of equality at present to that of Robert Recorde's which appeared in his book, Whetstone of Witte, in 1557. In defining the equal sign, he said, "I will sette as I doe often in woorke use, a paire of paralleles, of Gemowe (twin) lines of one lengthe, thus: $=$, bicause noe 2 thynges, can be moare equalle" (11, p. 297).

Literature Related To Relevant Problems, Application, and Continued Practice

In mathematics, there exist two main camps, the applied mathematicians and the pure mathematicians. In explaining the thinking of the pure mathematician, G. H. Hardy wrote:

> . . .I must deal with a misconception. It is sometimes suggested that pure mathematicians glory in the uselessness of their work, and make it boast that it has no practical applications. The imputation is usually based on an incautious saying attributed to Gauss, to the effect that, if mathematics is the queen of the sciences, then the theory of numbers, because of its supreme uselessness, the queen of mathematics--I have never been able to find an exact quotation. I am sure that Gauss's saying (if indeed it be his) has been rather crudely misinterpreted. If the theory of numbers could be employed for any practical and obviously honourable purpose, if it could be turned directly to the furtherance of human happiness or the relief of human suffering; as physiology and even chemistry can, then surely neither Gauss nor any other mathematician would have been so foolish as to decry or regret such applications. But science works for evil as well as good (and particularly, of course, in time of war); and both Gauss and lesser mathematicians may be justified in rejoicing that there is one science at any rate, and that their own, whose very remoteness from ordinary human activities should keep it gentle and clean (51, pp. 120-121).

Of course, Hardy's statement may not make much impact on a pre-calculus student who faces memorizing the quadratic formula, but Willcox (108, pp. 27-28) related a situation in which a student asked his instructor how a topic being studied could be used in the student's field of study, and the instructor could not give an example, even after a weekend's thought. When the instructor appealed to the student that they were studying the topic because it was "beautiful," the student replied that "he didn't have time to play chess."

Very often it is difficult to give an example of the use of a mathematical concept that is very plausible for the student to follow. Kline (61, pp. 173-174) noted that mathematics of the past were inspired by problems of the real world and through these problems and their solutions, found meaning in their mathematics. Also, applications of mathematical principles to everyday occurrences is very important in good teaching. He went on to say that the experience of the instructor will well serve to provide good examples of applications. Aristotle supposedly asserted that "there is nothing in the intellect that was not first in the senses."

Field noted that

> it has become fashionable to call upon mathematical models to illustrate, at an elementary level, fundamental mathematical concepts and modern applications of mathematics. Finding a problem whose mathematical solution appeals to average college students and at the same time confronts them with its underlying assumptions is indeed challenging (40, p. 196).

In his book, Earle (35, pp. 82-84) listed a set of activities and special interest mathematics books that could be used in pre-calculus mathematics courses to provide motivation and increase the interest of the students in the course. Another view of providing suitable problems is presented by Lancaster (66, pp. 2-3). He pointed out that usually real-life problems are too complicated without some simplifying hypotheses being made.

In applied mathematics a physical way of thinking is first found, e.g., a dot representing a set of coordinates, and then a process of idealization is followed to produce a more abstract representation of the problem at hand. However, care must be taken not to strip the problem of too many features in the idealizing process, or of retaining too many features, for fear of ending up with a problem that is meaningless or impossible to be solved (66, pp. 2-3).

Lamon (65, p. 5) pointed out that since mathematics is founded on three basic structures, those being: (1) the algebraic structure, (2) the ordering structure, and (3) the topological structure, structured learning experiences should be stressed continuously during the developing years in public education. Also, based on Gestalt psychology, understanding of structure is enhanced through learning situations that allow the student to discover how parts relate to each other as well as how the wholes are formed.

Rollins (85) discussed a new approach to applications which is called the situation-model-theory (SMT) approach to teaching mathematical concepts. The approach is characterized by the following properties:

> (1) Applications are used to formulate a situation from which the student himself develops new mathematical ideas.

(2) Consideration of these situations serves to teach the student important aspects of applying mathematics; in particular, that finding what problem needs to be solved often is more difficult than solving the problem itself.

(3) Availability of realistic applications is the basis for determining which topics in mathematics are studied. Examples of the use of this approach at both the elementary and secondary levels were given (85, p. 3182-A).

Although the control group and the experimental group scored about the same on the achievement test at the end of the study, it was felt that this approach might offer some benefits to the slower learner.

G. Papy (78, pp. 54-55) said that in teaching applications one of the most difficult points in the study is in recognizing when a problem lends itself to a mathematical solution. He stressed that practice in conceptualizing a concrete situation must be provided for the student and that mathematics must be presented in such a way that the student learns to keep an open mind to new possibilities. Hunsucker (56) noted that problems selected should be those that are not too specialized but are attractive and interesting and emphasize the fact that mathematics can be fun or at least entertaining.

Wilder (65, p. 46) pointed out that mathematicians should not be surprised by an application being found for their work. He went on to say that

> while he may be working on a level of abstraction that seems so high on today's mathematical structure as to be virtually in the clouds, he should know that the relations between the various levels are such that even the concepts of the highest levels repeatedly find their counterparts not only in the lower levels, but also in the nonmathematical cultural environment (65, p. 46).

Now if mathematicians don't want their work to be applied, who will teach applications? Buswell (17, p. 769) wrote about many experiments in which problem solving was of great important and also of results hinting that problem solving and reading are closely related. Call and Wiggin (18, p. 769) suggested that an English teacher with little work in mathematics may be more effective in teaching problem solving than a mathematics instructor. Swenson (99, p. 769) wrote that more emphasis should be placed on the ability of students to solve problems encountered in reality, rather than from reading about them in a book. It may well be that written problems might be better taught in the English classroom than in the classroom of the mathematician.

In teaching mathematics, there is a problem not only in not being able to provide a suitable application of a concept, but also of introducing a concept too soon in the course. Dubisch (33, p. 26) acknowledged that one of the most common errors made by mathematics instructors is that skills should not be acquired far in advance of needs that may lie in the future. Sloyer related that there are two basic problems with applications of mathematics:

> (I) There is ambiguity as to what actually constitutes an application of mathematics.
>
> (II) Students (as well as some teachers) feel that when a buzzer sounds and the mathematics class is finished for the day, the text is closed and mathematics is dismissed until the next meeting of that class, except possibly for some time spent doing a routine assignment (91, p. 19).

Sloyer also agreed that applications of mathematics do form a vital force in motivating mathematics students to study mathematics and that the mathematics instructor should make the student aware of the importance that the field of mathematics holds in the real world (91, p. 26).

Saxon (87, 88, 89) provided many real world problems in his three texts and by the nature of the problem sets, provides valuable continued practice for the student.

Literature Concerning Evaluation And Grade Inflation

Exactly what is meant by testing or evaluation in mathematics? There are so many different meanings that the concept of testing has indeed become one important point of contention in mathematics.

Davis, (27, pp. 57-59) listed a few examples of what is meant by the term "testing." He cited the instructors who give the students re-tests, or even third or fourth chances on the test. Some institutions have experimented with the idea of letting students take an exam as a group effort, with dissenters being allowed to file minority reports. Some instructors view testing as another hurdle for the student, and stress the importance of study sessions for the students to prepare them specifically for the test to be taken.

However, others are more interested in how the student attacks a problem and not so concerned that the answer may be in error. Some wish to construct the examination to determine how a student applies the concepts being studied "when there is no pressure on him to use mathematics at all." Some instructors are interested in how elegantly the student can work a problem, or the style in which he works it. And some check to see how a student can pose a problem, instead of, or in conjunction with, being able to solve the problem, once it is posed.

Gurau (46) wrote of a testing scheme in which a student works on an examination until help is needed, at which time the student stops work on the test and seeks help from the instructor. The test is graded to the point noted, the student is helped on the concepts not understood and re-tested over the section not completed until a satisfactory score is obtained.

There has also been little study in teacher behavior with respect to testing (27, p. 58). Hobbs (55) said that "grading might be endured if we could be reasonably confident of its accuracy and authority, but most professors who bother to think about it realize quickly how tenuous and subjective even their most conscientiously considered grades are" (55). He further said that the professor is influenced by his moods, the students' poor handwriting, number of exams to grade, limited time, order of grading, pre-conceived notions, and the like. He added that if students could see the grading process, they would not take grades as seriously as they do. DePue noted that "not so surprising is the fact that apparently a majority of students want grading" (28, p. 237). DePue said of students that "in particular they believe, with few exceptions, that grades do measure something worth measuring. . ." (28, p. 237).

Bentley (8, p. 773) found that examinations tend to favor memory and cognitive abilities and tend to penalize the highly creative student. He said that it is well known that students study more for the test than for what the instructor is trying to teach them, and with this new evidence, the instructor should consider the examinations given very carefully so as not to unduly discourage the student's creativity.

Recently, there has been a great deal of controversy in mathematics in two areas: (i) the types of tests that should be administered to students, and (ii) the evaluation of these tests and the resulting grading practices used. With respect to the first question, there are presently several accepted ways of administering examinations. The pros and cons of each method are many and well documented.

In the multiple-choice type of examination, care must be taken not to make the right answer too obvious. An example of how such precaution can be exercised is the following:

> For what positive number k will the triangle formed by the coordinate axes and the line $2x+ky=6$ have area k?
>
> (a) 2 (b) 3 (c) $3\sqrt{2}$ (d) 6 (e) 12 (37, p. 363)

Students are sometimes surprised to find a multiple-choice examination given in a mathematics course and often do not understand how to take the examination. Experience has shown that students do tend to do less computational work and scratch work on multiple-choice examinations than on some other types of tests. One important advantage of the examination is that it can be machine or teacher graded quickly, and provides the student with immediate feedback on progress made in the course.

As to the reliability of multiple-choice tests, Epstein (37, p. 363) noted that in a certain calculus Advanced Placement test consisting of two 90-minute sections, the first multiple-choice and the second seven involved problems requiring proofs and theoretical considerations, the correlation between students' scores on the two sections had been above 0.80 and the students' rankings would not have been significantly altered had the examination been entirely multiple-choice.

In considering the problem or essay type of test in mathematics, Epstein (37, p. 364) pointed out that there are difficulties and unreliability in grading the papers. Also, there are problems in sampling of the material to be tested, relatively large penalties if some one concept is not understood or if a question is misinterpreted. However, it was pointed out that this type of examination requires the student to develop solutions from his previous work in the course or previous courses and allows him to explain the answer in his terms, instead of having to work the problem and then possibly translate his answer into the instructor's "right" answer as on a multiple-choice test.

Davis (27, p. 58) wrote that many educators consider a test as a sample of possible problems that may be encountered in the future, and with this view, the problem-type test would be superior to the multiple-choice style of of testing. He pointed out that these same educators are strongly against the drilling of students specifically for the test.

Traub and Fisher (102) did research on three types of tests; the standard multiple-choice, constructed response, and the Coombs multiple-choice in order to determine whether or not each type of examination measured the same attributes. With respect to the mathematical portions of the examinations, there were no significant differences in the answers given by the respondents.

With respect to the answering of multiple-choice examinations, McMorris and Leonard (73) found that low anxious students tended to make more changes and to gain from the changes than did high-anxious students. This study tended to refute the conventional wisdom that a test taker should not change the first response made on a multiple-choice examination.

DePue (28, p. 238) wrote that over a period of time he had been able to devise a simple way to achieve a true relative zero for all multiple-choice tests. After additional time, he achieved an accurate and stable standard by which to grade which combined:

> (1) a true decimal scale based on a valid relative zero with a ratio scale including the two variables of knowledge and student ability normalized on the constant of an ideal percentage midscore, and (2) the 5-letter scale for subjective marking (28, p. 238).

DePue (28, p. 237) noted that some authorities feel the use of the college grade point average provides grading with an accuracy usually associated with numbers. However, he also noted that others argue that a letter scale can be just as accurate as a number scale and gave examples to back their contention.

Milton and Edgerly (75) pointed out that letter grading, the most commonly accepted form of evaluation, is particularly susceptible to the charge of insufficient feedback to the student. They also mentioned that growing external pressures are forcing professors to reconsider their evaluation procedures and attempt to come up with better ways in which to grade their students. They recommended the use of external examiners and the establishment of campus grievance committees as two possible ways to improve the problem of student evaluation at the college and university.

One possibility for the concept of the external examiner is the implementation of the standardized test. Epstein

(37, p. 364) noted that some of the advantages of the standardized test are as follows: many authorities are involved in determining what concepts are to be tested; items may be pre-tested as to relevance and difficulty; ambiguities are eliminated from the final version of the examination; reliability is increased to insure better discrimination between the good and the poor student; and there is access to a wide variety of schools with respect to normative data.

