THE EFFECT OF THE RECOMMENDATIONS OF THE COMMITTEE ON THE
UNDERGRADUATE PROGRAM IN MATHEMATICS UPON THE
MATHEMATICS CURRICULA OF THE
COLLEGES OF MARYLAND

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

by

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* * * * *

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

Much has been written in recent years about the great demand in America today for mathematics abilities and mathematical training. Colleges are being called upon to prepare many more professional mathematicians, mathematics teachers, and mathematically-skilled personnel for the many activities of life. The rate of development in mathematics since 1900 has been very great, but our educational system has not, until recently, responded to these developments.

The past decade has witnessed many changes in the mathematics curricula of the public schools and the colleges and universities of the nation. One body associated with this change in higher education is the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America. This body (commonly referred to as CUPM) is charged by the Association with making recommendations for the overall improvement of college and university mathematics curricula at all levels.

The investigator has been a collegiate mathematics teacher for almost six years, and in this capacity has had a number of opportunities to consider curricular changes within his undergraduate department. He has also served as his institution's representative in the Maryland School-College Mathematics Association, a body

specifically concerned with the preparation of mathematics teachers in the State of Maryland. In both areas of professional responsibility, the recommendations of the Committee on the Undergraduate Program in Mathematics have played a part in his thinking and planning, and it seemed appropriate to study the effect and impact of selected recommendations of this Committee on the mathematics curricula of the colleges in the State of Maryland.

Statement of the Problem

The problem was to study the mathematics curricula of the colleges in the State of Maryland

- (a) to determine what the mathematics curriculum of each undergraduate college was five years ago;
- (b) to determine what the mathematics curriculum of each college is at present;
- (c) to determine any trends in the development of the collegiate mathematics curricula in the State;
- (d) to determine what influences the recommendations of CUPM had on the collegiate mathematics curricular changes:
 - (1) in the program for the general curriculum in mathematics;
 - (2) in the program for the training of teachers of mathematics;
 - (3) in the program for the preparation for graduate study in mathematics.

Related to the problem was the attempt to determine the academic, professional and experiential backgrounds of the faculty members in the departments of mathematics in the colleges in Maryland.

Design of the Study

In planning the study, the investigator was aware of a variety of earlier groups which had, at times explicitly but more often implicitly, made recommendations for changes in the curriculum of collegiate mathematics. These recommendations were, however, deemed to be outside the scope of this study which was limited to the effect of the CUPM recommendations. In seeking specific references to other studies of the effect of the CUPM recommendations, the investigator soon became aware that few or none existed. This was further borne out by a communication from the executive director of CUPM, L. K. Durst, who reported only one previous evaluative effort, a limited study of the effect of the CUPM Level I recommendations for the training of elementary teachers. Because of this lack of pertinent related studies, no section in which there is a review of the literature was included in this study.

The investigation of the problem was conducted by interview. Each college in the State of Maryland which had a mathematics department which offered a major in the field or which prepared teachers in this field was visited by the investigator. The chairman of each mathematics department was interviewed, the interview was tape-recorded, and the findings were later transferred

to a standard questionnaire-checklist form for analysis. The catalogs of each school, both for 1962-1963 and 1967-1968, were collected and studied.

The data sought were:

- (1) brief background about the institution and the mathematics department;
- (2) background information about the person being interviewed and the other members of his department;
- (3) the changes in the mathematics curriculum in the college since September, 1962;
- (4) the present mathematics curriculum, degree or major requirements, and textual materials employed;
- (5) the factors, as perceived by the interviewees, which influenced the curricular changes, particularly the effect of the CUPM recommendations;
- (6) the feelings about the CUPM recommendations held by the interviewees.

Instrumentation

A battery-operated, portable tape recorder was used to collect all comments and conversation during the interview. A questionnaire-checklist for later recording purposes was devised which contained a short series of questions dealing with the college and the mathematics department, a series of questions dealing with the background of the interviewee and the other members of his department, a longer series of questions dealing with the 1962-1963

mathematics curriculum, major requirements and textual materials and with the 1967-1968 curriculum, requirements and texts, and a series of questions dealing with the changes that have occurred. Ample room was provided for noting reactions and explanatory comments as well as the perceptions of the influences of the CUPM recommendations upon the changed curriculum. (See Appendix D for a copy of this checklist.)

Data Collection

Soon after the beginning of the fall semester, on October 16, 1967, a letter of explanation and request for interview was sent to the chairman of the mathematics department of each of the twenty-one four-year colleges in Maryland offering a major or concentration in mathematics. An accompanying cover-letter of endorsement for the project by the Maryland School-College Mathematics Association was also included. Return self-addressed postal cards were included on which was a form to be filled out and returned, indicating suitable dates and times for the interviews. Upon receipt of this card, by the investigator, a second letter was sent, confirming the date and time of the interview and indicating more specifically the information desired. Because of the size of the sample there was concern and hope that there would be full participation; for this reason, in the instances when the card had not been returned by November 6, 1967, a telephone call was made to the departmental chairman, repeating the request for the interview and arrangements were usually made at this time.

The investigator arranged his interviews so that ample time was available for the conference as well as for a visit to the Registrar's Office to obtain copies of the 1962-1963 and 1967-1968 catalogs for each college. Usually one or two schools were visited each day, depending upon the necessary driving which was required from the candidate's home and the interview schedule which was finally established. Western Maryland College, the institution where the investigator teaches in the mathematics department, provided a lighter teaching schedule which permitted him to be away from campus two days each week. The interviews were completed on December 12, 1967. Following each interview a thank-you letter was sent to each participant, reiterating the fact that a summary of the findings would be sent to him following the completion of the study. (See Appendix B for copies of the letters sent. See Appendix C for a list of all participating colleges and interviewees.)

Analysis of the Data

The data concerning curriculum were assembled and compared with the CUPM recommendations to see how closely these had been followed, purposely or otherwise. The information concerning the institution, the department and the mathematics faculty was tallied and presented in charts as well as in exposition. The perceived influences and views of the CUPM recommendations were summarized and certain quotations were selected for inclusion in this written report. The investigator then made an assessment of the effect

of the recommendations as it appeared to him, together with some observations about the development of collegiate mathematics and future national recommendations, as well as the work of CUPM.

Assumptions

Certain assumptions were necessary to undergird the investigation of the problem stated:

- (1) People responding to the questions in the interview would be honest in reporting factual data and in discussing the changes in collegiate mathematics curricula and the influence of CUPM on these changes.
- (2) The chairmen of the collegiate mathematics departments throughout the state would be knowledgeable about the changes in their departments and factors influencing these changes.
- (3) The catalogs of the colleges in Maryland would report reasonably accurately the course offerings and requirements in the mathematics curricula of the colleges.

Significance of the Study

To the investigator's knowledge, little or nothing has been done to study the relationship of the CUPM recommendations to the mathematics curricula which have evolved over the last five years. In a letter to the investigator, William L. Duren, then-chairman of CUPM, stated that he knew of no formal study of CUPM influences on college mathematics. He attributed this to the difficulty of

determining indirect influences, since colleges rarely adopt or reject a proposed program in its entirety. This study provides a description of the situation in one state and the status of the implementation of the recommendations, which may enable the Mathematical Association of America, through its committees and members, to make some speculations, as it devotes its energies to efforts in realizing the recommendations. Although the sample is admittedly small, the colleges are diverse enough in size, calibre, purpose and type so as to provide some picture of national trends.

Of more immediate concern is the fact that CUPM itself is interested in ascertaining the effect of its work. In a letter sent to the investigator just prior to the completion of the study, George B. Pedrick, Associate Director of CUPM, remarked that the results "would probably be of great value to CUPM in its continuing efforts to evaluate and improve its effectiveness." He went on to say that "self-evaluation is always haunted by the specter of a possibly slanted point of view" and that CUPM was pleased to learn of the "availability of an evaluation by an independent agency." (See Appendix A for copies of these letters from CUPM.)

Of equal importance is the fact that the results of the study now provide each college in the State of Maryland with a clear picture of the mathematics programs (in the three selected areas) in the other neighboring colleges in a generalized way. Furthermore, the findings indicate to the Maryland School-College Mathematics Association areas which need more emphasis in teacher-education. This body can then focus its efforts more directly to improve the

mathematics programs through conferences, state-wide meetings of educational leaders, etc. Because of the interest of this organization and its individual members (representing most of the colleges in the State) in the undergraduate program in mathematics, it seemed that the time was ripe for such a study, and, indeed, cooperation in gathering information was readily forthcoming.

The study also provides a comprehensive analysis of some of the strengths and weaknesses in the mathematics curricula in the colleges in Maryland, at least as viewed against the recommendations of the Committee on the Undergraduate Program in Mathematics; this analysis can provide the basis for much thought and constructive change both at the local and state level in higher education.

The Organization of the Dissertation

In the first chapter the author has outlined the problem, the design of the study including instrumentation and methods of data collection, the assumptions, the significance of the study, and the plan for the dissertation. In the second chapter the development of the Committee on the Undergraduate Program in Mathematics and its recommendations are presented. Chapter Three deals with the participating colleges, the nature of their mathematics programs, and the changes in the mathematics curricula from 1962 to 1967. The effect of the CUPM recommendations on the curricular changes is discussed in Chapter Four, including the views of the participants concerning the recommendations and the role of CUPM for the future. Chapter Five assesses the effect of the CUPM

recommendations on the collegiate mathematics programs in Maryland and includes some observations and recommendations concerning the future development of mathematics curricula and the work of CUPM as well as a summary of the study. Appendixes and a bibliography of references are also included for the reader's use and interest.