Epstein (37, p. 365) also mentioned that by using a standardized examination, the halo effects of personality interaction, attitude in class, and several other possible factors are ignored in the scoring. However, a possible minus with respect to the use of the standardized exam is the too heavy reliance on the norms of the examination. For example, if a small rural school in a mining town achieves a class average at the median of a standardized exam, that may be a real triumph, whereas if the same is accomplished by a school in an affluent suburb whose students are college bound, there might be cause for real concern. Therefore, the test results must be judged realistically.

Schoenfeld (90) wrote that one way to provide students experience in test taking without the accompanying trauma was to give brief, unannounced quizzes, to be taken anonymously by the students. The examination of the papers by the instructor would give him insight into troubles encountered by the students, and the students are given the needed practice, not only in problem solving, but also the taking of examinations.

Let us consider now the ultimate result of the types of testing and the philosophies behind these tests--the grades of students. In recent years, combined with the problems of testing and the meaning of tests has been the ever-present charge of grade inflation. And along with supposed easing of the traditional grading, new concepts of evaluation have been introduced--pass-fail and the P grades, to name only two of many.

Juola (58) reported that on compiling data from a 1974 survey of 134 colleges, the grade point average of students had risen .404 points from 1965 to 1973, with about two-thirds of the increase occurring since 1968 and the 1968-1970 period showing the highest average annual increases. (Possibly the Viet Nam War had something to do with that.) Juola noted that the grade inflation was only another indication of increased concern for the views of students and indicated innovations in instruction in an effort to adapt to those views.

Suslow (98) found from his survey that, in agreement with Juola, there had been a drastic rise in grade point averages since the early 1960's. However, further analysis of his data indicated a flattening of the G.P.A. curve. Some innovations in grading noted by Suslow are pass/fail, credit/no credit, and withdrawal without penalty regulations for courses enrolled in, but not completed. The institutions taking part in the survey did not indicate any plans to change the current practices in grading.

Breland (13) presented a paper that agreed with Suslow and Juola, but went further to indicate that while the G.P.A. had risen, the reliability of the grades given has not diminished, due to comparable correlations between present-day grades and test scores of the SAT and the ACT with those same correlations in the past. He noted that with the publicity received concerning the declining SAT scores, a leveling off and possible rise of those scores may be predicted for the near future.

C. A. Hardy (50, pp. 19-20) agreed in stating that while the sharpest drop in the SAT scores had been witnessed in 1975, a prediction had been made that the SAT scores would bottom out in 1980 and then experience an upturn.

Considering the grade inflation from a different view point, Vasta and Sarmiento (104) found in their research that while liberal grading significantly improved the student evaluations of the course and the instructor, there was not an increase in performance, study habits, or attendance.

Burgess, et al, (16) studied two divisions at Indiana University and found that whereas one division did not exhibit grade inflation between 1971 and 1976, there was a significant G.P.A. increase in the second division, due to lenient grading in certain courses. Recommendations of the study included replicating the study, studying the attitudes of faculty with regards to grading, making a study of the grading practices in the courses in question and possibly using an alternate grading system for those courses.

Esp (38) found that while grades at New College had not changed significantly in 1975-1976--remaining at a B level--there was a trend toward more DE (deferred evaluation) and H (hold) grades. Stein (94) also studied the P grade at Metropolitan Community College in Minneapolis, and found that from 1971 to 1975, the amount of P grades given had remained stable, but the distribution had significantly changed in the cases opting for the P or the W grade. She attributed this to a change in attitude as to what constitutes an acceptable grade.

C. A. Hardy (49) found that the pass/fail option was met with good support from both involved faculty members and their students. It was also pointed out that this option might encourage certain students to enroll in academic courses that they would ordinarily avoid.

So as not to end this discussion without some sign of hope for the future, let us recall that Allendoerfer (2, p. 21) reported that at the Ivy League Universities, almost all entering students have studied calculus in high school, and the physics departments were able to stiffen the mathematics requirements for their beginning courses. Davis (27, p. 59) cited certain curriculum workers in biology who would like to make it a senior course because of the level of mathematics which they would like to be able to introduce into the course. It is not uncommon for concern to exist concerning the maintenance of standards. For example, Charles Babbage asserted in 1813 that "the golden age of mathematical literature is undoubtedly past" (11, p. 656). He was brilliant in mathematics, and the construction of calculating machines, but he was not a very good seer.

Literature Regarding Placement Examinations, and the Assistance of Deficiencies in Mathematics

The early diagnosis and assistance in removal of deficiencies is perhaps more crucial and important in mathematics than in any other subject studied in school because of its cumulative nature. Krutetskii (62, p. 313) explained that "the existence of different types of mathematical cast of mind is a consequence not only of individual and typical psychological differences among people, but also of the different demands made on a person by different branches of mathematics" (62, p. 313). He went on to show the different abilities needed in the various fields of study in mathematics, whereby computational skills are of great importance in one area and not in another, or that the ability to perform geometric interpretations are useful in one field of mathematics and of little use in yet another. He also told of the geometer B. K. Mlodzeevskii who had great difficulty in the field of number theory and of Charles Hermite who had trouble in his studies of descriptive geometry, although he was to eventually become a member of the Paris academy and hold the rank of professor at the University of Paris.

Fremont (41, p. 524) stated that there are many standardized tests available to help the instructor recognize and diagnose potential deficiencies of mathematics students. Monroe (76, p. 114) noted that remedial programs are of great benefit to students who are on the line of success and failure in the regular classes, but for the student who is far below the line of success, the difficulty of remediation is far greater.

Kline (61, p. 169) made note of the fact that in two-year colleges 40 percent of the mathematics students are enrolled in some type of remedial or developmental mathematics course. Monroe (76, p. 37) cited a survey of two-year colleges that showed between 1970 and 1974, 20 percent fewer colleges were requiring their students to enroll in remedial or developmental courses. However, it appeared that a partial reason for this drop was that students were being provided better information on their abilities and were therefore able to better place themselves in the appropriate course of study. The value placed by the student regarding his choice is a prime consideration whether or not to require developmental or remedial work by the student, reported Roueche (86, p. 35).

The various methods of assistance to the student include: remedial or developmental courses, usually at three levels;

pre-algebra (arithmetic); elementary algebra (first-year high school algebra) and intermediate algebra (second-year high school algebra); tutoring services; C.A.I. (computer assisted instruction); Learning Laboratory settings; Cognitive Style Mapping; and many others. The formally offered courses are taught in practically every mode imaginable. Instructional strategies include: self-paced, flexible-entry, programmed, individualized, lecture, lecture-discussion, audio-tutorial, small group, correspondence, televised, and several others.

Rockhill (84) discussed the use of the computer in identifying student deficiencies and explained his program at New York State University College at Brockport. By use of the computer appropriate instructional materials are prescribed for the student and student tutors provided, if the mathematics student chooses to use a tutor. He pointed out that one problem with the use of upper class students as tutors is the tutor's inability to identify relevant deficiencies.

Caravella (19, p. 24) discussed the use of calculators as a means of providing slower students needed confidence in their study of mathematics. He has found that by removing the frustration of computational problems, students are able to spend more time in learning when to apply concepts. In support of this contention regarding problems in computation, Tobias (101, p. 57) said that "once a person has become frightened of math, she or he begins to fear all manner of computations, any quantitative data, and words like "proportion," "percentage," "variance," "curve," "exponential."

Tobias further reported the work of Lenore Blum, department head at Mills College in Oakland. Blum does not believe that the approach to math anxiety need be either psychological nor remedial, if care is taken to insure that students start their work in mathematics with positive experiences. Tobias (101, p. 58) noted that some authorities advocate the importance of persuading the learners, instructors, and curriculum policy formers that mathematical abilities are accessible to the majority of students when properly instructed and given the right kind and sufficient amount of support.

Leiderman, et al, (67, p. 772) found in their work concerning the SMSG project that there is a wide range of variability in students considered to be in need of assistance in mathematics. By noting and using this variability of abilities, McKeen and Davidson (72, p. 1008) have developed a program in small group instruction whereby the better students are able to help the slower students in each group. This mode of instruction also improved attitudes, since the entire group was able to attack and solve more difficult problems. Because the atmosphere tends to be one of cooperation and sharing, friendships are made among members of each small group and the student-teacher relationship tends to be a relaxed and informal one. The authors also pointed to the fact that many different grading schemes are compatible with the small group method.

Hampton (48) agreed with McKeen and Davidson in their use of classroom students helping their fellow students. He also listed the following as being important in the teaching of students with deficiencies: know your students; accept and utilize the wide differences that occur in your students; work on motivating your students; correctly pace the work of your students; teach concepts rather than facts; and encourage various activities while teaching your students. Kline (61, p. 101) mentioned that pace is one area which graduate assistants have trouble with in teaching their undergraduate classes. The expertise in pacing students comes partially from experience, and most graduate assistants do not have much experience in teaching.

Allendoerfer (2, p. 23) raised another problem in mathematical deficiencies--that of curriculum for the lower third of the ability group. He pointed to this omission as one serious problem with respect to the Cambridge Report, and noted that something must be done to improve the situation of those low in mathematical ability, since the occupations that this group would have once gone into--the unskilled jobs--are fast disappearing. And to provide the insight and expertise in teaching the new curriculum that will be introduced in the future, CUPM (21, pp. 5-6) stressed that the recommendations they had issued with respect to mathematics teacher preparation included those teachers who would be primarily involved with the teaching of the pre-calculus student. However, recalling the recommendations made by Hampton above, the preparation must be in fields other than mathematics also.

Monroe, (76, p. 115) told of a developmental program at the Wilson campus of the City Colleges of Chicago, saying:

> However, more important than the curriculum was the contribution of the faculty and the counseling department to the program. Teachers were difficult to find. Too many were unqualified to teach this level of students, and others were hostile to the program or completely uninterested. Only volunteer teachers were selected. Thus, the courses offered often depended on the teachers who were willing to volunteer their services. Good teachers for the developmental program were those who had some empathy and understanding for the lower-ability students. Former high school teachers were found to be better than teachers who had come from college teaching or graduate programs in the university. Teachers were encouraged to place emphasis upon counseling students rather than on subject mastery, yet teachers were expected to maintain good academic standards in the courses, which were geared to the students' level of reading and comprehension (76, p. 115).

As can be seen from Monroe's comments of not stressing mastery, yet maintaining high standards, there is a most difficult situation in the teaching of developmental courses. Nevertheless, although the requirements of an effective remedial or developmental mathematics instructor are stringent and varied, the skill can be developed and put to good use in many situations where mathematics remediation is required.

Many schools now use some type of mathematics placement examination in order to place the student in the mathematics course that seems most suitable at the time. Educational Testing Services has developed a series of placement examinations for the Mathematical Association of America, which were validated at the University of Texas.

Williams (109, p. 11) found in her survey that at that time, 17 percent of the students either had completed or were enrolled in an advanced placement course in mathematics for which "they hoped to gain advanced standing and/or credit in college, with 5 percent taking a College Board Advanced placement course and 12 percent taking an advanced placement course other than that sponsored by the College Entrance Board" (109, p. 11).

Farmer concluded in his study that

> 1. The placement of a student in a college mathematics course where success is most likely will be achieved more often when the significant predictors are considered rather than the best single predictor;
>
> 2. The proper placement of a beginning freshman in college mathematics where success is most likely will be achieved more often when the high school mathematics record is available to the advisor;
>
> 3. The predictive value of the American College Test battery reduces after a student has completed a semester's work in college mathematics;
>
> 4. The use of multiple regression techniques for predicting success represents an improvement over the use of single predictor variables. The resulting multiple correlation coefficients are high enough to warrant the use of predictions based on the multiple regression equations for placement of students in appropriate mathematics courses where success is most likely.

From his findings, Farmer went on to recommend that

> 1. When an advisor is determining the appropriate mathematics course for a student, a multiple regression equation and the student's previous record of mathematics courses should be utilized;
>
> 2. In the advisement of students in the area of mathematics after their first college mathematics course, it is recommended that their college mathematics course grades be available to the advisor;
>
> 3. A student making a grade of D in any college mathematics course should be strongly advised not to continue into a higher course until he has repeated and improved his achievement in the course where the D was received;
>
> 4. A departmental examination should be constructed and administered during freshman orientation, then computer-graded with the output data indicating the course recommendations and predicted grade-point average;
>
> 5. Each type of college or university should establish its own set of predictive validities so that it may be aware of the meaning of test scores applicable to its curricula and students;
>
> 6. The use of additional predictors for measuring attitude, motivation, study habits, and other non-academic areas should be researched with a reduced battery of variables measuring the academic area (39).