CHAPTER II

THE COMMITTEE ON THE UNDERGRADUATE PROGRAM IN MATHEMATICS

In the first chapter the problem was stated as a study to determine the effect of certain recommendations of the Committee on the Undergraduate Program in Mathematics on the mathematics curricula of the colleges of Maryland. To provide a foundation for the analysis of the effect of these recommendations, the second chapter deals with the development of CUPM and its panels, and with the specific recommendations for the general mathematics curriculum, for the training of teachers of mathematics, and for the preparation for graduate study in mathematics.

Recommendations for Collegiate Mathematics Curricula Prior to CUPM

A little over fifty years ago, in 1915, the Mathematical Association of America, the national organization of American collegiate mathematicians, was formed. Over these fifty years, this association has played a part in improving the state of undergraduate mathematics education. Through these years, as colleges have undergone changes while the nation moved toward compulsory general education, suffered a lengthy depression, a world war and Sputnik, collegiate mathematics has changed also. A number of

organizations have periodically examined the status of undergraduate mathematics, particularly those programs for the training of public school teachers, and some have made recommendations for further change. One of these groups was the International Commission on the Teaching of Mathematics (1911-1918) which examined the level and placement of college mathematics courses and observed some changes in content and instructional techniques over earlier times. [2:41-47]

As secondary education was also changing, mathematicians seemed to become increasingly concerned with the training of mathematics teachers. In 1935 the Commission on the Training and Utilization of Advanced Students in Mathematics of the Mathematical Association of America made its report on the training of teachers of mathematics, for both colleges and secondary schools. The Commission's recommendations for the preparation of secondary school teachers included courses in trigonometry, college algebra, analytic geometry, calculus, college geometry, theory of equations, and history of mathematics. [9:275-276] Five years later, in 1940, the Joint Commission of the Mathematical Association of America and the National Council of Teachers of Mathematics published its report, The Place of Mathematics in Secondary Education, which included an analysis of and recommendations for teacher training. [17:187-203] Immediately following World War II, two other committees reported upon the problem of teacher training and made appropriate recommendations. The Commission on Post War Plans of the National Council of Teachers of Mathematics in its Second Report

of 1945 devoted nine theses to significant problems of mathematics teacher preparation. [8:195-221] In 1946, the American Association for the Advancement of Science Cooperative Committee on the Teaching of Science and Mathematics presented its recommendations in The Preparation of High School Science and Mathematics Teachers [1:107-118]; a second report followed in 1959.

Also concerned with the training of elementary and secondary school mathematics teachers was the Commission on Mathematics of the College Entrance Examination Board which was appointed in 1955 and which reported its recommendations for teacher preparation as part of a larger body of recommendations for mathematics curricular change for the junior-senior high school program for the college-capable students. [7:48-58] Still another list of "Recommendations for the Preparation of High School Teachers of Science and Mathematics" appeared in School Science and Mathematics in 1959. [13:181-189]

Almost concurrently with the publication of the first CUPM recommendations, those dealing with the training of teachers of mathematics, there was published another set of guidelines, again concerned with teacher preparation. These were drawn up by a joint group on teacher preparation-certification study of the National Association of State Directors of Teacher Education and Certification (NASDTEC) and the American Association for the Advancement of Science (AAAS) with the support of the Carnegie Corporation of New York. [20:23-26]

From all of the commissions, reports and sets of recommendations mentioned above, one might conclude that the only concern in America prior to 1960 over the undergraduate mathematics curricula lay with the collegiate preparation of teachers of mathematics for the public schools; to the author this appears to be least partially true. One must not overlook, however, the growing discontent with public school mathematics as it was prior to about 1950, and the many and varied efforts to update the school mathematics program. While these efforts dealt exclusively with K-12 programs, it has been generally recognized in recent years that most of the materials produced were designed for the more-able, college-bound student. To this extent, these curricular study groups also had an indirect effect on the general college mathematics curricula in America, as they set forth what they considered to be a desirable pre-college curriculum and implied that the colleges should be prepared to move the student on from this point.

There is also a body of literature, as reviewed in Cavanagh's 1965 study [6:9-22], to support the view that there was dissatisfaction with the mathematics curricula of the junior colleges. There had been some concern over this as early as 1940 when the Joint Commission dealt with it in its report [17:149-161]. A variety of recent recommendations has also been forthcoming.

It appears, then, that in the decade of the 1950's there was growing dissatisfaction with the college mathematics program among mathematicians and educators across the country. Many recommendations for curricular changes of one sort or another were

made, but the total effect of these (if indeed there was any effect) is now impossible to measure. The dissatisfaction was heightened further by an increasing need for mathematically trained personnel in industry and government. The movement for change gained momentum with the establishment of the National Science Foundation, setting forth a national policy of cultivating science and mathematics for the public welfare. In 1953, E. J. McShane, as President of the Mathematical Association of America, sensed the opportunity for educational reform which would be supported professionally by college mathematicians and financially by foundations, and appointed an ad hoc Committee on the Undergraduate Program, with William L. Duren as chairman. After a quick survey, this committee reported back to the Board of Governors and recommended a national "program of 'doing' to overcome the inertia of the enormously ponderous structure which carries onward the present program with all its deficiencies." [12:24-25] The ad hoc committee was then discharged and reconstituted as the Committee on the Undergraduate Program (CUP).

The Development of CUPM, Its Panels, and the Recommendations

On December 31, 1965, on the occasion of the Fiftieth Anniversary of the founding of the Mathematical Association of America in 1915, William L. Duren, then chairman of CUPM, presented a detailed report on the history and development of CUPM. This address was later published in the Fiftieth Anniversary Issue of The American Mathematical Monthly [12:23-37]. It is not within the scope of this study nor the intent of this chapter to present

an exhaustive history of CUPM. What does seem appropriate, however, is a brief sketch of the development of the Committee and its panels, to see the nature of the body making the recommendations and the philosophy and spirit in which these recommendations are made.

Under a mandate "to consider the problems of making available in our society the values of modern mathematics and to attack the problem with broader scientific and cultural objectives than could be expressed through another mere study of curriculum revision" [4:35], the CUP immediately planned summer writing sessions with several books resulting: Universal Mathematics--Functions and Limits, Elementary Mathematics of Sets with Applications, and Modern Mathematical Methods and Models, Volumes I and II. The Committee also sponsored the publication of Emil Artin's Notes for a Princeton Honors Course in Calculus, Polya's Mathematical Discovery, Volume I, and several Carus Monographs. Sensitive to the limitations of its scope and its inability to keep abreast of the rapidly developing national curriculum work, the CUP resolved to liquidate so that a new committee might be formed with a much broader program. It summarized its own work in two reports and almost as an after-thought, included a sketchy outline of a recommended college mathematics curriculum. The CUP had avoided making recommendations but came to believe that its successor should publish recommendations. [4:35-36] [12:28-29]

In January, 1959, the Committee on the Undergraduate Program in Mathematics (CUPM) was formed, as a distinct arm of the Association. It was organized into four panels: The Panel on Teacher Training;

The Panel on Mathematics for the Physical Sciences and Engineering; The Panel on Mathematics for the Biological, Management, and Social Sciences; and The Panel on Pre-Graduate Training. Each panel was composed of about ten to fifteen mathematicians (some CUPM members and others as well) who were at times assisted by invited experts from various areas. Each panel was independent of the others and was responsible for curricular change in its particular area of interest and for making consistent effort to implement these recommendations. In addition to these panels, certain ad hoc committees and special sub-committees were appointed from time to time to prepare such reports as Qualifications for a College Faculty in Mathematics [23], Basic Library List [3], and A General Curriculum in Mathematics for Colleges [14]. [4:36] CUPM operated under grants from the National Science Foundation and the Ford Foundation as well as with financial support from its parent organization.

Upon being reconstituted and reorganized, CUPM adopted a basic policy of operation which was different from that of the original CUP. It included the critical issue of improving mathematical education from a national point of view and organization. R. Creighton Buck, then-chairman of CUPM, expressed the policy in this way: "Any approach to college curricula revision must take account of valid differences of opinion about both content and pedagogy; thus there is no attempt to insist upon one specific program. In all documents released by CUPM, there have been attempts to indicate alternatives, and indeed to encourage experimentation

as an aid to national activity." [12:31] Whereas the original CUP, perhaps for economy and unity, had exhibited only one sample of course materials, each of the new CUPM panels produced at least one four-year curriculum recommendation with alternative structures and organization, and a varied list of possible textual materials. Because the scope of this study is limited to the recommendations of two of these panels, only these will be discussed in detail.

Recommendations for the Training of Teachers

The Panel on Teacher Training, under the original chairmanship of John G. Kemeny, produced its first recommendations within a matter of months after it was formed. These recommendations were then reviewed in a series of state conferences involving administrators, supervisors and teachers. In its January, 1961, published report, the Panel outlined what it considered the minimal college training program for teachers of mathematics at five different levels. The recommendations [24] for each level follow.

For teachers of elementary school (K-6) mathematics (Level I), the following courses or their equivalent were suggested:

- (a) a two-course sequence devoted to the structure of the real number system and its subsystems;
- (b) a course devoted to the basic concepts of algebra;
- (c) a course in informal geometry.

It was further suggested that at least twenty per cent of the Level I teachers in each school have stronger preparation in mathematics than that described above.

For prospective teachers of the elements of algebra and geometry (Level II), it was recommended that their college mathematics training include:

- (a) three courses in elementary analysis (including or presupposing the fundamentals of analytic geometry);
- (b) four other courses: one in abstract algebra, one in geometry, one in probability from a set-theoretic point of view, and one elective. One of these courses should contain an introduction to the language of logic and sets, and a course in applied mathematics or statistics should also be included if possible.

It was recommended that prospective teachers of high school mathematics (Level III) should complete a major in mathematics which should include, in addition to the work for Level II, at least an additional course in each of algebra, geometry, and probability-statistics, and one more elective. In the December, 1966, revision of these recommendations, an additional course was highly recommended, a course in computer science. Thus the minimum requirements for Level III teachers would be:

- (a) three courses in analysis;
- (b) two courses in abstract algebra;
- (c) two courses in geometry beyond analytic geometry;
- (d) two courses in probability and statistics;
- (e) a course in computer science;
- (f) two upper-class elective courses, perhaps introduction to real variables, number theory, topology, history of mathematics, or applied mathematics.

For Level IV teachers of advanced programs in high school (e.g. calculus, linear algebra, probability, etc.), the Panel recommended a master's degree with at least two-thirds of the courses

being in mathematics, and for which an undergraduate program at least as strong as Level III training is a prerequisite.

Teachers of college mathematics (Level V) should be qualified to teach all basic courses offered in a strong undergraduate college curriculum, the Panel stated. They believed that this required the knowledge and talents of a person holding the Ph.D. in mathematics or at least having a training corresponding to the subject matter competence of the Ph.D. More detailed discussion of the Qualifications for a College Faculty in Mathematics was published in January, 1967, by the ad hoc CUPM committee appointed to deal with this issue. [23]

In addition to preparing the recommendations outlined above, The Panel on Teacher Training also prepared Course Guides for the Training of Teachers of Junior High and High School Mathematics [11] and two editions of Mathematics Text Materials for the Undergraduate Preparation of Elementary School Teachers [19].

Recommendations for Pre-Graduate Training

The Panel on Pre-Graduate Training had as its task to recommend programs for undergraduates who intend to go on to graduate work in mathematics. Its first document in 1963, Pregraduate Preparation of Research Mathematicians [21] made no allowance for the student's possible deficiencies in preparation or tardiness in selecting his goal, for inadequacies of staff, for lack of suitable textbooks, etc.; it was generally agreed that the recommendations aimed too far into the future to be immediately useful to any but

a very few young, exceptional mathematicians. [12:32] As a result of this "overshooting the mark", the Panel in 1965 produced a second set of recommendations, Preparation for Graduate Study in Mathematics [22], a program in partial fulfillment of the goals set out in the earlier report. Leon Cohen, a member of this panel (1959-1966) and the Chairman of the Mathematics Department at the University of Maryland, recalled the work of the Panel and the thinking during both of these stages of their work:

There was a lively debate within the panel as to the realism of the recommendations. A considerable number of people on the panel . . . said that it would be shortsighted on the part of the panel to limit itself to attainable objectives, that the speed with which the changes were taking place in the undergraduate curriculum was so great that if we shot only at what was a feasible program within our sights, the program would no sooner be published than it would be obsolete, since in a number of places it would already be surpassed. . . .

However, it is fairly sure that it was not the case that this program had already been incorporated in this substance in many undergraduate programs. As a matter of fact, it was so much beyond the capacities, both of the undergraduate teaching community (I am speaking on the whole) and the capacities of the student body that the next thing we did was to try to produce a modified program which would be a preparation for the graduate study in mathematics; I would say that the principal characteristic of the first program that was retained in the second . . . was the effort to introduce year courses instead of semester or quarter courses. . . .

I think we were really struggling for a realistic point of view covering the context within which mathematics enters the undergraduate curriculum on a national level. I think there is a little more clarity about this now than when CUPM began, simply because a lot of people have struggled with the problem. . . .

There was no expectation that it would become the law. We were all people who had been in undergraduate classrooms and knew perfectly well that nobody was going to come tell us what was going to go into our course, so that there was never any thought that this would be the case. What was hoped was that we would give some models that made sense.

The present minimum course recommendations for pre-graduate preparation [22] are predicated on a realization that no single curriculum will work for all schools. The basic courses are as follows:

Lower Division Courses

- Mathematics 1. Introductory Calculus
- Mathematics 2. Mathematical Analysis I
- Mathematics 3. Linear Algebra
- Mathematics 4. Mathematical Analysis II
- Mathematics 5. Advanced Multivariable Calculus

Upper Division Courses

- A year-course in abstract algebra
- A year-course in real analysis

The panel felt strongly that every pre-graduate curriculum should include work to develop mathematical self-reliance, initiative, and confidence.

Recommendations for a General Curriculum in Mathematics

In March, 1963, the central office of CUPM was moved to Berkeley, California, and William L. Duren, Jr. again assumed chairmanship of the Committee. Soon thereafter a special subcommittee was appointed and a major effort was put forth to construct an economical synthesis of the recommendations of the four panels for colleges whose programs were too limited to provide the diversity of courses that each panel recommended. The result was A General Curriculum in Mathematics for Colleges [14], a system of one-semester course modular units from which a variety of curricula could be constructed to suit the needs of an individual school. This report

was presented, not as a set of recommendations from CUPM per se, but as a report to the Mathematical Association of America with a request for criticism and evaluation from the Sections of the Association. This evaluation had not yet been completed in 1967.

The outline of the proposed basic program is as follows:

Lower Division Courses (offered every semester)

Mathematics	0.	Elementary Functions and Coordinate Geometry
Mathematics	1.	Introductory Calculus
Mathematics	2.	Mathematical Analysis I
Mathematics	2P.	Probability
Mathematics	3.	Linear Algebra
Mathematics	4.	Mathematical Analysis II
Introduction to Computer Science		

Upper Division Courses (possibly offered once a year or in alternate years)

Mathematics	5.	Advanced Multivariable Calculus
Mathematics	6.	Algebraic Structures
Mathematics	7.	Probability and Statistics
Mathematics	8.	Numerical Analysis
Mathematics	9.	Geometry
Mathematics	10.	Applied Mathematics
Mathematics	11.	Introductory Real Variable Theory I
Mathematics	12.	Introductory Real Variable Theory II
Mathematics	13.	Complex Analysis

The recommended minimal mathematics major program should include at least six semester courses from the list of upper division courses.

The report considered how this program might be adopted and made the following statement:

CUPM believes that the wide adoption in colleges of course programs conforming to this general pattern will go a long way towards the elimination of the confusion which now exists, will speed up the process of orderly transfer to high school of mathematical subjects which can be appropriately taught there, will leave the colleges at all stages of this transfer with a workable program, and will take care of both the individual students from schools where the new improved mathematics programs have taken hold, as well as the students from

secondary schools where only the old-style preparation is yet available.

Instead of trying to secure national adoption of our program specifically as we conceive it, we invite colleges to adapt this program outline to their own needs and to publish their own detailed course outlines with comments on text materials used and classroom experience, particularly with reference to the handling of students who come with superior high school backgrounds. Such an exchange of information and such a broad distribution of the work will do much more than CUPM can accomplish with conferences, writing sessions, consultants, and recommendations, to reap the harvest of the pioneer experimental work which has already been done. [14:28]

Other Work of CUPM

It was pointed out in the discussion of the development of CUPM that in addition to the panels of the Committee, certain special committees were occasionally appointed to make specific reports and to deal with specific topics. One of these was the Advisory Group on Communications of CUPM which prepared the Basic Library List [3]. This project was an attempt to define a minimal college mathematics library, a nucleus for a library whose further acquisitions should be dictated by the needs and interests of students and faculty. This list will be revised from time to time, to include appropriate recent publications.

Another part of the CUPM work rests with the Consultants Bureau, a group organized seven years ago to provide convenient and effective channels of communication between CUPM and the colleges of the country. Available for two-day visits to colleges, junior colleges and state departments of education, the consultant is prepared to discuss questions of all kinds pertaining to undergraduate mathematics curricula. [10]

Also a part of the total work of CUPM is the participation in an advisory capacity in several national, regional and state surveys and conferences on mathematics in universities and colleges. One of these was the 1961 comprehensive survey of graduate and undergraduate mathematics programs directed by Clarence B. Lindquist. The members of CUPM are credited with making a number of helpful suggestions in regard to the survey published as Mathematics in Colleges and Universities [18]. This survey was repeated and expanded in 1967 by the Conference Board of Mathematical Sciences. Its report was Aspects of Undergraduate Training in the Mathematical Sciences [16]. Representatives of CUPM frequently discussed the recommendations of one of the panels or committees at special conferences. One of these was the Conference for Improving Mathematics Education for Elementary School Teachers held at Michigan State University in August, 1967. Gail Young interpreted the CUPM recommendations for the training of elementary mathematics teachers while Earle Loman examined the recommendations of the Cambridge Conference on Teacher Training. [15] [5] Several conferences in a similar vein have been sponsored in Maryland by the Maryland School-College Mathematics Association, and CUPM representatives have been present to discuss Level I and Level II recommendations with the college and school representatives attending.

The work of CUPM is not yet completed; it is doubtful that it will see the attainment of all its goals in the near future. There is a variety of reports and studies yet to be completed and published, and others just in the planning stages. But as Duren

concluded in his analysis of the development of CUPM: "Whatever CUPM can contribute will depend on finding radically new patterns for an organized national educational improvement group to attack this problem [of undergraduate mathematics curricula]. That is where we are today." [12:34]

CHAPTER III

THE COLLEGES AND THEIR PROGRAMS

In the preceding chapter the development of CUPM and the recommendations of its panels were presented. Before attempting an analysis of the effect of these recommendations, it seems appropriate to discuss the nature of the participating colleges and their mathematics programs, as well as the curricular changes which have occurred over the five year period of the study. Chapter III presents this information.