Farmer's recommendations seem to go a long way in correcting what Kline (61, p. 106) called to attention in saying "nor does it occur to the usual undergraduate professor, however intelligent, that he must know what background high school students bring to college." He went on to say that all too often what should be of first importance in dealing with entering college students are considered belatedly or never.

Literature Related to the Computer and Hand-held Calculator

The oldest form of mechanical calculating device is the abacus, which is still widely used in many Oriental countries. It was not until 1630 that the first slide-rule was constructed, prompted by the recently developed logarithms of Napier. After that, there was a long succession of calculating machines built by such prominent mathematicians as Pascal, Leibniz, and Babbage. It was not until 1936 that Turing defined his Turing Machine--an abstract and generalized model of all possible logical machines. Couffignal showed in 1938 that the binary number system was more useful in computing than the decimal number system, and finally, the first working computer, "The Automatic Sequence Controlled Calculator" known as the A.S.C.G., or Mark 1 was publicly revealed in 1944 (32).

Strauss (97) wrote that the first electronic computer was the ENIAC built at the Moore School of Engineering in Philadelphia in 1946. The computer needed a room 100 feet long, had 18,000 valves, and required 100kW power (32). In the 1950's the second generation computers were developed in which the valves were replaced by transistors, and finally, the third generation computers were developed in the 1960's which made use of transistors and diodes with circuits etched onto semi-conductor chips known as micro-integrated circuitry. This advancement in computer technology enabled the speed of basic arithmetic operations to be reduced to the order of a few microseconds.

Strauss (97) also pointed out that the old argument that the computer could not do anything man could not do is erroneous, since the drastic change of the magnitude of speed in computations--approximately a change of six orders--had produced fundamentally new effects in most fields of technology. He went on to say that although the computer had been used immediately in the thermonuclear project at Los Alamos, more peaceful uses were found in the distribution of the prime numbers, preparation of tables of sines, cosines, logarithms, definite integrals, square roots and statistical parameters. But what was the direct effect made in education?

With regard to the question of curriculum and instructional reform, DeVault, Suppes, and Kaufman (110, p. 772) found in each of their studies that computer-assisted instruction served a valuable purpose in the individualization of instruction. Also, due to the work of Gurau (45; 47) in this area and his use of diagnostic examinations, different sets of exercises, various forms of tests for re-test purposes, and students working at varied rates of speed on prescribed materials, the computer is almost mandatory in order for the instructor to keep abreast of the teaching activities.

Henderson (52) remarked that computer-based teaching was just as effective as the more traditional forms of instruction, and students seemed to enjoy the variation in style provided when working on the computer terminals. He did point out that students tended to tire of excessive use of the terminals and longed for classroom discussion after a while. He noted that the immediate feedback provided the student was most beneficial, and that continued drops in the cost per student hour for the use of computers were making this form of instruction more attractive as time went by.

Caravella reported on a statement issued by the NCTM Board of Directors in 1975 which listed nine ways the mini-calculator could be used in the classroom. Some of the ways listed included

> 1. To encourage students to be inquisitive and creative as they experiment with mathematical ideas
>
> 2. To assist the individual to become a wiser consumer
>
> 3. To reinforce the learning of basic number facts and properties in addition, subtraction, multiplication, and division
>
> 4. To develop the understanding of computational algorithms by repeated operations (10, p. 17).

Pollak (79, p. 293-294) urged "that we consider. . . what are some of the most difficult problems we have in teaching school mathematics with which the calculator can help?" He gave an example of how the calculator could be effectively used in teaching the concept of function in the mathematics classroom, and also named solution of simultaneous equations, probability, and practical statistics as possible areas in which calculators could give the student fresh insight into the true nature of the concepts involved.

Caravella (19, p. 21) concurred that methods of instruction would change and that the use of the calculator would broaden the student's understanding of mathematical concepts and ideas. He mentioned that teachers had already made note of the impact calculators had produced with respect to homework assignments. He concluded that calculators would never replace the need for understanding concepts, acquiring computational skills, or teaching of mathematics, but would increase the teacher's opportunities for providing meaningful activities in the classroom to broaden the scope of the existing topics and provide for introducing innovative procedures in the mathematics curriculum.

What courses in mathematics lend themselves to the utilization of the computer or calculator? Leitzel and Waits (68) described a remedial mathematics course at The Ohio State University with a semester enrollment of about 2,600 students. Calculators were required in the course, so arrangements were made with Texas Instruments Corporation to manufacture a special calculator of four-function, six-digit, floating-decimal, algebraic-entry design with a built-in repeat-operation capability, which would sell for $16.30, without batteries. They found that 91 percent of the students thought that the calculator had been helpful in the course, 89 percent were glad that they had taken the course, 59 percent reported a favorable attitude toward mathematics, but that 54 percent disagreed that the course had improved their attitude towards mathematics.

Begle (7, p. 214) noted that although the best predictor of computational skill at the end of the school year is the computational skills at the beginning of the year, predictors of performance for the higher levels of understanding, analysis and application did not often include the student's skill in computation.

Pagni (77) wrote that in using the computer in the classroom, a worthwhile activity consisted of teaching students to write their own programs, and also teaching them how to run pre-prepared programs on the computer. He noted also that the activity lent itself to supplemental use, in which a box of programs are made available to the students to be used in their free class time. Pagni pointed out that a negative aspect of this practice was that it penalized the slower student who tended to have less free time in class, and recommended that the teacher make arrangements to give time in class for students to return to the use of certain programs periodically to insure continued practice in the targeted activities.

McKool (71) studied the use of the computer in teaching a two-semester business mathematics course and found the computer-aided instructional program to produce results comparable to those of a more traditionally taught course.

He further recommended that more research be done in determining which cognitive skills and attitudes were most effectively enhanced through computer-aided instruction.

To demonstrate the wide range of application of the calculator that is possible, McCarty (70) utilized the calculator in writing a calculus textbook. He stated that "a calculation that requires hours of labor when done by hand with tables is quite inappropriate as an example or exercise. . .but that same computation can become a delicate illustration when the student does it in seconds on his calculator" (70, p. ix). He went on to state that "the student's own personal involvement and easy accomplishment give him reassurance and encouragement" (70, p. ix).

Computer graphics are another aspect of use of the computer that holds much promise. Baltz (6) cited work in computer graphics that suggested that the student of less aptitude gained more from animated graphics. In his study, Baltz found that attitude outcomes were more positive when students studied via aid of computer graphics, but found that the treatment of computer-visuals did not prove to be as beneficial to high aptitude students as it did for students with moderate mathematical aptitude. He further found that videotaped lectures and the computer-visual treatments achieved the same results in a 39-item test administered after the experiment had been completed.

With respect to an entirely new course concept, Conrad, et al, (23) reported on a two-semester course in computer mathematics. They acknowledged two important realities about the world of computer technology. These realities are that computer technology students typically possess only modest abilities in mathematics, and that a very limited amount of curricular space is customarily allocated to computer mathematics (two-semesters or six credit hours.) They saw the course as a means for teaching aspects of formal languages, programming strategies, or computer behavior, and noted that their approach to mathematics turned out to be "formalistic in the starkest sense of that word" (22, p. 39).

How can the use of the calculator and computer be increased in the education of mathematics students? Andersen (4) reported on an in-service program conducted by the University of Minnesota and the Minneapolis Public schools which dealt with the problem of the use of the computer in the secondary school mathematics curriculum. An analysis of the program showed that participants in the project did change their classroom attitudes toward those of instituting more computer instructional activities in their teaching. The study also suggested that the project improved the students' performances on a problem-solving examination and on the amount of computer problem-solving tried by the students during the ensuing year.

One way that students may become more interested in working with calculators is through calculator or computer games. Boyle (12) noted that exercises and games serve "to demystify the strange, powerful, little packages for many students who feel threatened by a calculator." He cited a puzzle for the calculator in the following:

> Punch 142 for the number of Israeli soldiers. Now punch 154 for the number of Arabs. Don't add or subtract or anything, just make a continuous number. Now punch 69 for the length of the battle-front. Now hit the times (X) sign and a five for the Five Day War. Push the equal (=) button. Turn the computer (calculator) upside down and see who won (12, p. 281).

Caravella (19) also gave a list of such activities at the end of his book on the minicalculator. Boyle mentioned yet another example of such inverted puzzles.

> 1. Use a calculator to describe the number
>
> $$(16.599)^2-(29.59)$$
>
> Note that the calculation requires the use of a memory on most machines or the student must write down an intermediate result and reenter it. In any event, if you calculated it, you found it to be 91851345; and inverted, it displays SHEISBIG, which uses up the eight-digit display of most machines. For larger displays, one could use 9185.345 or 91834551.0 and divise appropriate calculations to obtain them (12, p. 281).

Thus, it can be seen that the computer and the calculator lend themselves to classroom instruction, curriculum development, and student motivation in ways that are limited only by the person's imagination.

Literature Related to Joint Meetings of Faculty and the Review of Mathematics Curriculum

In view of the cumulative nature of mathematics, whenever a review and revision of the curriculum in mathematics is considered, there must be considerable dialogue between instructors in the institutions at various levels. At the Cambridge conference in 1963 (36, p. 67), it was pointed out that "a proper development of the school mathematics curriculum requires a constant dialogue in the whole mathematical community, with essential contributions from both research scholars and classroom teachers" (36, p. 67). It went on to say that it had not been uncommon for the research mathematician to neglect this aspect of his role in the mathematical community. Also, the conception of goals set by some curriculum committee would always need to be adjusted to what turned out to be the limits of the possible.

A constant danger that the research mathematician faces is that of becoming too specialized in his field. Kline (61, p. 55) told of David Hilbert, the greatest mathematician of the twentieth century, writing:

> The question is forced upon us whether mathematics is once to face what other sciences have long ago experienced, namely, to fall apart into subdivisions whose representatives are hardly able to understand each other and whose connections for this reason will become ever looser. I neither believe nor wish this to happen; the science of mathematics as I see it is an indivisible whole, an organism whose ability to survive rests on the connection between its parts (61, p. 55).

Delessert (29, p. 125) noted that the educating of a student in mathematics consists of developing in each pupil the conception of a proper model of the mathematical structure. He went on to say that

> As in every construction, there are temporary parts--scaffoldings--and permanent parts. On the part of the university, the scaffoldings have been generally underestimated; on the part of the secondary school, it has often been forgotten that the scaffoldings must one day disappear, to the advantage of the ultimate structure (29, p. 125).

Bagnato made an "appeal for more study and publicity of mathematics as a collaborative enterprise" (5, p. 682). He also noted that such committee work as the SMSG, the CUPM, the cooperative work done at institutions such as the Courant and books consisting of efforts of many mathematicians, such as those of Bourbaki, are just as important in the concept of the "new Math" as any of the particular topics that have been introduced into the curriculum recently.

In outlining a list of provisions for the mathematically gifted student in the secondary school, the National Council of Teachers of Mathematics (82, p. 23) noted that in order to develop any programs for the gifted in the secondary schools, liaison must exist between the secondary schools and the colleges. They pointed out that accelerated work taken by the gifted student in high school should not be required to repeat the same work in college. The Council also noted that although in the past there had been insufficient communication between the various institutions, the situation at that time had improved and secondary school instructors seemed to be much more open to contacting various colleges for suggestions when curriculum revisions were made in the high school. It was also suggested that the high school instructor correspond directly with the college mathematics department when a particularly able high school student was entering college.

One way that colleges and community colleges may help in opening communications with secondary schools is to provide certain in-service programs for the high school instructors. Andersen (4) wrote of an in-service program offered by the University of Minnesota that produced significant changes in the utilization of the computer by the attending high school instructors and their students during the following year.

Miller (74, p. 90) found in his study that "because there are schools that may profit from conducting experimental programs in mathematics, a closer cooperation between high schools and colleges needs to be encouraged" (74, p. 90). He also noted that "a closer cooperation could be developed in the areas of programs approved by the colleges, high school credits accepted, and consultant services offered to the high schools by the colleges" (74, p. 90).

Jordan (57) wrote of a slightly different role that colleges could play in their assistance of the secondary schools. Washington State University sent thirteen Ph.D.'s in mathematics to work in various Washington state high schools. The program took a year to complete, and at its conclusion, the participants were awarded a master's degree in education. The general attitude of the participants was positive, and it was felt that they were better prepared to assist in pre-college mathematics revision than before their participation in the program. Since the participants were selected from across the United States, the effects of the program may well be felt in the near future.