The Participating Colleges

As the study began to develop, the investigator had some serious concern over the size of the sample with which he would be dealing, for without participation from at least a majority of the colleges in the State, the results would be of limited significance. He was pleased that, of the twenty-one public and private four-year institutions in the State, twenty agreed to participate in the study, with the chairman of each mathematics department (or his official designate) submitting to an hour interview. The investigator felt that the cooperation he received was excellent, since in almost every instance, the interviewee had taken time prior to the conference to obtain from official college offices certain factual data and catalogs for the five year period in question, as well as to think about the

changes in the curriculum which had occurred. Because of this, the investigator had no feeling that he was receiving inaccurate data or unfounded opinion. On the contrary, he was impressed with the thoroughness, frankness and clarity with which his questions were answered as well as the genuine interest which was shown for his study.

The investigator's knowledge of the colleges in his state had also led him to realize the wide diversity of type, program and purpose that existed among them. He was made even more acutely aware of this as he visited each campus and studied the catalogs. Each of the eleven private colleges, eight state institutions and one federal academy has a unique historical and philosophical development. At the same time, they share with the others broad educational goals. A brief description follows of each of the participating colleges, all of which are fully accredited by the Middle States Association of Colleges and Secondary Schools.

The College of Notre Dame of Maryland is a private liberal arts college for 800 women under auspices of the School Sisters of Notre Dame of the Roman Catholic Church. Founded in Baltimore as a school in 1863, it became a four-year institution in 1895, the first Catholic college for the baccalaureate education of young women in America. Training for several professions as well as for graduate study is provided within the broad liberal arts framework.

Founded in 1904 for the training of young men and women for Christian service, Columbia Union College today exists primarily

to provide special opportunities in higher education for 1000 Seventh Day Adventist youth in the Maryland and District of Columbia area. The coeducational institution, located near Washington, D.C., in Takoma Park, offers a liberal arts program as well as training in many pre-professional areas, especially nursing through the affiliated Washington Sanitarium and Hospital.

Goucher College, founded in 1885 as the Woman's College in Baltimore under the auspices of the Methodist Church, is now an independent liberal arts college for 1000 women. A charter member of the College Entrance Examination Board with a chapter of Phi Beta Kappa since 1905, the college's goal is "the formation of womanly character for womanly purposes." Its liberal arts program is organized in three divisions, and the college year is divided into three terms with students taking three courses each term.

Hood College is an independent liberal arts college for 750 women and is affiliated with the United Church of Christ. Located in Frederick, it was founded in 1893 and empowered to grant baccalaureate degrees in 1897. It provides a liberal arts program in many major fields, together with professional training in education and home economics, and preparation for graduate study.

Founded by the Society of Jesus of the Roman Catholic Church, Loyola College in Baltimore was opened in 1852 as a college for Catholic laymen. It now provides preparation for graduate study and the professions within the liberal arts framework for 850 men. Independent of church support, it is one of many Jesuit institutions

with the same name, established for the "improvement and betterment of society."

Mount Saint Agnes College, established by the Sisters of Mercy of the Roman Catholic Church in 1890, states that its purpose is to initiate students into adult Christian life by the scholarly way of achieving knowledge. This liberal arts college for 500 women offers some professional training in addition to programs in five academic divisions, and enjoys a cooperative arrangement with the other Catholic institutions in the Baltimore area.

Founded in 1808 as the second Catholic college in America, Mount Saint Mary's College in Emmitsburg is a private liberal arts institution for 800 men. Work in its program of five divisions provides the student with training for a career, for graduate study, and for later life, in a small college environment.

With historical roots going back to 1696 and King William's School, Saint John's College in Annapolis, chartered in 1784, claims to be the third oldest college in America. First chartered as the Western Shore branch of the first University of Maryland, it later became a traditional liberal arts college with a curriculum which changed with the times. In 1937 under the leadership of Stringfellow Barr, the classical liberal arts curriculum was restored, embodying a uniform course of study with no effort to prepare for careers or graduate school. It is most known for its "Great Books Program." Since 1951, it has been coeducational for 300 students, and in 1964 it opened its Santa Fe, New Mexico, branch.

Saint Joseph College in Emmitsburg is an independent liberal arts college for 750 women under the auspices of the Daughters of Charity of the Roman Catholic Church. Founded by Mother Elizabeth Seton in 1809, its charter was amended in 1902 to allow the granting of baccalaureate degrees. Philosophy and theology are fundamental subjects in the curriculum of this institution dedicated to providing a liberal education in a Catholic viewpoint.

Founded in Chestertown in 1782 as the Eastern Shore branch of the first University of Maryland, Washington College is the tenth oldest college in America. It is named for George Washington who was one of the original contributors. The present thirty-two course program is designed to prepare the 610 men and women students for citizenship, for entrance into graduate and professional study, and for lives based on a sound liberal education.

Western Maryland College is a private liberal arts institution affiliated with the Methodist Church. It was founded in 1867 as the first coeducational institution below the Mason-Dixon Line. The curriculum provides twenty-three majors as well as professional and pre-professional training built on the liberal arts foundation. The college is celebrating its Centennial by expanding its facilities and staff to serve an enlarged student body of 1200, an increase from the present 850.

Bowie State College, founded originally in 1867 to train teachers for Negro schools, became a State Normal School in 1910 and a State Teachers College in 1935. Its program was expanded over the years until, in 1963, it became a multipurpose institution with

a liberal arts program as well as an elementary and secondary teacher education program. Located at Bowie, most of its 600 students still prepare to teach, but the liberal arts program is slowly building.

Founded in Baltimore in 1900 as a one-year teacher training institution for Negroes, Coppin State College eventually became part of the State educational system in 1950. Its program became multi-purpose, providing liberal arts and teacher education, in 1963, when the entire state college system was converted to this pattern. Most of the 900 students still prepare for elementary teaching while the liberal arts program is slowly being established.

Frostburg State College, established as the State Normal School at Frostburg in 1902, has also experienced the changes in the state system and now is a four-year liberal arts and teacher education (K-12) institution in the far western area of the State. Majors and minors are provided in most academic disciplines for the 1700 students, about one-fourth of whom are enrolled in the liberal arts program.

Originally established as the Delaware Conference Academy in Princess Anne, Maryland, in 1886, Maryland State College moved through a series of institutional changes until it finally became a division of the University of Maryland. Begun as an institution to prepare Negroes on the Eastern Shore for teaching and the ministry, its emphasis has long been on vocational preparation. (It came under State control through the land-grant provisions requiring educational opportunities for Negroes.) It now provides both liberal arts and vocational education for 750 students.

Morgan State College was founded in Baltimore in 1867 under Methodist auspices, for the purpose of training Negro men for the ministry. Academic subjects and preparation for teaching were added in the 1880's. The college entered the state system in 1939 and has continued to provide both liberal arts and pre-professional training, aiming at a liberal yet functional curriculum to serve its present coeducational student body of 3500.

Salisbury State College is the newest of all the institutions, having been established on the lower Eastern Shore in 1925 as a two-year normal school. In 1935 it became a four-year state teachers college and assumed a multipurpose status in 1963. Still primarily a college preparing elementary and secondary teachers, it does offer liberal arts majors in seven fields and is expanding this program slowly as its student body, now numbering 700, continues to grow.

The oldest and largest of the state colleges is Towson State College, founded in 1865 in northern Baltimore. It too moved through the years of change and began offering liberal arts degrees in 1963. The major emphasis is still on teacher education (K-12), but the college has seen tremendous growth recently and the liberal arts program is expanding rapidly. Its coeducational student body now numbers 4500.

The University of Maryland, originally founded as two branches in the late 1700's, then as medical college in Baltimore in 1807, and reestablished in 1856, finally became a viable institution in 1920 by fusing with the Maryland Agriculture College, a small

land-grant institution in College Park. Since then the University has grown both in size and stature, to include sixteen schools and colleges as well as several branches throughout the State and in Europe. With its professional colleges in Baltimore and its undergraduate campus at College Park, the University serves the people of the State in many ways.

The United States Naval Academy, located in Annapolis, is a federal installation founded in 1845 to prepare men for naval careers as officers. Since 1850 the program has been four years in length, leading to a bachelor of science degree. In recent years there have been changes in the curriculum to allow the midshipmen to take academic majors and minors in addition to their naval science, and some of the 4000 men now enter graduate school upon receiving their commissions.

These are the twenty colleges which participated in the study. While it can be observed that they all strive to provide a good liberal arts education and, in most cases, sound pre-professional training in several fields, many contrasts can also be seen among the institutions. There is the small church-related woman's college and the large federal academy for the training of naval officers. There is the very large university and the very small classical liberal arts college. There is the century-old institution, liberal arts in character since its founding, and the very recently developed liberal arts program in the expanded state teachers college. There is the very well endowed institution and the college which is struggling for financial survival (as so many private colleges in

America are today). There is the predominantly Negro college which is opening its doors and its changing curriculum to white students, and there is the college, traditionally for Caucasians, which is adapting its curriculum to meet the needs and backgrounds of Negro students. These and other contrasts can be seen as one looks at the colleges in Maryland. It appears that there is in this state much of the diversity of institutions of higher learning that one would find anywhere in America, and for this reason, Maryland seems a good representative of the nation at large.

The Nature of the Mathematics Departments

We turn now to a description of the departments of mathematics in the schools described above. Included in our considerations will be the faculty, students and facilities. Because each chairman was guaranteed anonymity in reference to his comments and the specific data provided about his particular institution, it is inappropriate in most cases in the following discussion to provide anything other than summary statements and isolated factual data. The investigator wishes to reiterate at this point that at no time during the course of the interviews did he have the feeling that he was receiving false information or inaccurate data. This was verified a number of times by the admission of staffing difficulties and by the indications of variation and deviation in the actual courses offered from that list of mathematics courses presented in the catalogs for the years studied.