With respect to the questions concerning the revision of mathematics curriculum, Professor Leon Henkin (83, pp. 4-5) wrote that three forces in mathematics curriculum revision consist of (1) the existence of "traditionalism" in every part of our educational system...foremost among these traditional elements being Euclidean Geometry, and although mathematics might go through drastic changes, this form of geometry would probably play a part in the curriculum for many years to come; (2) The advancing frontier of research plays a part in the curriculum, but because of the lag between the discovery of a concept and its institution into the curriculum, there was time for the elimination of the most unstable features of change; (3) The many applications of mathematics is also a strong force in the shaping of the curriculum. As time goes by, mathematics will be introduced into more and more aspects of the other branches of education, and there will be great pressure on the high school mathematics instructor to give their students background sufficient for the study of the mathematical concepts in the other fields.

Henkin concluded with the observation, "When we observe the way in which mathematical applications change in our time, we are impressed not only with the great number of new places where mathematics appears but with the rate at which these places are found" (83, p. 5).

Aichele and Reys (1) noted that to understand what caused the changes in the secondary mathematics programs, one needed to reflect on the structure of mathematics, as well as the role of the learner. The growing attention aimed at the student as an active learner, rather than a passive recipient of mathematical facts has caused much change in the mathematics curriculum.

Aichele and Reys also pointed out

> Thus, it becomes increasingly more reasonable why mathematics educators refer to "modern mathematics" or "new mathematics" as a reorganization of content or new approaches to teaching mathematics, rather than as newly discovered mathematical content (1, pp. 2-3).

Aichele and Reys remarked that with respect to the curriculum changes in secondary schools, some authorities strongly advocate a return to the more traditional approaches to mathematics education, while others note the features of the traditional approaches that caused such radical changes during the past few years. Still other authorities point out that work must begin immediately if some of the long range goals are to be realized at all (1, pp. 2-3).

Allendoerfer (2, p.21) noted that history had shown that the SMSG materials were generally aimed at the college-bound students. Several had voiced hopes that with slight simplification, the SMSG materials could be used with the less-capable students, but there had not been very much work done in this direction with this type of curriculum.

Although there was wide-spread acceptance of the SMSG curriculum and the Cambridge Report, there was by no means universal agreement as to the direction that the "new math" should be taking. Freudenthal wrote:

> If I were asked what the most widespread tendency is in the instruction of what is called new mathematics, my honest answer (of which, however, I am ashamed) would have to be "a hoax!" It is displayed in all its pureness in literature, movies, and television broadcasts produced by honest but incompetent people, or by those whom I would call the opportunists of new mathematics. If teachers regret not understanding this new mathematics that they have to teach, or if exasperated parents ask for explanations from university professors about this new mathematics that their children must learn, I admit that their complaints are often justified, although actually the complaints ought not to be aimed at new mathematics, but at the abuses of it (65, p. 14).

And Freudenthal was not alone in his criticism of the curriculum in mathematics. However, there are several views that can be taken and Wisner (20) wrote that with respect to the work of CUPM, the aim was to improve the college curriculum so that students entering from high schools with revised curriculums would not laugh at the college mathematics courses being less careful mathematically than their secondary school predecessors. He also noted that unless something was accomplished in the direction of curriculum improvement in the colleges, that "we shall all experience the sensation of waiting at the station for a train which has already passed" (20).

Dubisch (33, p. 56) noted that generally speaking, numerical computation takes too much time in the study of trigonometry. He also noted other instances of how the topics in trigonometry could be changed in order to make the subject more relevant to students' needs.

Pollak (79, p. 295) held a similar opinion with respect to the need to delete some topics from the curriculum. He pointed out that probability is more important to the present-day student than the division of polynomials. He further said that by using the calculators now available, topics formerly taught in higher level courses could be considered in some depth without going into a rigorous treatment at the lower level.

Alspaugh and Delon (3, p. 768) noted that while many schools had changed their algebra and plane geometry courses to a more modern treatment, solid geometry had essentially disappeared from the curriculums of the schools studied.

What results can be expected if communications are improved between the secondary school teacher and the college instructor? Possibly some differences in opinion in the effectiveness of various teaching schemes may be uncovered and corrections made to fulfill the needs of the students better.

For example, Crothamel (26) found in his study that in researching ratings by mathematics instructors and science teachers, the revised mathematics curriculum in high school had not changed the mathematics achievement as seen in freshman chemistry and physics courses. However, mathematics instructors tended to believe that the curriculum changes had brought about improvements in achievement. The scientists generally called for more arithmetic and algebraic skills, especially in working with numerical approximations, irrational numbers, roots of equations and round off problems.

Some of the topics listed as of least use in college science courses included: determinants, inequalities, probability and statistics, and the study of sets. Crothamel recommended that more practice in applied problems be given in high schools, and stressed the importance of cooperation between mathematics educators and science educators in designing for curriculum changes and training of teachers to teach integrated materials.

Crawford (24) studied aspects of certain in-service programs offered in Georgia, and recommended that Georgia teacher training institutions should be prepared to meet the needs of teachers who exhibit tendencies not to fulfill their professional responsibilities in various instances.

In considering the various problems in curriculum revision and communications between faculties, it seems evident, therefore, that no one group is to blame for the problems in mathematics, nor can any one group be expected to provide an answer for the improvement of the situation in the mathematics curriculum. The mathematical community must work together to find ways in which constructive change may be brought about to keep mathematics a growing and interesting subject for students at all levels.

Literature Considering Teacher Attitudes

The study of teacher attitudes with respect to the teaching of mathematics at various levels is an area of great importance, because the attitudes of the instructors directly affect the attitudes of their students, even though some studies are available that show significant discrepancies in the two sets of attitudes. Hendrickson (53) pointed out that, although instructors teach for many reasons, it is unfortunate that the reasons so often have little to do with the desire to meet the needs and the goals of their students.

The Committee on the Undergraduate Program in Mathematics listed a set of characteristics which a college instructor or an instructor in university parallel mathematics courses in a two-year college should possess. The committee stated:

> It should be understood that no academic program or degree in itself qualifies an individual to teach effectively at any level unless this preparation is accompanied by a genuine interest in teaching and by professional activities reflecting continuing mathematical growth. These activities may assume the form of several of the following:
>
> (a) taking additional course work,
>
> (b) reading and studying to keep aware of new developments and to explore new fields,
>
> (c) engaging in research for new mathematical results (even when unpublished),

(d) developing new courses and new ways of teaching,

(e) publishing expository or research articles,

(f) participating in the activities of professional mathematical organizations.

The preceding list reflects our convictions that an effective teacher must maintain an active interest in the communication of ideas and have a dedication to studying, learning, and understanding mathematics at levels significantly beyond those at which he is teaching (21, p. 4).

As a recommendation for improving the teaching and teaching attitudes in the two-year college, CUPM also recommended that an apprenticeship in teaching in the two-year college be instituted and noted that "done well, it will attract and retain competent and interested persons" (21, pp. 10-11).

There is little if any correlation between the mathematical ability of the person and the type of teacher the person happens to be. However, Kline (61, p. 87) pointed out that two of the greatest mathematicians to ever live, Newton and Gauss, did not care to teach mathematics. It is reported that at times, while teaching at Cambridge University, no students attended Newton's classes, and those few that did hardly understood his lectures. It is said that "the paucity of students did not disturb him, but he was almost paranoid in his concern to receive credit for his creations" (61, p. 87).

Kline also said that Gauss wrote Wilhelm Olbers in 1802 and noted:

> I have a real aversion to teaching. For a professor of mathematics it consists of eternal work to just teach the ABC's of his science; of the few students who go on, most continue to gather a file of information and become only half-educated, whereas the rare gifted students will not allow themselves to be educated through lectures but instead learn by themselves. And through this thankless work the professor loses his precious time (61, p. 87).

Kline wrote that whereas Gauss attracted few students to his lectures, his colleague, Bernhard Friedrich Thibaut, who was not very prominent as a mathematician, would attract over a hundred. Thus, it can be seen that one may be an extremely capable mathematician, and yet hate to teach the subject.

Begle (7, p. 208) noted that in a longitudinal study made with respect to the SMSG curriculum, a background study made on teachers, degrees, training, experience, and other factors told them practically nothing about the effectiveness of the teacher. They also found that teacher attitudes toward teaching, students, mathematics and the like also failed to be a determinant with respect to effective teaching.

Garner (42) however found that there was a significant relationship in the following:

> (1) Teachers' backgrounds in mathematics and the Anglo- and composite Anglo- and Latin-American pupils' achievements in algebra.
>
> (2) Teachers' attitudes toward algebra and the end-of-course attitudes of pupils toward algebra.
>
> (3) Judgments of teachers concerning the practical value of algebra and the Anglo- and composite Anglo- and Latin-American pupils' achievements in algebra.
>
> (4) Teachers' attitudes toward algebra and the changes in attitude of Latin-American pupils toward algebra (42).

Garner found, however, that the teachers' attitudes toward algebra and the pupils' achievements in algebra held no significant relationship. He did demonstrate that a significant inverse relationship existed between the teachers' backgrounds in professional education and the pupils' achievements in algebra. He recommended that more research be done with respect to the characteristics of teachers who positively influence pupils.

In his study, Crittenden (25) found that teaching level was related to attitude differences among teachers more frequently than any of the other attributes. More experienced teachers held attitudes less approving of modern mathematics than less experienced teachers. Senior high teachers were more convinced that elementary teachers did not like to teach arithmetic than the elementary teachers actually were themselves. The study also found little relationship between mathematics credits and attitudes. The study also pointed to the need for more communications between elementary and secondary teachers.

In Bertram's study (9), he noted that over half of the teachers surveyed had participated in a National Science Foundation Program, and most felt that their teacher education programs had placed too much emphasis on subject matter and not enough on classroom management. He also noted that mathematics teachers in secondary schools do not seem to participate in their professional organizations, nor read the professional literature. He did note that the teachers preferred to teach students who were mathematically oriented and not those who had difficulty understanding the subject.

With respect to college faculties, Goldstein and Anderson (44) found in their study that while the college mathematics faculty preferred teaching to research, it was the research that was rewarded as opposed to the teaching. They indicated that the faculty members surveyed preferred to allocate the majority of their time to the teaching of students or public service (57 percent) as opposed to what was actually practiced--that of being able to allot only 43 percent to either teaching or public service. Also, 84 percent of the instructors surveyed favored promoting faculty members who were outstanding teachers.

Dubisch (33, p. 5) stated that in polls of students in college, a friendly attitude by the instructor was not considered to be of great importance. He did point out that although an instructor may be effective while being disinterested in his students, he is likely to be ineffective if he dislikes the students, since the instructor may tend to be sarcastic and overbearing to the students. Also, a professor who is disinterested in the students is likely to become bored in teaching, and not experience much fun or enjoyment in his work.

Warner (105) argued that the teacher's attitude plays an important role in his understanding of the professional role and in the teaching provided the students. She also noted that the attitudes of teachers toward their own schooling and student-teacher relationships played a big part in their selection of teaching as a profession and their attitudes toward the profession, as a whole. She therefore concluded that based on the study, it appeared that future teachers are encouraged to enter the teaching profession because of the types of teachers they have had themselves. Thus, present-day teachers may play a great role in influencing the profession for years to come.

Brown (15) found in his study that "students who have a positive attitude toward mathematics had a significantly higher achievement level than those students who had a negative attitude toward mathematics" (15). Kallingal (59) found in his study that students who were taught through activities stressing independence and self-motivation felt positively about what they learned in class, and that most of the students felt that the instructor was trying to help them in their growth and development.

Cooper and Petrosky (23) made note of studies in which the perceptions of the school situation by the teacher and by the students were significantly different. They also acknowledged the fact that while many outside of the classroom felt that attitudes were of little importance in the mathematics classroom, the Cambridge conferences in the 1960's had gone to great length to stress the importance of attitudes and motivation in mathematics. They also reported on studies in which students expressed respect for teachers who served as good role models and disdain for those teachers who served as poor models. They reported, additionally, that the instructor's attention to the type of personal transactions and interactions with their students is paramount in creating in the student good attitudes toward mathematics and its associated parts.

It can thus be seen that an instructor with a positive attitude toward the teaching of mathematics and its integral parts will probably be more effective than the instructor who does not possess such a positive attitude. Although the characteristics of the effective instructor are not known, specifically, there is enough evidence available to support the contention that the attitude of the instructor is tied closely with that of the student. Thus, instructor attitude becomes a very important consideration when studying the field of mathematics education.

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CHAPTER III

PRESENTATION OF FINDINGS

Introduction

The research hypotheses for this study concerned the following three areas: (1) differences in attitudes among the high school, community/junior college, and senior college/university mathematics instructors with respect to the teaching of college preparatory mathematics courses; (2) differences in attitudes among the high school, community/junior college, and senior college/university mathematics instructors toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations; and (3) correlations between the attitudes toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations and the attitudes toward teaching in the college preparatory mathematics courses held by the instructors in high schools, community/junior colleges, and senior colleges/universities.

The analysis of variance was employed to determine whether the between-groups variance was significantly greater than the within-groups variance. When a significant difference was found, then the implication was made that at least one of the groups differed significantly from at least one another group. When such a significant F-ratio was found, Scheffé's F Test was used to test for all possible comparisons. For df=2,146, an F-ratio of at least 3.00 was necessary for significance at the 0.05 level and at least 4.61 for significance at the 0.01 level. A Pearson correlation coefficient was also computed for each of the three groups between the attitudes toward teaching and the recommendations. For the high school mathematics instructors, a critical value of 0.195 or more with df=71 was found for the 0.05 level of significance for the two-tailed test. For the community/junior college mathematics instructors, a critical value of 0.304 or more with df=41 was found for the 0.05 level of significance for the two-tailed test. For the senior college/university mathematics instructor, a critical value of 0.349 or more with df=31 was found for the 0.05 level of significance for the two-tailed test.

The results of the statistical tests are presented for the attitudes toward teaching, the attitudes toward the recommendations, and the correlations for the attitudes toward teaching college preparatory mathematics courses and the recommendations.

The significant analysis of variance F-ratios and the Scheffé's F-ratios are presented in tabular form for the items of the two attitudinal instruments, and the coefficients are presented in tabular form for the correlations between the two different scores. A discussion of the results of each table is included, also. The data as received from the North Texas State University Computer Center are presented in Appendix E.

Findings Concerning The Attitudes Toward Teaching College Preparatory Mathematics Courses

In Table I and the tables found in the rest of this paper, the high school mathematics instructors will be referred to as Group 1, the community/junior college mathematics instructors will be referred to as Group 2, and the senior college/university mathematics instructors will be referred to as Group 3. The results are given according to the appropriateness of group or group pairing.

TABLE I

SUMMARY FOR RESPONSES TO THE *PURDUE SCALE FOR MEASURING ATTITUDES TOWARD ANY VOCATION*

ANOVA F	Group 1 and Group 2	Group 1 and Group 3	Group 2 and Group 3
	S. F[a]	S. F	S. F
NS	..	..	..

[a]Scheffé's F Test

As can be seen from the table, there did not exist a significant difference between any two of the groups with respect to the attitudes toward teaching college preparatory mathematics courses. The average score for each group was approximately 8.1, which indicated that each group held a favorable attitude toward the teaching of such courses. The maximum attitudinal scale score was 10.3, and the neutral attitude score was 6.0. A copy of this instrument is included in Appendix D. A copy of the instrument "A Survey of Certain Practices and Attitudes of Pre-Calculus Mathematics Instructors" is found in Appendix C.

Findings Concerning Items 1-8 in "A Survey of Certain Practices and Attitudes of Pre-Calculus Mathematics Instructors

All three groups were in agreement with respect to Items 1, 4, 6, 7, and 8.

All three groups were in strong agreement concerning Item 1. They seemed to feel most strongly that proficiency in mathematics cannot be acquired without individual practice.

Considering Item 2, a significant difference between the attitudes of the high school mathematics instructors and the senior college/university mathematics instructors was found. The senior college/university mathematics instructor seemed to place more emphasis on regular assignments to be completed outside of class than did the high school mathematics instructor (Item 2). There was no significant difference between the high school and community/junior college instructor nor between the community/junior college and senior college/university mathematics instructors regarding Item 2.

TABLE II

SUMMARY FOR ITEMS 1-8 OF RECOMMENDATIONS QUESTIONNAIRE

Item	ANOVA F	Group 1 and Group 2	Group 1 and Group 3	Group 2 and Group 3
		S. F[a]	S. F	S. F
1	NS	..	..	..
2	6.1203**	..	5.7192**	..
3	9.9025**	4.8905**	8.1617**	..
4	NS	..	..	..
5	6.1042**	4.1188*	4.0589*	..
6	NS	..	..	..
7	NS	..	..	..
8	NS	..	..	..

[a]Scheffé's F Test, $*p < 0.05$, $**p < 0.01$.

On Item 3, there was a significant difference between the high school mathematics instructors and each of the other two groups in the study. The high school mathematics instructors appeared to put more emphasis on the instruction of the formation of good study habits than did the community/ junior college mathematics instructors, and also more emphasis on the instruction of good study habits than did the senior college/university mathematics instructors. The community/ junior college mathematics instructors and the senior college/ university mathematics instructors were in agreement concerning the amount of class time taken in instructing students in the formation of good study habits. It should be noted that all three groups indicated agreements to some degree with respect to this particular item. However, the differences in degree of agreement were significant, as discussed.

On Item 4, there was general agreement with reservations concerning the use of class time in helping students improve their reading.

With regard to Item 5, high school instructors tended to place more emphasis on the encouragement of positive homework attitudes in their students than did the other two groups of instructors. It should be noted however, that each of the three groups agreed to some extent with this item.

There was general agreement with reservations to Item 6, in which the instructor's ability to provide meaningful real-world examples of most, if not all, concepts and procedures studied in their course was stated.

Concerning Item 7, there was fairly strong general agreement among the three groups of mathematics instructors that they provide problems which reinforce manipulative skills. However, a general agreement existed with reservations on Item 8 that each group of instructors had to struggle to maintain standards in their courses.

Findings Concerning Items 9-16 in "A Survey of Certain Practices of Attitudes of Pre-Calculus Mathematics Instructors"

With respect to Item 9, there was a significant difference shown between the community/junior college mathematics instructors and the senior college/university mathematics instructors. The senior college/university mathematics instructors seemed to feel there was much more of a problem with grade inflation in education than did the community/junior college instructors. However, no significant difference was shown between either Group 1 and Group 2, nor Group 1 and Group 3. It should be noted that although there was a significant difference in their attitudes, all three groups agreed to some extent that there was a serious problem of grade inflation in education.

TABLE III

SUMMARY FOR ITEMS 9-16 OF RECOMMENDATIONS QUESTIONNAIRE

Item	ANOVA F	Group 1 and Group 2	Group 1 and Group 3	Group 2 and Group 3
		S. F[a]	S. F	S. F
9	4.4184*	..	..	4.2125*
10	NS	..	..	..
11	NS	..	..	..
12	NS	..	..	..
13	NS	..	..	..
14	10.1788**	9.4412**	3.4285*	..
15	NS	..	..	..
16	7.8517**	..	7.6808**	..

aScheffé's F Test, $*p < 0.05$, $p < 0.01$.

Items 10, 11, 12, 13 and 15 yielded no indication of a significant difference between any of the three groups. All three groups essentially agreed that with some reservations, their students' grades were based on achievement in Item 10. All three groups also agreed with reservation that their administrations would support the practice of grading with respect to achievement in Item 11. The groups were in strong agreement with the statements in Items 12 and 13 that the advancement of students without appropriate achievement had a detrimental effect not only on the individual, but also upon the entire class.

Regarding Item 14, there was a significant difference shown between the attitudes of the high school mathematics instructors and the community/junior college mathematics instructors, as well as between the attitudes of the high school mathematics instructors and the senior college/ university mathematics instructors. Both the community/ junior college mathematics instructors and the senior college/ university mathematics instructors seemed to feel that their institutions provided more assistance to students with deficiencies than did the instructors from the high school mathematics programs. There was no significant difference demonstrated between the attitudes of the community/junior college mathematics instructors and the senior college/ university mathematics instructors with respect to their institutions' provisions for assistance of students when deficiencies were first noted.

Although the groups were also in agreement that evaluation given was cumulative in nature, there was some reservations with respect to this statement of Item 15.

Considering Item 16, there was a significant difference between the attitudes of the high school mathematics instructors and the attitudes of the senior college/university mathematics instructors with respect to giving comprehensive final examinations. From reading the remarks made by the high school mathematics instructors, it seemed that this difference is more attributable to school policy than anything else. It seems that many high schools exempt seniors, especially, from a comprehensive final examination. However, all three groups agreed to some extent that they did give comprehensive final examinations.

Findings Concerning Items 17-24 in "A Survey of Certain Practices and Attitudes of Pre-Calculus Mathematics Instructors"

In reviewing the statistical findings with respect to Item 17, there was a significant difference between the attitudes of the high school mathematics instructors and community/junior college mathematics instructors, as well as between the attitudes of the high school mathematics instructors and the senior college/university mathematics instructors. Again, as in Item 16, the differences shown may well be because of school policy, since many high school mathematics instructors indicated that their schools exempted senior students from taking final examinations the spring semester of the year. The community/junior college mathematics instructors and the senior college/university mathematics instructors were in agreement with not many reservations regarding the exemption of students from any test.

TABLE IV

SUMMARY OF ITEMS 17-24 OF RECOMMENDATIONS QUESTIONNAIRE

Item	ANOVA F	Group 1 and Group 2	Group 1 and Group 3	Group 2 and Group 3
		S. F[a]	S. F	S. F
17	15.7303**	10.6465**	10.4269**	..
18	NS	..	..	..
19	3.4496*	3.4364*	..	..
20	NS	..	..	..
21	NS	..	..	..
22	NS	..	..	..
23	NS	..	..	..
24	14.2320**	12.0308**	6.6241*	..

[a]Scheffé's F Test, *$p < 0.05$, **$p < 0.01$.

With respect to Item 18, there was no significant difference shown between any two of the three groups in the study. All three groups indicated that with reservations, they were in agreement that the absence of cumulative evaluations promoted short-term learning.

A significant difference is indicated regarding Item 19 in a table. Although no significant difference existed between the high school and senior college/university mathematics instructors, nor the community/junior college and senior college/university mathematics instructors, a significant difference is noted between the instructors of high school mathematics and community/junior college mathematics. It seemed that the community/junior college mathematics instructors are more willing to allow students to use calculators and/or computers than are the high school mathematics instructors when teaching classes where arithmetic skill is assumed. Here too, it should be noted that each group agreed to this statement to some extent.

Considering Items 20, 21, 22, and 23, no significant difference is found in the table for any of the pairs of groups. All three groups agreed with some reservations that calculators and/or computers, used in imaginative ways, can both reinforce learning and motivate students (Items 20 and 21). All three groups also agreed with reservations that class time should be taken in basic courses to stress the importance of developing computational skills and the advantages such skills provide when using the calculator (Item 22). The three groups of mathematics instructors strongly agreed with few reservations that calculators and computers should be used to supplement rather than to supplant the study of necessary computational skills (Item 23).

With respect to Item 24, there was a significant difference between the practices of the high school mathematics instructors as compared to the community/junior college mathematics instructors, and also a significant difference between the practices of the high school mathematics instructor as compared to the senior college/university mathematics instructor. Both the community/junior college group and the senior college/university group agreed with some reservations that they provided placement examinations of some sort for helping students select appropriate courses, whereas the high school mathematics instructors seemed to slightly disagree with the provision of such examinations by their institutions. No signficant difference was revealed with respect to the community/junior college and the senior college/university groups' provisions of such tests.

Findings Concerning Items 25-32 in "A Survey of Certain Practices and Attitudes of Pre-Calculus Mathematics Instructors

With respect to Items 25 and 26, as shown in the table, no significant difference was shown between any of the groups. All three groups were essentially neutral with respect to having taken part in a joint meeting between college and secondary mathematics instructors. They held a similar view in consideration of a joint effort in coordinating secondary/ developmental college preparatory courses with the curricula of the colleges served by their institutions.

In considering Item 27, a significant difference was shown between the high school and senior college/university mathematics instructors and also between the community/ junior college and senior college/university mathematics instructors. The senior college/university mathematics instructors appeared to believe that their institutions lent more assistance in providing in-service programs for secondary school faculties than was perceived to be true by either the community/junior college mathematics instructors or the high school mathematics instructors. There was no significant difference between the mathematics instructors at the high schools and at the community/junior colleges.