Before any description of departments and curricula can be meaningful, it seems necessary to examine the present size of the institutions involved in the study. If one considers as separate entities the two colleges within the University of Maryland which prepare mathematics teachers, then a total of twenty-one colleges are involved in the investigation. Of these twenty-one separate institutions, fifteen have enrollments of approximately 1000 students or less. The range of enrollments is from 300 to 10,300 for the twenty-one schools, the mean enrollment is 1929, and the median enrollment is 850. The nature of the data indicates that the median is a more descriptive average for this study, and it will be employed hereafter unless otherwise indicated. The median number of total undergraduate degrees awarded by these twenty-one colleges in 1967 was 166 with a range from fifty-five to 1297.

The investigator sought to determine the total number of mathematics majors in the colleges, but this information was not readily available since some schools classify majors only at the beginning of the junior year while others are aware of freshman and sophomore majors as well. For some institutions the spokesman was not able to provide the information because detailed records were not readily available. Furthermore, such figures are not very meaningful since students change their minds often during the course of a four-year period. Data on the total mathematics graduates for the year 1967 were available and indicated a range from one to sixty-seven, with a median of eight major graduates. A total of 335 mathematics majors were graduated from all the colleges

in the study. (St. John's College is not included in these figures since this school defines no majors and has no mathematics department per se.) Each chairman was asked to determine how many of the 1967 mathematics graduates had entered each of four areas: graduate school, teaching, industrial and governmental work, and other fields. The maximum number of graduates entering graduate school was twenty-three while the minimum was zero, and the median was 1.5. The total number of entering graduate students in mathematics was seventy-one, or 21 per cent of the graduates. The range of graduates entering teaching was from zero to thirty-five, and the median was four. The total number of graduates entering teaching was 120, or 36 per cent of the mathematics graduates. The largest number of students entering industrial and/or governmental work was twenty while the smallest number was zero. The total number of graduates entering this work was eighty, or 24 per cent of the graduates, while the median for the schools in the study was two. Sixty-four graduates or 19 per cent of the total entered some other field of work, most usually military service; fifty-three of these graduates were naval officers, from the United States Naval Academy. The median for all schools in the study was zero.

The teaching staff of each collegiate mathematics department was divided into two categories: full-time and part-time. For all the schools (except St. John's College) in the study, there were 244 full-time instructors and twenty-one part-time teachers,

thus a total of 265 staff members. The range for the colleges was from one to eighty-two full-time staff members, and from two to eighty-five full and part-time staff members. The median number of full-time staff was four, and the median number of full and part-time staff was five.

The 265 college mathematics teachers had a variety of levels of academic training. Although the investigator sought to distinguish among several levels of post-master's degree work, it soon became evident that this would be impossible to do since the specific level for each teacher in an institution was not always known by his chairman who provided the information. Also, in several cases there were too many staff members to make distinctions about the degrees. Consequently the data were grouped into the traditional three levels of academic degrees: bachelors, masters and doctorate. It was reported that 108 (or 40 per cent) of the 265 college mathematics teachers held doctorates in pure or applied mathematics or mathematics-education. One hundred thirty-two (or 49 per cent) held master's degrees while twenty-five (or 11 per cent) held bachelor's degrees. Many bachelor's and master's degree holders had pursued work toward a higher degree but had not yet attained that degree.

To the investigator these figures seemed to be somewhat misleading and not indicative of the total state picture. If one considers that the University of Maryland is the one institution in the study which, in addition to its undergraduate program, is also very much involved in a graduate mathematics program which

requires a staff trained at the doctoral level, then he might well temporarily exclude the University from the analysis and obtain a more accurate description of the staff preparation for the undergraduate mathematics teaching across the State. In doing so, it was revealed that only forty-two of 183 total staff (or 23 per cent) held doctorates. One hundred nineteen (65 per cent) held master's degrees while twenty-two (12 per cent) held bachelor's degrees. It was impossible to obtain complete delineation of the areas of the highest degrees held by each of the 265 staff members in all the schools, but in eighty-six cases, such information was available. Of these staff members, sixty-two held their highest degree in pure mathematics, seven were in applied mathematics, and seventeen were in mathematics-education. These figures are interesting in light of the recent findings of the Conference Board of the Mathematical Sciences about faculty preparation for mathematics teaching.

[16:31-43]

The chairmen were asked to estimate the average teaching load per week for the staff members in their departments. They reported semester-hour loads ranging from nine hours to fifteen hours with a median load of thirteen hours and a mean of 12.4 hours.

The investigator was interested in determining whether departments, while endeavoring to establish and maintain modern mathematics programs and describing such in catalogs, might in reality not be as successful as they hoped due to staffing problems. These problems might occur either in trying to obtain competent

additional teachers or in updating the backgrounds of older staff members who might be "in a rut." In answering this question frankly, a number of the interviewees were quick to describe their growing staffs as quite competent, young and "fresh from graduate schools." Seven chairmen reported, however, that they did have some problems. The concern of six of these respondents was with older staff members, usually one in each department, who were not competent to teach upper-level courses now a part of the curriculum or who were unwilling to change viewpoints and approaches to courses. For example, one chairman reported: "Some of our staff still don't do what they should in some of these courses. I think they are able to do it, but it's a case of making 'believers' of them through experience, experimentation and repetition of courses. For example, our big problem now is how to teach linear algebra to sophomores." In another instance a staff member had been assigned by the Dean to a course which he knew himself to be incompetent to teach. His request for reassignment was denied, and so he did the best that he could with his meager background.

A staffing problem of a different nature was reported by a chairman who said: "The department here has had too much turnover of young staff members. We've had too much instability. We could use a little more 'rut formation' to provide some continuity!" In general, however, the investigator concluded, on the basis of the chairmen's comments, that the departments were staffed with faculty members who were adequately trained both in the spirit and method of modern mathematics and who taught in this same spirit.

One final area of concern to the investigator was the library holdings in mathematics for the schools in the study. His survey revealed that the mathematics collections housed in the main libraries ranged in size from 150 volumes to 13,000 volumes, with the median being 750 volumes. All libraries subscribed to at least two journals, with the maximum number being 200. The median number of journals in mathematics and mathematics-education for all libraries was six. Five colleges also had departmental libraries of one sort or another, in addition to the main collection.

In summary, the survey revealed what one sensibly could consider the "average" college and the "average" mathematics department in the State, using in all cases the median as the average. This "typical" college had 850 students, and awarded 166 undergraduate degrees in 1967, of which eight were in mathematics. Of these eight graduates, two went to graduate school in mathematics, four entered teaching and two found employment in industry and/or government. The mathematics department had four full-time and one part-time staff members, and of these five teachers, one held a doctorate while the other four held at least master's degrees. The teaching load of this staff was thirteen hours per week per semester. The college library housed the mathematics collection of 750 volumes and subscribed to six journals in mathematics and mathematics-education.

Having ascertained the present status of the mathematics departments in the colleges of the study, we turn now to a discussion of the changes in the mathematics curriculum over the five year period from 1962-1963 to 1967-1968.

Changes in the Mathematics Programs

In attempting to determine the amount of change that had taken place in the mathematics curricula over the five year period of the study, the investigator not only questioned the departmental chairman but also referred to the catalogs of the institutions for the school years 1962-1963 and 1967-1968. It was realized at the outset that the catalogs were not necessarily a good description of what the curricula really were at any particular time, and this was borne out in the discussions with the interviewees. However, it was of interest to see the variety of types and names of courses which were and are offered, as well as to determine how many additions and deletions had been made over the five year period. The courses were grouped into eight major categories and each course with a sufficiently different name was listed. A tally was made of all such courses with roughly similar titles, both for 1962-1963 and 1967-1968. These tallies are presented in Tables 1--8. A summary of these is as follows: The twenty colleges in the state offered approximately sixty-two pre-calculus courses under nineteen different titles in 1962. By 1967 the number of courses had increased to sixty-seven with twenty-two different titles. Calculus (and differential equations) was offered in sixty-seven courses at various levels under nineteen different titles in 1962, while in 1967 the number of courses was eighty with twenty-two varied titles. Courses in analysis (real, complex, topological, etc.) numbered thirty under eleven titles in 1962; by 1967 the number of courses had increased to forty-six under eleven different titles. There were

TABLE 1
CATALOG LISTINGS: PRE-CALCULUS
1962-1967

Title	No. in 1962	No. in 1967
Analytic Geometry	8	6
Basic Mathematics	0	1
College Algebra	8	6
College Algebra and Trigonometry	1	1
Elementary Set Theory	0	1
Elements of Mathematics	1	3
Finite Mathematical Structures	1	0
Foundations of Analysis	2	2
Foundations of Mathematics	2	4
Freshman Mathematics	2	1
Functional Mathematics	1	1
Fundamental Concepts of Arithmetic	5	4
Fundamental Concepts of Mathematics	11	14
Intermediate Algebra	1	1
Introduction to Modern Mathematics	2	4
Introductory College Mathematics	2	3
Language and Concepts of Mathematics	1	1
Mathematical Analysis	3	4
Mathematics Review	1	0
Plane Geometry	0	1
Pre-Calculus	0	1
Solid Geometry	1	0
Sophomore Mathematics	0	1
Survey of Mathematics	0	1
Trigonometry	9	6
Total courses (25 names)	62	67