TABLE V

SUMMARY OF ITEMS 25-32 OF RECOMMENDATIONS QUESTIONNAIRE

Item	ANOVA F	Group 1 and Group 2	Group 1 and Group 3	Group 2 and Group 3
		S. F[a]	S. F	S. F
25	NS	..	..	..
26	NS	..	..	..
27	8.2496**	..	3.4476*	8.2428**
28	NS	..	..	..
29	NS	..	..	..
30	3.8256*	..	3.6362	..
31	NS	..	..	..
32	NS	..	..	..

[a]Scheffé's F Test, *$p < 0.05$, **$p < 0.01$.

Concerning Item 28 and Item 29, no significant difference was shown between any of the three groups. All three groups tended to be either neutral or slightly in disagreement with the statement that in their locality, there seemed to a free interchange of information between area secondary and college faculties. However, in Item 29, all three groups were in agreement with reservations that the mathematics curriculum in their institution needed to be reviewed or had been reviewed recently.

In consideration of Item 30, it can be seen from the table that a significant difference existed between the high school mathematics instructors and the mathematics instructors of senior colleges/universities. The high school mathematics instructors seemed to have fewer reservations than did the senior college/university mathematics instructors that the college preparatory mathematics curriculum at their school level met the needs of students preparing for college mathematics. There was no significant difference between the high school-community/junior college mathematics instructors, nor between the community/junior college-senior college/university mathematics instructors.

With respect to Items 31 and 32, no significant difference was shown between any of the groups on either item. All three groups seemed to be fairly neutral with respect to the omission or de-emphasizing of certain topics in order to provide sufficient time for more important topics. However, all three groups were strongly in agreement with the statement that they made efforts to incorporate algebraic concepts and skills in courses whenever possible to provide reinforcement and retention of such skills.

Findings Concerning the Correlations of the Two Sets of Attitudes

Since no significant difference had been hypothesized, a two-tailed test was used for studying the significance of the correlation coefficient. From the table, it can be seen that for Group 1, there was not a significant correlation between the attitudes of the high school mathematics instructors toward the teaching of the college preparatory mathematics courses and toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations.

However, it can be seen in Table VI that there was a significant correlation between the attitudes toward teaching college preparatory mathematics courses and toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations of both the community/junior college mathematics instructors and the senior college/university mathematics instructors.

The correlation coefficient for the entire sample of 143 mathematics instructors was also computed and it was found to be not significant. It should be noted that the correlations shown are negative since the scales of the attitudinal instruments run in different directions, i.e., the questionnaire has 1 as high and 4 as low, whereas the vocational attitude scale has 1.0 as low and 10.3 as high.

TABLE VI

SUMMARY FOR CORRELATIONS BETWEEN THE TWO ATTITUDINAL SCALES

"A Survey of Certain Practices and Attitudes of Pre-Calculus Mathematics Instructors	Purdue Scale For Measuring Attitudes Toward Any Vocation			
	Group[a] 1	Group[b] 2	Group[c] 3	Groups[d] 1,2,&3
	-0.0338	-0.3058*	-0.3646*	-0.1462

[a]N=73, [b]N=43, [c]N=33, [d]N-149, *$p < 0.05$.

Summary of Findings for the Acceptance or Rejection of Hypotheses

The hypotheses of this study indicated that there were no significant differences between either the attitudes toward teaching college preparatory mathematics courses, or toward the recommendations, of the high school, community/junior college, and the senior college/university mathematics instructors. Also it was hypothesized that there would be no significant correlation between the two attitudes in any one of the three groups of mathematics instructors. The hypotheses with respect to the attitudes toward teaching college preparatory mathematics courses were accepted or rejected on the basis of the F-ratios at the 0.05 level. The hypotheses regarding the attitudes toward the recommendations were accepted or rejected on the basis of the number of items with significant Scheffé F-ratios that are significant at the 0.05 level. A majority of the items must have significant Scheffé F-ratios for the rejection of the hypothesis. The hypotheses regarding the correlations between the two attitudinal scales were accepted or rejected on the basis of critical values for the correlation coefficient. The level of significance for these correlations was also set at the 0.05 level, and used the two-tailed test, since the direction of correlation had not been hypothesized.

In reference to Table I, it is evident that there were no significant differences discovered in any of the three possible groupings, with respect to the attitudes toward teaching college preparatory mathematics courses. However, the score of approximately 8.1 for all three groups indicated that the three groups of mathematics instructors held favorable attitudes toward the teaching of those mathematics courses.

A summary of the questionnaire items for each of the three possible groupings of the three groups of mathematics instructors which had significant Scheffé F-ratios, non-significant Scheffé F-ratios, and the percentages of the total in each category is presented in Table VII. In order for a grouping to indicate a rejection of the hypothesis, more than 50 percent of the items had to have significant Scheffé F-ratios.

In consideration of Table VII, it is evident that there were no significant differences found in any of the

TABLE VII

SUMMARY OF THE NUMBER AND PERCENTAGE OF ITEMS WITH SIGNIFICANT AND NON-SIGNIFICANT SCHEFFÉ F-RATIOS

Groupings	Group 1 and Group 2	Group 1 and Group 3	Group 2 and Group 3
Number of Items With Significant Scheffé F-Ratios	6	9	2
Number of Items With Non-Significant Scheffé F-Ratios	26	23	30
Total Number Of Items	32	32	32
Percentage of Items With Significant Scheffé F-Ratios	19	28	6
Percentage of Items With Non-Significant Scheffé F-Ratios	81	72	94
Total Percentage	100	100	100

groupings. However, it should be noted that while the community/junior college and senior college/university mathematics instructors exhibited the fewest number of differences--2 or 32 or 6 percent of the total possible--the grouping composed of high school mathematics instructors and senior college/university mathematics instructors demonstrated the most differences--9 or 32 or 28 percent of the total possible.

With respect to the correlations between the two sets of attitudes for the three groups of mathematics instructors, in reference to Table VI, it is evident that while no significant correlation was shown for the group of high school mathematics instructors, the groups of community/junior college and senior college/university mathematics instructors demonstrated significant correlations with respect to the two sets of attitudes. Again, it should be pointed out that although the correlations shown are negative, because of the scales of the two attitudinal instruments being rated in different directions, the correlations suggest that the more favorable a mathematics instructor in the two groups views the teaching of college preparatory mathematics courses, the more likely will be the possibility that that instructor will view the recommendations in a favorable light, also, and vice versa.

Therefore, of the nine hypotheses originally made, the first seven hypotheses were retained, and the last two hypotheses were rejected. Thus, it was found that there are no significant differences between the attitudes of high school, community/junior college, and senior college/university mathematics instructors with respect to the teaching of college preparatory mathematics courses. Also, there are no significant differences between the attitudes of high school, community/junior college, and senior college/ university mathematics instructors toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations. However, although there is no significant correlation between the attitudes of the high school mathematics instructors with respect to the recommendations and the teaching of college preparatory mathematics courses, there is a significant correlation between the attitudes of both the community/junior college mathematics instructors and the senior college/university mathematics instructors toward the teaching of college preparatory mathematics courses and the Mathematical Association of America-National Council of Teachers of Mathematics recommendations.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine how well the three groups of mathematics instructors--high school, community/junior college, and senior college/university--agreed with respect to the recommendations issued jointly by the Mathematical Association of America and the National Council of Teachers of Mathematics in December, 1977. Additionally, the study attempted to determine if a difference existed in how the three groups viewed teaching college preparatory mathematics courses. A final aspect of this study dealt with the correlation of attitudes toward teaching the college preparatory mathematics courses and toward the recommendations held by the three groups of mathematics instructors.

The instruments used in the study consisted of a specially-constructed questionnaire for measuring attitudes toward the recommendations and an attitudinal scale entitled, the Purdue Scale For Measuring Attitudes Toward Any Vocation. The questionnaire concerning the recommendations was constructed after making a sentence-by-sentence analysis of the recommendations. The statements of the questionnaire reflected the recommendations in a positive manner. The two instruments were completed by a random sample of seventy-three Texas 4-A high school mathematics instructors, forty-three Texas community/junior college mathematics instructors, and thirty-three Texas senior college/university mathematics instructors. The same instruments were used for all three groups, and additional communications were made to insure a response of at least sixty percent.

An analysis of variance was computed on the data to determine any differences among the three simple pair-wise comparisons of the three groups, and regarding the attitudes toward teaching of college preparatory mathematics courses and toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations. Scheffé's F Test was used to determine significant differences when a significant ANOVA F-ratio was discovered. The level of significance was 0.05. The Pearson correlation coefficient was computed for all three groups using the scale values for the attitudes toward teaching college preparatory mathematics courses and the mean of the Likert scale values on the questionnaire concerning the recommendations as the two sets of scores. Significance was set again at the 0.05 level.

With respect to the nine null hypotheses made for this study, the first seven hypotheses were retained and the last two hypotheses were rejected. A hypothesis concerning the questionnaire was rejected if a majority of items on the questionnaire yielded a significant difference for the two groups considered in that particular hypothesis.

In reviewing the significant differences shown concerning the questionnaire items, the two groups of high school and senior college/university mathematics instructors indicated a significant difference on nine of the thirty-two items. The high school and community/junior college goups followed with a significant difference indicated for six items, and the community/junior college and senior college/university groups demonstrated just two items with a significant difference in attitude.

Conclusions

A study of the data leads to the following conclusions.

1. Senior college/university mathematics instructors placed more emphasis on regular assignments to be completed outside of class than did the high school mathematics instructors.

2. High school instructors of mathematics placed more emphasis on the instruction of the formation of good study habits and positive homework attitudes than did either the community/junior college mathematics instructors, or the senior college/university mathematics instructors.

3. Senior college/university mathematics instructors felt more strongly than did the community/junior college mathematics instructors that there was a serious problem with grade inflation in education.

4. The high school mathematics instructors were in less agreement than the other two groups that their

institutions provided assistance to students with deficiencies in their mathematics courses.

5. High school mathematics instructors were also in less agreement than were the senior college/university mathematics instructors that comprehensive final examinations were given and students not exempted from any tests in their schools.

6. Community/junior college mathematics instructors were more willing to allow their students to use calculators and/or computers than were the high school mathematics instructors when teaching classes where arithmetic skill was assumed.

7. Both the community/junior colleges and the senior colleges/universities made better provisions for the taking of placement examinations in mathematics than did the high schools.

8. The senior college/university mathematics instructors believed that their institutions lent a greater amount of assistance in providing in-service programs for secondary school faculties than the amount of such assistance perceived by either the high school or the community/junior college mathematics instructors.

9. The high school mathematics instructors were more convinced that the college preparatory mathematics courses offered by their schools met the needs of their students than were the senior college/university mathematics instructors with respect to college preparatory mathematics courses taught in the senior colleges/universities.

10. In general, except for the differences noted above, the three groups of instructors were in essential agreement on every item. The extent of agreement varied from one of neutrality to a high degree of strong agreement.

11. There was a significant correlation between the attitudes toward teaching college preparatory mathematics courses and toward the Mathematical Association of America-National Council of Teachers of Mathematics recommendations held by the group consisting of community/junior college mathematics instructors and, also, the group consisting of senior college/university mathematics instructors.

12. All three groups of mathematics instructors had the same favorable attitude toward the teaching of college preparatory mathematics courses.

Recommendations

The data collected implied that although there are significant differences between the three groups of mathematics instructors concerning certain aspects of the Mathematical Association of America-National Council of Teachers of Mathematics recommendations overall, there did not exist a significant difference in the attitudes of the three groups. There was also an indication that no significant difference existed between the three groups with respect to their attitudes toward teaching college preparatory mathematics courses.

The data also indicated, though, that there was a significant correlation of a positive nature between the attitudes concerning the recommendations and the attitudes toward teaching college preparatory mathematics courses in the group of community/junior college mathematics instructors and the group of senior college/university mathematics instructors.

Therefore, after due consideration of the data and findings, the following recommendations are made.

1. More aid in the grading of homework assignments should be provided the high school mathematics instructors, in order they might be able to provide their students with regular homework assignments that would prove meaningful to the students. This aid could be in the form of reduced loads, additional paper graders, or special machine-graded materials, among others.

2. College instructors at all levels should become more aware of problems and positive homework attitudes. The apparent maturity of the college student is so often offset by the necessities of work schedules, family obligations, and other conflicts that preclude the formation of good study habits. It is for this reason that in many colleges, centers for the study of learning skills are being instituted with great success. This is not to assume that there cannot be improvement at the high school level, however. The provision of learning skill techniques is of utmost importance at all levels of education.

3. The community/junior college mathematics instructors must take care not to allow the grades of their students to "inflate" in a mis-directed effort at aiding the students, academically. This is a special problem at an "open door" institution where an entire class may possess severe deficiencies in a particular mathematics topic. Many such institutions are now emphasizing competencies to guard against such inflating of grades.