TABLE 2
CATALOG LISTINGS: CALCULUS
1962-1967

Title	No. in 1962	No. in 1967
Advanced Calculus	4	0
Calculus	3	2
Calculus I	3	6
Calculus II	3	6
Calculus III	2	6
Calculus with Analytic Geometry I	4	5
Calculus with Analytic Geometry II	4	5
Calculus with Analytic Geometry III	3	4
Calculus with Analytic Geometry IV	1	2
Differential and Integral Calculus	2	1
Differential Calculus	6	5
Elementary Calculus	2	2
Integral Calculus	6	5
Intermediate Calculus	4	4
Introduction to Calculus	3	2
Introductory Analysis	2	3
Mathematical Analysis I	0	2
Mathematical Analysis II	0	2
Mathematical Analysis III	0	2
Multidimensional Calculus	1	1
Advanced Differential Equations	0	1
Differential Equations	13	12
Series and Differential Equations	1	0
Theory of Ordinary Differential Equations	0	2
Total courses (24 names)	67	70

TABLE 3
 CATALOG LISTINGS: ANALYSIS
 1962-1967

Title	No. in 1962	No. in 1967
Advanced Calculus I	7	10
Advanced Calculus II	6	7
Calculus IV	0	2
Complex Variables	1	1
Introduction to Complex Analysis	3	6
Introduction to Linear Analysis	1	0
Introduction to Real Analysis	3	5
Introduction to Set Theoretic Topology	3	3
Theory of Functions	2	1
Theory of Measure	1	1
Total courses (10 names)	30	46

TABLE 4
 CATALOG LISTINGS: FOUNDATIONS
 1962-1967

Title	No. in 1962	No. in 1967
History of Mathematics	3	3
Logic	1	0
Mathematical Logic	1	4
Symbolic Logic	0	1
Total courses (4 names)	5	8

TABLE 5
 CATALOG LISTINGS: ALGEBRA
 1962-1967

Title	No. in 1962	No. in 1967
Abstract Algebra	2	4
Algebraic Structures	0	4
Elements of Modern Algebra	2	3
Higher Algebra	2	2
Introduction to Matrices	1	1
Introduction to Modern Algebra	4	3
Linear Algebra	3	9
Matrix Algebra	2	1
Modern Algebra	8	6
Theory of Equations	6	3
Theory of Numbers	7	8
Vectors and Matrices	1	1
Total courses (14 names)	38	45

TABLE 6
 CATALOG LISTINGS: PROBABILITY AND STATISTICS
 1962-1967

Title	No. in 1962	No. in 1967
Elementary Statistics	6	5
Mathematical Statistics	4	4
Probability	2	4
Probability and Statistics	7	8
Statistics	2	0
Theory of Probability and Mathematical Statistics	1	0
Total courses (6 names)	22	21

TABLE 7
CATALOG LISTINGS: GEOMETRY
1962-1967

Title	No. in 1962	No. in 1967
College Geometry	5	4
Elementary Geometry from an Advanced Standpoint	0	1
Elements of Geometry	1	2
Euclidean Geometry	1	0
Fundamental Concepts of Geometry	0	3
Geometrical Structures	0	1
Higher Geometry	1	1
Informal Geometry	0	1
Introduction to Geometry	0	1
Modern Geometry	3	5
Projective Geometry	2	2
Solid Analytic Geometry	2	1
Total courses (12 names)	15	22

TABLE 8
CATALOG LISTINGS: APPLIED MATHEMATICS
1962-1967

Title	No. in 1962	No. in 1967
Advanced Mathematics	2	0
Applied Mathematics	1	3
Engineering Mathematics	2	2
Fourier Series and Boundary Value Problems	1	2
Mechanics	1	0
Numerical Analysis	2	5
Operational Methods	0	1
Business Mathematics	1	1
Introduction to Mathematical Economics	0	1
Mathematics of Finance	4	4
Mathematics for General Education	1	0
Introduction to Computer Science	0	2
Linear Programming	0	3
Field Work in Mathematics	1	1
Logarithms and the Slide Rule	2	2
Total courses (15 names)	18	27

thirty-eight courses in algebra offered in 1962 under eleven different titles while in 1967 there were forty-five courses offered with twelve different names. Courses in logic, history and foundations of mathematics were five in number under three titles in 1962, and eight in number under three titles in 1967. There were twenty-two probability and statistics courses offered in 1962 under six titles, while in 1967 there were twenty-one courses with four titles. The colleges offered fifteen geometry courses under seven titles in 1962; by 1967 the number of courses had increased to twenty-two and the number of titles to eleven. A variety of applied mathematics courses, eighteen in number, under eleven titles, was offered in 1962. By 1967 this number of courses had increased to twenty-seven under twelve titles. From this initial look at the mathematics programs it is apparent that considerably more courses are now being given in calculus, analysis, geometry and applied mathematics than were given in 1962, in some cases a 50 per cent increase in courses offered.

The study of catalogs together with some of the interview comments also revealed increases in course offerings. In 1962 the nineteen colleges teaching a standard mathematics program offered courses ranging in number from five to sixty-two, with the median being fourteen. In 1967 the minimum number of courses offered was seven while the maximum was fifty-nine; the median was sixteen. As closely as the investigator could determine, these figures reflected additional courses ranging from zero to fifteen with the median number of additions being 4.5. The number of deletions ranged from zero to six with the median being two. In all schools there appeared

to have been some restructuring and changing of other courses over the five year period, but it was impossible to determine exactly how many had been actually changed and how much. Again, it was realized that catalog descriptions and even course syllabi do not give a completely accurate picture of what is taught, and certainly not necessarily how it is taught. Courses and content are most often a function of the teacher involved. Nevertheless, it was quite clear that changes in curricula had been occurring at varying rates and in some instances would continue to occur. Specifically, eight schools reported anticipated curricular revision of varying magnitude, and four others listed several additional courses planned for the near future.

In light of the fact that this study is focused on the CUPM recommendations and their effect on curriculum, it seems appropriate to examine the specific changes in the curriculum in those mathematical areas with which CUPM specifically dealt. While there were courses added (or changed) in a variety of topics, we consider for the moment only those which correlate with the courses recommended for a general curriculum in mathematics and for a curriculum for teacher training. It might be added at this point that, whereas the study sought to examine three different curricular organizations (general program, teacher training, and preparation for graduate school), this goal was not completely realized. Virtually no college had established in writing any specific requirements or course sequences for graduate school preparation per se. Only six colleges made any distinction at all between general majors and majors

preparing to teach. It was conceded by at least eight chairmen in the other colleges that they suggested differing programs (over and above a few basic courses) for different vocational plans but this was done purely through advisement, on an individual basis, with little or no attempt to maintain rigid patterns of programs. In view of this, the following comments will attempt to analyze the mathematics course offerings of each college as they relate to the CUPM suggested courses; where information was available, further comments will be made about departmental requirements.

General Curriculum in Mathematics

In Chapter II, the recommendations for courses for the general curriculum were stated. With the exception of the elementary calculus courses, this list is repeated here for reference:

Mathematics	2P	- Probability
Mathematics	3	- Linear Algebra
Mathematics	5	- Advanced Multivariable Calculus
Mathematics	6	- Algebraic Structures
Mathematics	7	- Probability and Statistics
Mathematics	8	- Numerical Analysis
Mathematics	9	- Geometry
Mathematics	10	- Applied Mathematics
Mathematics	11	- Introductory Real Variable Theory I
Mathematics	12	- Introductory Real Variable Theory II
Mathematics	13	- Complex Analysis

[14]

These eleven courses, and their accompanying descriptions, were used as a framework upon which to compare the programs in the twenty colleges in the study. The elementary calculus courses were omitted from this analysis since all twenty colleges offered some work in this area, but in such a variety of organizations, credits

and fusion of topics as to make any summary meaningless. Tables 1 and 2 bear this out.

In first considering merely the number of courses from the above list of eleven which were offered by the colleges in 1962, the investigator found a variation in offerings from zero to eleven. The median number of courses offered was five while the mode was four. One college appeared to offer all eleven recommended courses, another listed ten courses, one college slated eight, and three institutions offered seven courses. Three schools offered six of these courses, one listed five, four provided four of the courses, two slated three of them, while one college offered two and another only one. One institution offered none of the recommended courses (in fact, no work above elementary calculus). St. John's College was again omitted from this analysis since the courses offered there are completely different from those recommended by CUPM.

The picture changed slightly when one looked at the offerings for 1967. In this school year, the range of offerings was from one to eleven, with the median being seven and the modes being seven and six. Again one college appeared to offer all eleven recommended courses while two institutions listed ten such courses. One college offered nine courses, two slated eight, four listed seven, and four listed six. Two schools offered five courses, one provided four of the courses, and two offered only one. It is clear from these data that, as far as the eleven CUPM recommended courses for a general curriculum are concerned, there has been an overall increase in the number of them being offered in the Maryland colleges over the five

years of the study. Of the nineteen schools in this part of the analysis, ten had added one or more of these courses, eight offered as many in 1967 as in 1962, and only one offered less in 1967 than in 1962.

Turning now to the specific courses in question, it was found that in 1962, of the nineteen schools under consideration, ten offered Mathematics 3: Linear Algebra in some form or another, although not necessarily under this title. By 1967, seventeen colleges were offering one or more courses in this area, an increase of seven colleges (or a 70 per cent increase over the 1962 offerings). Also, by 1967 five colleges now appeared to be offering linear algebra to sophomores. Mathematics 5: Advanced Multivariable Calculus seemed not to share the same growth. Whereas in 1962 six colleges appeared to offer course work in the areas described for this course, in 1967 only four colleges seemed to be offering comparable courses.