4. The senior college/university mathematics instructors should review the contents of the college preparatory mathematics courses taught in their colleges to determine if any sections could be shortened or eliminated to allow the students more time in mastering the material that is covered in the course, thereby better meeting the needs of the student. Also, better communications should be encouraged between the college level mathematics faculty and the faculty of developmental or remedial mathematics, if two separate faculties exist.

5. High schools should be especially aware of problems in their provision of assistance to students when deficiencies in their mathematics preparation is first noted. Possible sources of assistance might come from students in more-advanced mathematics classes, volunteers from the local population, or students from nearby post-secondary institutions.

6. For the college-bound high school student, provisions should be made to provide for adequate comprehensive

examinations in order to provide a record of achievement to insure the correct placement of the student in the college attended. The privilege of an exempted examination is probably viewed with less favor by the student when the first college mathematics course is failed or dropped because of inadequate preparation or placement.

7. The advantages of the calculator and computer should be pointed out to all three groups of instructors, with possible added emphasis to the high school instructors of mathematics. The utilization of the calculator or the computer in more topics using interesting procedures, and the dissemination of research noting differences between computational skills and the concept development would aid in wider-spread use of the hand-held calculator and the computer in the teaching of mathematics at all levels.

8. Better placement and counseling procedures should be implemented in high schools to enable students to enroll in subjects which would be suitable for the student's level. However, it must be mentioned that there are still problems in placement at the colleges, also. The college faculties, at all levels, need to be ever vigilant for sudden student trends that render an in-house placement examination obsolete, or changes in curriculum that cause a standardized examination to be inappropriate for placement purposes.

9. The attendance of and participation in the various professional organization meetings is highly recommended.

At these meetings, views can be shared, defended, or changed, and, through these activities, the mathematical community will experience more open communications, thus benefitting greatly from this occurrence.

Communications is of great importance in providing instructors of mathematics in the different types of institutions with information that is of mutual or individual interest. The instructors of college preparatory mathematics in the different institutions can be of great assistance to one another if an atmosphere of mutual respect and trust is created in the mathematical community. Without this trust and respect, any effort toward improving the teaching or curriculum of college preparatory mathematics courses will be severely hampered.

There are several vehicles that would prove beneficial with respect to the implementation of these recommendations. Professional journals are helpful in communicating with a wide variety of mathematics instructors. Since textbook authors are usually interested in a new approach to an old topic, the encouragement by the mathematics instructors to increase the utilization of the hand-held calculators and computers in their published materials would be helpful in attaining a more general acceptance of such devices in the college preparatory mathematics classroom.

Area community/junior colleges and senior colleges/ universities are always anxious to gain visibility in the communities served, and the provision of pertinent in-service programs to secondary school faculties would be a very positive step toward establishing effective lines of communications. In addition, sponsorship of a sharing day for mathematics instructors in the area would be most welcome, if handled properly, and would not only provide another means of communication between the different faculties, but would also tend to put mathematics instructors from the different levels of education on an equal footing, and hopefully increase the mutual respect and trust of the participants for their counterparts in the other institutions.

Recommendations for Further Research

There are several areas considered in this study which admit to further research. One aspect might be to study why there was no correlation apparent for the high school mathematics instructors between their two sets of attitudes, while a significant correlation was found for the two sets of attitudes of the community/junior college instructors, as well as the senior college/university instructors. Is the attitudinal scale used for vocational satisfaction sensitive enough for this type of profession to actually indicate a significant difference, if a difference exists? There may exist scales that are better suited for the purposes of educational research.

What factors exist in high schools that possible make increased use of the hand-held calculator or the computer impractical? Are comprehensive final examinations and non-exemption of students important factors in increasing the learning of college preparatory mathematics? What types of placement examinations are most effective, and are there other factors that contribute to the success of a student in a particular mathematics course, and can these factors be determined?

How can the curriculum for college preparatory mathematics be changed to better suit the present-day student? What topics are of most importance, and how can these topics be arranged so as to complement related concepts in other areas of mathematics? Finally, what is the effect of college preparatory mathematics on the typical student? How do these courses change personal, educational, and career field plans for the students in the courses? What are the responsibilities of the mathematics instructors at the various levels to these students?

As can be seen, many questions can be raised and many recommendations made for further research in the fields of the teaching and curriculum of college preparatory mathematics. As previously noted, much time and effort has gone into past recommendations and related research of the field. Undoubtedly, very much more effort will go into the future research of the field. The common tie for all of the past recommendations may someday be found in the associated field of learning theory. Whatever the ultimate methods are with respect to the learning and the teaching of college preparatory mathematics courses, the opinions of the mathematics instructors, educational specialists, and scientists from the related fields will continue to contribute greatly to the improvement of the entire field of college preparatory mathematics.

APPENDIX A

SAMPLE LETTER TO HIGH SCHOOL PRINCIPALS

As you are well aware, much debate has taken place recently regarding the apparent decline of skills of mathematics students.

As part of a doctoral study at North Texas State University the attitudes of mathematics instructors toward a list of teaching recommendations recently issued by the Mathematical Association of America and the National Council of Teachers of Mathematics and their attitudes toward teaching pre-calculus mathematics courses are being researched. Your school was selected in a random sample of Texas 4-A high schools.

I would appreciate it very much if you would forward the enclosed materials to two of your mathematics instructors so that they might respond to the instruments.

The time required to complete the questionnaire will not exceed twenty minutes, and responses will be handled in confidence. A post card is attached for you to send me the instructor's names so that any needed follow-up correspondence can be directed to them.

If possible, it would be appreciated if the completed instruments were returned to me prior to April 1. I will be happy to send you a summary of the results of the study if you so desire. Thank you for your time and valuable assistance on this project.

Sincerely,

Howard Love Penn
Instructor of Mathematics

Dr. C. A. Hardy
Professor of Education
Chairman, Doctoral Committee

APPENDIX B

SAMPLE LETTER TO MATHEMATICS INSTRUCTORS

The apparent decline in recent years of mathematical skills of students has been of great concern to all of us in the teaching profession.

Recently, in a joint effort of the Mathematical Association of America and the National Council of Teachers of Mathematics, a document was issued containing ten recommendations pertaining to the improvement of the teaching of pre-calculus mathematics courses, or what the documents refer to as "college preparatory mathematics courses." A study of the attitudes of mathematics instructors toward teaching pre-calculus courses and toward the recommendations is being undertaken as part of a doctoral study in progress at North Texas State University.

You have been chosen in a random sample of Texas mathematical instructors who teach pre-calculus courses. I would appreciate your help in the study of attitudes toward certain teaching practices and toward teaching the pre-calculus courses. Responses on both instruments will be handled confidentially.

The time required to answer both instruments should be no more than twenty minutes. Feel free to write any comments that you wish to make on the backs of the instruments.

If possible, please return the completed instruments prior to April 1. I will be happy to send you a summary of the results of the study if you so desire. Thank you for your time and cooperation.

Sincerely,

Howard Love Penn
Instructor of Mathematics

APPENDIX C

A SURVEY OF CERTAIN PRACTICES AND ATTITUDES OF PRE-CALCULUS MATHEMATICS INSTRUCTORS

<u>Instructions</u>:

The following statements reflect various aspects of the attached recommendations. Please indicate your attitude toward each statement by circling the following:

1--Strongly Agree
2--Agree with Reservations
3--Disagree with Reservations
4--Strongly Disagree

1.	Proficiency in mathematics cannot be acquired without individual practice.(1)	1	2	3	4
2.	Regular assignments are made to be completed outside class.(1)	1	2	3	4
3.	Class time is used for instructing students in forming good study habits.(1)	1	2	3	4
4.	Class time is used in helping students improve their reading of mathematics.(1)	1	2	3	4
5.	It is part of my job to encourage positive homework attitudes in my students.(2)	1	2	3	4
6.	I am able to provide meaningful real world examples of most, if not all, concepts and procedures studied in my course.(2)	1	2	3	4
7.	I provide problems that reinforce manipulative skills.(3)	1	2	3	4
8.	I feel that I have to struggle to maintain standards in my courses.(3)	1	2	3	4
9.	There is a serious problem of grade inflation in education.(3)	1	2	3	4

10. My students' grade are based on achievement.(3) 1 2 3 4

11. My administration would support the practice of grading with respect to achievement.(3) 1 2 3 4

12. The advancement of students without appropriate achievement has a detrimental effect on the individual student.(4) 1 2 3 4

13. The advancement of students without appropriate achievement has a detrimental effect on the entire class.(4) 1 2 3 4

14. My school has made special provisions to assist students when deficiencies are first noted.(4) 1 2 3 4

15. Evaluation given is cumulative in nature.(5) 1 2 3 4

16. A comprehensive final examination is given.(5) 1 2 3 4

17. Students are not exempted from any tests.(5) 1 2 3 4

18. The absence of cumulative evaluations promotes short term learning.(5) 1 2 3 4

19. In courses where arithmetic skill is assumed, students are allowed to use calculators and/or computers.(6) 1 2 3 4

20. As proficiency in mathematics is gained, calculators and/or computers, used in imaginative ways, reinforce learning.(6) 1 2 3 4

21. As proficiency in mathematics is gained, calculators and/or computers, used in imaginative ways, motivate students.(6) 1 2 3 4

22. In basic courses, class time should be taken to stress the importance of developing computational skills and the advantages such skills provide when using the calculator.(6) 1 2 3 4

23. Calculators and computers should be used to supplement rather than to supplant the study of necessary computational skills.(6) 1 2 3 4

24. An in-house or standarized placement exam is used for helping students select appropriate courses. Circle which type exam.(7) 1 2 3 4

25. I have taken part in a joint meeting between college and secondary mathematics instructors.(8) 1 2 3 4

26. There has been a joint effort in coordinating secondary/developmental college preparatory courses with the curricula of the colleges served by my institution.(8) 1 2 3 4

27. In my locality, colleges lend assistance in providing in-service programs for secondary school faculties.(8) 1 2 3 4

28. There seems to be a free interchange of information between area secondary and college faculties.(8) 1 2 3 4

29. The mathematics curriculum in my institution needs to be reviewed or has been reviewed recently.(9) 1 2 3 4

30. The college preparatory mathematics curriculum, i.e., the pre-calculus curriculum, at my institution seems to meet the needs of students preparing for college mathematics.(9) 1 2 3 4

31. Certain topics being taught in the curriculum of my institution could be omitted or de-emphasized to provide sufficient time for more important topics.(9) 1 2 3 4

32. I make an effort to incorporate algebraic concepts and skills in courses whenever possible, to provide reinforcement and retention of such skills.(10) 1 2 3 4

APPENDIX D

A SCALE FOR MEASURING ATTITUDES

TOWARD ANY VOCATION

Form A   Edited by H. H. Remmers

Directions: Following is a list of statements about the vocation of teaching college preparatory mathematics. Place a plus sign (+) before each statement with which you agree about the vocation.

___ 1. I love to do this work.

___ 2. I wouldn't mind working seven days a week on this job.

___ 3. This work gives me a great deal of pleasure.

___ 4. This occupation will mean a great deal to me when I am old.

___ 5. This job will bring benefits to everyone who does it.

___ 6. This job is undoubtedly worth having.

___ 7. This vocation is a good pastime.

___ 8. This is a pleasant vocation some of the time.

___ 9. I don't think this work would harm anyone.

___ 10. The advantages and disadvantages of this work about balance each other.

___ 11. This job is all right when no others are available.

___ 12. Many people do not like this work.

___ 13. The advantages of this work will never outweigh the disadvantages.

___ 14. I have no desire to do this kind of work.

___ 15. I would be better off without this job.

___ 16. Only a very stupid person could be satisfied with this work.

___ 17. I have a feeling of hatred for this vocation.

APPENDIX E

ANALYSIS OF VARIANCE
SURVEY DATA

Analysis of Variance

Item No. 1

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Between	0.0706	2.	0.0353	0.9060
Within	5.6878	146.	0.0390	
Total	5.7584	148.		

Item No. 2

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Between	2.5366	2.	1.2683	6.1203
Within	30.2553	146.	0.2072	
Total	32.7919	148.		

Item No. 3

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Between	7.4956	2.	3.7478	9.9025
Within	55.2561	146.	0.3785	
Total	62.7517	148.		

Item No. 4

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Between	2.0677	2.	1.0339	2.5500
Within	59.1940	146.	0.4054	
Total	61.2617	148.		