In 1962 Mathematics 6: Algebraic Structures appeared to be offered by seventeen colleges with one school offering a second course in the same field. By 1967, although the number of first-course offerings had risen only to eighteen, the second-course offerings had risen to six. Thus the total offerings in algebraic structures had risen from eighteen courses to twenty-four in the five year period.

The CUPM recommendations included two courses in probability and statistics: Mathematics 2P and Mathematics 7. In 1962 sixteen colleges were offering a first course, while eight offered a second

course in addition. By 1967, the number of first-courses being offered had dropped slightly to fifteen (two colleges dropped their offerings entirely), while the second-course offerings had risen to ten. Thus the total offerings in this area had grown only slightly, from twenty-four to twenty-five. Mathematics 8: Numerical Analysis showed a slight gain, from three courses offered in 1962 to five offered in 1967.

Geometry (Mathematics 9) seemed to be offered in one form or another in eleven colleges in 1962. Three of these colleges also offered a second-course in the field. By 1967 the number of first-courses had risen to fifteen while the second courses had increased to five. Hence the total geometry offerings had grown by 43 per cent, from fourteen to twenty over the five year period. Applied Mathematics (Mathematics 10) was offered in four colleges in 1962 and in five in 1967. One college had dropped its course while two others had begun to offer courses in the five year period between 1962 and 1967.

In 1962, Mathematics 11: Real Variable Theory I was offered in ten colleges while seven schools also offered Mathematics 12: Real Variable Theory II. The study revealed that in 1967, sixteen colleges were now offering Real Variables I and nine now offered the second course. Thus real analysis courses increased in total from seventeen to twenty-five in number over the period of the study. Complex Analysis (Mathematics 13) also was offered in more schools in 1967 than in 1962, the number of courses having increased from six to eleven.

In summary, it is clear from the data outlined above that the number of course offerings for the mathematics major had increased noticeably in the following areas: linear algebra, geometry, real analysis and complex analysis. A second course in algebraic structures was also offered in more institutions. On the other hand, there was little noticeable gain in the number of course offerings in probability and statistics, numerical analysis or applied mathematics, and there was actually a decrease in the offering of advanced multivariable calculus over the five year period of the study. One final comment seems in order: although the colleges declared no specific program for preparation for graduate study in mathematics, it is interesting to note that the two-semester sequences in both algebra and analysis (as recommended by the CUPM panel) had become a reality in a number of institutions (six for algebra and eight for analysis) during the years 1962-1967.

Curriculum for the Training of Mathematics Teachers

As soon as the interviews were well under way, the investigator realized that, perhaps due to the state certification requirements, the colleges prepared teachers for essentially only two levels, elementary and secondary schools. Whereas CUPM had made specific recommendations for three levels which had included an intermediate level of junior high school, the colleges made no such official distinction. Consequently, the data received for analysis had to be compared with only the Level I and Level III recommendations

as stated in Chapter II. These are repeated here for reference.

Level I (K-6)

- (1) A two-course sequence devoted to the structure of the real number system and its subsystems.
- (2) A course devoted to the basic concepts of algebra.
- (3) A course in informal geometry.

Level III (High School)

- (1) Three courses in analysis
- (2) Two courses in abstract algebra
- (3) Two courses in geometry beyond analytic geometry
- (4) Two courses in probability and statistics
- (5) A course in computer science
- (6) Two upper-class elective courses, perhaps introduction to real variables, number theory, topology, history of mathematics, or applied mathematics. [24]

Of the twenty colleges represented in the study, twelve had specific programs for Level I. One other college prepared teachers only for early-childhood education (K-3). Seven of these schools are state-supported while the other six are private institutions. The investigation revealed that in 1962, the colleges preparing for K-6 required exactly two courses in mathematics, this being the state certification requirement for elementary teachers. These courses took a variety of forms and names, usually incorporating elements of arithmetic (number systems) and some elementary algebra and geometry. A fairly common (six of the twelve) set of titles for these courses was Fundamental Concepts of Arithmetic and Fundamental Concepts of Mathematics. In this year, the early-childhood education program did not require any mathematics. An examination of the 1967 program provided no significant changes except that the K-3 program now required, by law, one course in mathematics and the one college

specifically involved now offered Elements of Modern Mathematics. The interviewees commented on course restructuring and content reorganization within the basic two courses, but no additional coursework was required. By this time, however, four institutions were offering to prospective teachers at Level I an elective course in geometry. No figures were available as to how many students availed themselves of this opportunity. It seems, then, that although CUPM recommended four mathematics courses for elementary teachers, only two courses are presently required, apparently because of state certification requirements and very full preparation programs for this level. The content of the courses, however, seems to be roughly in the same areas (although not in the same depth) as those recommended for the four CUPM courses.

When the recommendations for Level III are considered, it must be remembered that the twelve courses listed are presented as minimal content requirements for the training of high school mathematics teachers. Sixteen of the twenty colleges offer programs of mathematics teacher training for Level III, and one other school offers the equivalent of a certification major although it has not yet been empowered to offer a full major in mathematics. The chairmen in these seventeen schools were asked the question: "What are the course requirements in mathematics for students preparing to teach high school?" Their answers varied considerably, since some departments specify a rather complete program of studies, while others require only a small number of basic courses and build an individual tailor-made program for each student in conference with

his adviser. Nevertheless, it was found that in 1962, the minimum number of courses required was six, while the maximum was twelve; the median was nine courses required. In 1967 the range of number of courses required was still the same, from six to twelve, but the median had now risen to ten; the mode was also ten, six schools stating that they required ten specific courses of their mathematics teaching majors. When one considers the status of the twelve CUPM recommended courses over the five year period, a different picture results. In 1962, the range of required courses from the CUPM list was from two to nine with the median being five. In 1967 the range was now from three to ten, with a median of seven. The obvious conclusion that one can draw from these data is that, although a number of mathematics courses were and are being required of prospective mathematics teachers, they are not necessarily courses which CUPM had recommended. A more detailed analysis of these courses follows.

Virtually all of the seventeen colleges involved with teacher training for Level III required the equivalent of three courses in elementary analysis (calculus) both in 1962 and 1967. On the other hand, required courses in abstract algebra had increased considerably. In 1962, four colleges required one course in algebra, and one of these schools also required a second course. By 1967, the number of schools requiring such a course of prospective teachers had risen to fourteen, and five of these schools also required a second course in the field. These figures, of course, do not take into account the

possibilities of elective courses which were offered in the general curriculum, a full description of which precedes this discussion.

For 1962, the study revealed that five schools required one course in geometry and that no schools required a second course. In 1967, the number of required geometry courses was ten and one school required a second course. In contrast to this growth in course requirements, the study also showed that in 1962 a first course in probability and statistics was required in four colleges with one school requiring a second course. By 1967, the number of required first-courses had risen only to six, and second-courses were now required in three colleges.

Computer science was virtually nonexistent as a required course both in 1962 and 1967. However, where it was not reported by any college as being offered even as an elective in 1962, computer science was a suggested elective course in nine colleges in 1967. Several other schools proposed to include such a course, either as a requirement or an elective, as soon as finances, facilities and staff permitted. Electives in general were required of prospective mathematics teachers in nine colleges in 1962 and took a variety of forms, as is suggested in the tables provided for an earlier discussion. By 1967, the requirement of additional electives above the basic requirements had risen so that now, fifteen schools required at least one elective course and thirteen required a second elective.

By way of summary of this section, it appears that the required programs for prospective mathematics teachers had changed over the five year period of this study, with almost all of the seventeen schools increasing the requirements of courses on the CUPM recommended list. (The median number of additional required courses over the five year period was two in a range from zero to five.) Specifically, at least one course in abstract algebra and geometry had become almost universal requirements, and electives of the type described by CUPM had become more plentiful and required. It is interesting to note, however, the lack of change in the probability and statistics area over the five year period.

During the course of the interviews, the investigator sought some additional information which would give him further indications of how much change had taken place in the mathematics curricula. This information dealt with textbooks and examinations for the courses offered. It was his hope to compare the textbooks in use in 1962 and 1967 with those suggested in the reports of some of the CUPM panels, to determine not only the changes made but also the spirit and depth of the courses offered. It was further hoped that test items would give some indication of the areas of emphasis in courses as well as the amount of "modern flavor" therein. Unfortunately this goal was not realized simply because the interviewees in many cases did not have accurate records of textbooks in use in 1962 nor files of tests and examinations given in the courses in that academic year. In some instances the chairman could recall some titles, perhaps for his own courses, but few others. Where the information was

available, it was noted and later tallied. This meager information led the investigator to only the most general of conclusions.

From the titles of texts presented for the years of this study, it seemed clear that the colleges changed textbooks regularly although for little apparent reason. In 1962 very few schools seemed to be using textbooks that had been suggested by CUPM as being appropriate for the level and spirit of the recommended courses. By 1967 the usage seemed to have increased slightly. On the basis of the investigator's own knowledge of the current textbooks, and on the basis of what he was told in the interviews, it would seem that in general the textbooks being employed both in 1962 and 1967 were less rigorous and less sophisticated than those suggested in the CUPM reports. In three colleges of the twenty, the investigator obtained the impression that, although the more "rigorous" textbooks (e.g. Halmos, Finite Dimensional Vector Spaces, or Feller, Probability Theory and its Applications, Volume I or Birkhoff and MacLane, Survey of Modern Algebra) were in use, in reality the courses being offered were not as sophisticated as the textbooks. This seemed to be true in light of the students and the departmental staff, in comparison with other colleges.