Item No. 5

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Between	2.7635	2.	1.3817	6.1042
Within	33.0486	146.	0.2264	
Total	35.8121	148.		

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Item No. 6				
Between	0.0944	2.	0.0472	0.1279
Within	53.8788	146.	0.3690	
Total	53.9732	148.		
Item No. 7				
Between	0.1243	2.	0.0621	0.2632
Within	34.4664	146.	0.2361	
Total	34.5906	148.		
Item No. 8				
Between	2.1059	2.	1.530	1.2966
Within	118.5652	146.	0.8121	
Total	120.6711	148.		
Item No. 9				
Between	3.8479	2.	1.9240	4.4184
Within	63.5749	146.	0.4354	
Total	67.4228	148.		
Item No. 10				
Between	0.4315	2.	0.2158	0.6645
Within	47.4074	146.	0.3247	
Total	47.8389	148.		
Item No. 11				
Between	0.2538	2.	0.1269	0.2465
Within	75.1556	146.	0.5148	
Total	75.4094	148.		
Item No. 12				
Between	0.0273	2.	0.0137	0.0574
Within	34.7512	146.	0.2380	
Total	34.7785	148.		

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Item No. 13				
Between	0.4162	2.	0.2081	0.5932
Within	51.2214	146.	0.3508	
Total	51.6376	148.		
Item No. 14				
Between	15.1365	2.	7.56832	10.1788
Within	108.5548	146.	0.7435	
Total	123.6913	148.		
Item No. 15				
Between	1.5396	2.	0.7698	1.7090
Within	65.7624	146.	0.4504	
Total	67.3020	148.		
Item No. 16				
Between	13.8200	2.	6.9100	7.8517
Within	128.4888	146.	0.8801	
Total	142.3087	148.		
Item No. 17				
Between	31.7442	2.	15.8721	15.7303
Within	147.3162	146.	1.0090	
Total	179.0604	148.		
Item No. 18				
Between	0.5875	2.	0.2937	0.4544
Within	94.3656	146.	0.6463	
Total	94.9530	148.		
Item No. 19				
Between	4.0967	2.	2.0484	3.4496
Within	86.6952	146.	0.5958	
Total	90.7919	148.		

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Item No. 20				
Between	2.0602	2.	1.0301	2.5427
Within	59.1478	146.	0.4051	
Total	61.2081	148.		
Item No. 21				
Between	1.1513	2.	0.5756	1.4499
Within	57.9628	146.	0.3970	
Total	59.1141	148.		
Item No. 22				
Between	1.0465	2.	0.5232	0.9356
Within	81.6515	146.	0.5593	
Total	82.6980	148.		
Item No. 23				
Between	0.1402	2.	0.0701	0.2401
Within	42.6383	146.	0.2920	
Total	42.7785	148.		
Item No. 24				
Between	26.7787	2.	13.3894	14.2320
Within	137.3555	146.	0.9408	
Total	164.1342	148.		
Item No. 25				
Between	8.5614	2.	4.2807	2.6340
Within	237.2775	146.	1.6252	
Total	245.8389	148.		
Item No. 26				
Between	5.9226	2.	2.9613	2.7488
Within	157.2854	146.	1.0773	
Total	163.2081	148.		

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Item No. 27				
Between	14.2925	2.	7.1462	8.2496
Within	126.4726	146.	0.8663	
Total	140.7651	148.		
Item No. 28				
Between	3.3830	2.	1.6915	2.2528
Within	109.6238	146.	0.7508	
Total	113.0067	148.		
Item No. 29				
Between	0.8581	2.	0.4291	0.9167
Within	68.3365	146.	0.4681	
Total	69.1946	148.		
Item No. 30				
Between	2.5713	2.	1.2857	3.8256
Within	49.0663	146.	0.3361	
Total	51.6376	148.		
Item No. 31				
Between	3.1104	2.	1.5552	1.9017
Within	119.3997	146.	0.8178	
Total	122.5101	148.		
Item No. 32				
Between	0.9285	2.	0.4643	2.0613
Within	32.8836	146.	0.2252	
Total	33.8121	148.		

PAIRS OF GROUPS

	Group 1		Group 2		
	High School Mathematics Instructors		Community/Junior College Mathematics Instructors		
	OBS = 73		OBS = 43		
Item Number	Mean	Standard Deviation	Mean	Standard Deviation	Scheffé's F-Test
1	1.05479	0.22915	1.04651	0.21308	0.0238
2	1.38356	0.48962	1.20930	0.46589	1.9827
3	1.63014	0.61253	2.00000	0.57735	4.8905
4	1.61644	0.59232	1.88370	0.73060	2.3841
5	1.10959	0.31454	1.37209	0.57831	4.1188
6	2.00000	0.57735	2.00000	0.65465	0.0000
7	1.26027	0.47221	1.32558	0.52194	0.2444
8	1.95890	0.87303	2.09302	0.97135	0.2997
9	1.57534	0.64373	1.83721	0.75373	2.1307
10	1.43836	0.57702	1.41860	0.62612	0.0163
11	1.73973	0.78222	1.65116	0.57253	0.2062
12	1.24658	0.54724	1.23256	0.42746	0.0112
13	1.43836	0.66638	1.39535	0.54070	0.0713
14	2.53425	0.81789	1.81395	0.85233	9.4412
15	1.83562	0.66695	1.76744	0.78185	0.1396
16	2.01370	1.11172	1.67442	0.86523	1.7697
17	2.35616	1.14710	1.46512	0.93475	10.6465
18	1.57534	0.72491	1.72093	0.93416	0.4437
19	1.87671	0.84894	1.48837	0.73589	3.4363
20	1.57534	0.72491	1.30233	0.51339	2.4894
21	1.53425	0.66838	1.41860	0.49917	0.4558
22	1.58904	0.79644	1.58140	0.66306	0.0014
23	1.26027	0.60156	1.23256	0.52722	0.0356
24	2.58904	0.95504	1.67442	1.04017	12.0308
25	2.42466	1.29011	2.67442	1.28584	0.5193
26	2.65753	1.09569	2.44186	1.14022	0.5842
27	2.45205	0.95802	2.81395	0.98212	2.0457
28	2.68493	0.89562	2.90698	0.83990	0.8885
29	1.58904	0.70387	1.55814	0.70042	0.0276
30	1.52055	0.60345	1.55814	0.58969	0.0569
31	2.31507	0.98428	2.65116	0.86969	1.8689
32	1.21918	0.44866	1.18605	0.45018	0.0659

	Group 1		Group 3		
	High School Mathematics Instructors		Senior College/University Mathematics INstructors		
	OBS = 73		OBS = 33		
Item Number	Mean	Standard Deviation	Mean	Standard Deviation	Scheffé's F-Test
1	1.05479	0.22915	1.00000	0.00000	0.8758
2	1.38356	0.48962	1.06061	0.34816	5.7192
3	1.63014	0.61253	2.15152	0.66714	8.1617
4	1.61644	0.59232	1.78788	0.59987	0.8238
5	1.10959	0.31454	1.39394	0.60927	4.0589
6	2.00000	0.57735	1.93939	0.60927	0.1131
7	1.26027	0.47221	1.30303	0.46669	0.0880
8	1.95890	0.87303	1.75758	0.86712	0.5672
9	1.57534	0.64373	1.39394	0.55562	0.8587
10	1.43836	0.57702	1.30303	0.46669	0.6409
11	1.73973	0.78222	1.66667	0.73598	0.1178
12	1.24658	0.54724	1.21212	0.41515	0.0567
13	1.43836	0.66638	1.30303	0.46669	0.5931
14	2.53435	0.81789	2.06061	0.96629	3.4285
15	1.83562	0.66695	1.57576	0.50189	1.7035
16	2.01370	1.11172	1.24242	0.50189	7.6808
17	2.35616	1.14710	1.39394	0.70442	10.4269
18	1.57534	0.72491	1.60606	0.78817	0.0166
19	1.87671	0.84894	1.75758	0.61392	0.2716
20	1.57534	0.72491	1.51515	0.56575	0.1016
21	1.53425	0.66838	1.66667	0.69222	0.5019
22	1.58904	0.79644	1.78788	0.73983	0.8033
23	1.26027	0.60156	1.18182	0.39167	0.2395
24	2.58904	0.95504	1.84848	0.90558	6.6241
25	2.42466	1.29011	2.00000	1.22474	1.2609
26	2.65753	1.09569	2.15152	0.71244	2.7008
27	2.45205	0.95802	1.93939	0.78817	3.4476
28	2.68493	0.89562	2.48485	0.83371	0.6059
29	1.58904	0.70387	1.75758	0.61392	0.6896
30	1.52055	0.60345	1.84848	0.50752	3.6362
31	2.31507	0.98428	2.39394	0.74747	0.0864
32	1.21918	0.44866	1.30394	0.55562	1.5409

	Group 2		Group 3		
	Community/Junior College Mathematics Instructors		Senior College/University Mathematics Instructors		
	OBS = 43		OBS = 33		
Item Number	Mean	Standard Deviation	Mean	Stanrdard Deviation	Scheffé's F-Test
1	1.04651	0.21308	1.00000	0.00000	0.5184
2	1.20930	0.46589	1.06061	0.34816	0.9961
3	2.00000	0.57735	2.15152	0.66714	0.5663
4	1.88372	0.73060	1.78788	0.59987	0.2115
5	1.37209	0.57831	1.39394	0.60927	0.0197
6	2.00000	0.65465	1.93939	0.60927	0.0929
7	1.32558	0.52194	1.30303	0.46669	0.0201
8	2.09302	0.97135	1.75758	0.86712	1.2936
9	1.83721	0.75373	1.39394	0.55562	4.2125
10	1.41860	0.62612	1.30303	0.46669	0.3840
11	1.65116	0.57253	1.66667	0.73598	0.0044
12	1.23256	0.42746	1.21212	0.41515	0.0164
13	1.39535	0.54070	1.30303	0.46669	0.2268
14	1.81395	0.85233	2.06061	0.96629	0.7639
15	1.76744	0.78185	1.57576	0.50189	0.7615
16	1.67442	0.86523	1.24242	0.50189	1.9796
17	1.46512	0.93475	1.39394	0.70442	0.0469
18	1.72093	0.93416	1.60606	0.78817	0.1906
19	1.48837	0.73589	1.75758	0.61392	1.1394
20	1.30233	0.51339	1.51515	0.56575	1.0438
21	1.41800	0.49917	1.66667	0.69222	1.4470
22	1.58140	0.66306	1.78788	0.73983	0.7117
23	1.23256	0.52722	1.18182	0.39167	0.0823
24	1.67442	1.04017	1.84848	0.90558	0.3007
25	2.67442	1.28584	2.00000	1.22474	2.6127
26	2.44186	1.14022	2.15152	0.71244	0.7305
27	2.81395	0.98212	1.93939	0.78817	8.2428
28	2.90698	0.83990	2.48485	0.83371	2.2155
29	1.55814	0.70042	1.75758	0.61392	0.7933
30	1.55814	0.58969	1.84848	0.50752	2.3417
31	2.65116	0.86969	2.39394	0.74747	0.7553
32	1.18605	0.45018	1.39394	0.55562	1.7914

APPENDIX F

ANALYSIS OF VARIANCE
VOCATIONAL ATTITUDE DATA

Analysis of Variance

Source	Sum Squares	Degrees of Freedom	Variance Estimate	F Ratio
Between	0.1310	2.	0.0655	0.0705
Within	135.6986	146	0.9294	
Total	135.8296	148		

Group 1			Group 2	
High School Mathematics Instructors			Community/Junior College Mathematics Instructors	
OBS = 73			OBS = 43	
Mean	Standard Deviation	Scheffé's F-Test	Mean	Standard Deviation
8.1658	0.9033	0.0022	8.1535	0.8998

Group 1			Group 3	
High School Mathematics Instructors			Senior College/University Mathematics Instructors	
OBS = 73			OBS = 33	
Mean	Standard Deviation	Scheffé's F-Test	Mean	Standard Deviation
8.1658	0.9033	0.0685	8.0909	1.1585

Group 2			Group 3	
Community/Junior College Mathematics Instructors			Senior College/University Mathematics Instructors	
OBS = 43			OBS = 33	
Mean	Standard Deviation	Scheffé's F-Test	Mean	Standard Deviation
8.1535	0.8998	0.0393	8.0909	1.1585

CORRELATIONAL DATA

Group	Questionnaire Mean	Purdue Scale Mean	Correlational Coefficient
1	1.7849	8.1658	0.0338
2	1.7395	8.1535	-0.3058
3	1.6576	8.0909	-0.3634

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