In examining what few tests and final examinations were available, the investigator obtained the impression that there had been some attempt to move in a "modern" direction, particularly to emphasize theoretical aspects and proof as well as more computational matters. If these few examples were any indication of the general spirit of the courses being offered throughout the State, then the

investigator had to conclude that there is no major problem in this area. The main concern of the departments seemed to be with depth of material and how much farther they could go.

Trends in Course Changes

In order to completely and adequately describe changes in course offerings, an investigator would have to see detailed course syllabi for the time interval in question, visit and get to know each teacher and school very well to determine the philosophy and pedagogy of both the teacher and the school, and observe a number of classes of each course in session. In addition the investigator would have to involve himself in a detailed analysis of textbooks and their application to the courses. All of these things might have been possible in this study, although it seems unlikely and physically impossible. The scope of this study as well as the nature of the interview technique restricted such detailed activity. A great deal of information was obtained from both the chairmen and the college catalogs, and the results have been presented above. The comments and summaries are made with the full realization that in the final analysis, each course is really a separate, non-describable entity, an interaction between teacher and students employing a variety of aids including textbooks. What change really had taken place in the mathematics classrooms in Maryland is essentially still unknown. We can only base our knowledge of change on external signs, and these signs indicated the following trends in curriculum. Over the five years of this study there had been a definite and marked increase in

the amount and depth of linear algebra being offered in the mathematics departments. This change had been almost matched by the increasing offerings in real and complex analysis. Expanded interest in abstract algebra was reflected by the increase in the offerings of a second course in the area. To a lesser degree there had been a move toward more logic, geometry (especially for prospective teachers), numerical analysis, topology, and computer science. On the other hand, there seemed to have been a slight decrease in offerings in probability and statistics, and in areas of applied mathematics, but no reasons for this were forthcoming from the chairmen interviewed. (The reader's attention is called to Appendix E which includes a collection of supplementary tables presenting a variety of specific data on which the preceding summary comments were based.)

Logical next questions, of course, would be: "What caused these changes in mathematics curricula? Why have these particular courses been added to the curricula with such speed and in such magnitude?" The answers to these questions are not simple ones, for they inevitably involve many seemingly unrelated factors. Certainly the growth of almost all the colleges (in some cases very rapid) put pressures on the curricula of all departments. The growing and expanding needs of government, business and industry as reflected in the work pursued by the colleges' graduates cause the departments to reexamine the course offerings and requirements. Changing staffs and new faculty, many with recent graduate education, bring new ideas and fresh viewpoints for careful consideration. All these and others might be part of the answer; and perhaps the recommendations

of CUPM had some effect on the mathematics departments and brought about some of the changes described above. This effect the investigator would now like to assess.

In this chapter a brief description of each college in the study was presented and this was followed by a summary of the nature of the mathematics departments in the State. Then a description of the changes in the general mathematics curriculum and requirements for prospective mathematics teachers was given, followed by a summary of these changes and trends in curriculum. Chapter IV will deal specifically with the effect of the CUPM recommendations on the departments in the twenty colleges, as they may be reflected in the changed curricula.

CHAPTER IV

THE EFFECT OF THE CUPM RECOMMENDATIONS

In the preceding chapter, a description of the participating colleges and their mathematics departments was given, together with a detailed discussion of the changes in the mathematics curriculum that had taken place over the five year period of this study. We turn now, in this chapter, to the effect of the CUPM recommendations on the mathematics departments, to determine how many of the curricular changes described earlier can be attributed to these recommendations.

The Participants' General Attitudes Toward the Recommendations

As the investigator planned his interviews, he sought to keep them reasonably unstructured, so as to elicit as many candid reactions as possible. To this end, in each interview, instead of using a formal interview schedule, he employed a variety of questions, worded in a number of ways and aimed at providing the participant with the necessary stimuli to evoke honest appraisals of the recommendations. Basically, answers were sought to the following questions: Are you as mathematics department chairman familiar with the CUPM recommendations? What is your general feeling about these recommendations? Do you have any reservations about them? What effect, if any, did these recommendations have on your thinking as you planned for changes in your mathematics curriculum?

As was stated in earlier chapters, there was some concern in the investigator's mind as to whether he would receive accurate information and honest reactions. As the interviews got underway this concern was soon dissipated as he heard the frank comments and thoughtful answers being expressed by the interviewees. He was also delighted with the reception he received at each institution, where in almost every instance private facilities for the interview had been arranged, special materials had been collected, and interruptions were kept to a minimum. Positive verbal reactions to the study were also forthcoming from the participants who expressed interest in the project, inquired as to the findings thus far, and requested a summary of the results for their own comparative study.

During the planning stages of the study, it was decided to employ a tape recorder during the interviews, rather than try to record in writing all reactions and information. This decision proved to be most wise and practical, but it brought with it some concern as to whether some of the prospective participants might object to having their comments recorded in this manner. The use of the tape recorder was carefully indicated in the initial letter requesting the interview, and the returns indicated that only one chairman objected to the use of the recorder. He explained that he would be willing to write out and edit his remarks on some form of questionnaire, but he preferred not to speak them directly onto the tape. The problem was alleviated amicably when he suggested that the interview be held with the former chairman of the department, the individual most closely associated with the changes that had occurred

in the departmental curriculum. This interview was held in the normal fashion, employing the tape recorder, and the information received proved very helpful. The present chairman graciously provided factual information about the present department in written communications to the investigator. No one else expressed any concern over the tape recorder or seemed at all bothered by its presence during the interview. In fact, one chairman specifically expressed his appreciation for having the taped interview to obtain information rather than having to fill out a long and involved written questionnaire.

In the discussion to follow, the attitudes and reactions of the participants toward the CUPM recommendations have been summarized by the investigator, and, where it seemed appropriate, certain comments have been quoted from the interview transcripts. These quotations give further evidence of the complete frankness and honesty with which the investigator was met as he conducted his interviews across the State.

Early in each interview the investigator asked each chairman about his familiarity with the CUPM publications and recommendations. The total responses showed that virtually all respondents were familiar with at least one of the publications involved in this study. Seventeen of the twenty interviewees declared knowledge of the recommendations for teacher training; fourteen stated they were familiar with the proposals for the general curriculum; and thirteen acknowledged familiarity with the recommendations for pre-graduate mathematics study. Several of the respondents also stated that they

were aware of the publications but could not consider themselves familiar with the contents or recommendations therein.

When asked what their general reaction was to the recommendations (without regard to specific panels or courses), the interviewees all responded with positive comments in varying degrees. For example, one chairman said that "The recommendations have been a great stimulus to us to work harder," while another stated that "The recommendations are good to strive for, even if we do not necessarily reach them!" Several people also gave some indication of concerns which would be explored later in the interview when they made such comments as, "The recommendations are very good. We would like to do things that way, as suggested, but we just can't!"

As the interview progressed, the investigator sought to obtain some more specific comments about the nature of the recommendations. These responses continued to reflect a positive attitude and seemed to be summarized by one chairman who said:

I can't see how anybody can argue with the recommendations as they stand (perhaps internal content could be rearranged, but the course recommendations are quite sound). They give good coverage and balance in the various areas of mathematics.

Another comment seemed to summarize the generally receptive attitude of the total group of chairmen:

As I read the recommendations, I was impressed with the fact that the mathematics major now would have a much stronger program in undergraduate school than I had ten years ago. I was interested to see what these people thought undergraduates were capable of in the various years and tried to check whether I would have been capable of it. It helped me to think about our students and what we do here.

Although there was a generally positive and receptive attitude toward the work of CUPM, there seemed to be a dichotomy of opinion concerning the makeup of some of the CUPM panels. Although it became apparent that most of the interviewees were not directly familiar with the members of the panels, they nevertheless had certain feelings about the work of the panels on the basis of what they saw in the recommendations. One chairman commented:

Here are people who have been given time to think and to organize some ideas which will be useful to the rest of us who don't have the time to work as diligently. I think it is a good thing that there are people who are concerned about the profession.

Another, in a similar vein, stated:

CUPM is a responsible and competent group, and any committee working with mathematics curricula should give careful consideration to the recommendations, particularly since CUPM came out of the MAA which is the group of teachers of college mathematics.

Others commented that they hoped to gain from the work and experimentation of others (CUPM) since they were in a small college and could not themselves experiment very much with curriculum; the CUPM panels know what is needed in today's mathematics, and that they as chairmen should read and study what is recommended.

On the other hand there were those who agreed with one chairman who said:

I have the impression that the recommendations were written by people who had not had extensive contact with the ordinary mathematics major! The panels seem dominated by people from the prestige universities, who don't know the problems of small colleges.

Perhaps somewhat defensively, another interviewee commented:

The panels seem to come from larger schools; these people are used to having more resources and people available. I feel that we do as good a job as we can and that our students are reasonable well-prepared.

Some of these latter comments reflect some reservations about the recommendations which will be discussed in more detail later. Regardless of these, however, there seemed to be a generally positive attitude toward national recommendations, whether they be from CUPM or some other agency. As one chairman aptly stated it:

I'm grateful for having recommendations of all sorts as a source for ideas. They give something to keep your eye on, something to test yourself against, but not something that indicates 'this is it,' and nothing else matters.

His latter comment also reflects the feeling of the chairmen concerning the prescriptive nature of recommendations. Each interviewee was asked whether he felt pressured to follow the CUPM recommendations because they came from an outside, national group of mathematicians. No one indicated that they considered the recommendations overly prescriptive or demanding of implementation, although of course there were varying degrees of acceptance of the recommendations. As one interviewee commented:

I don't feel the recommendations are prescriptions, though I am well aware that far more experienced people have provided the recommendations for my thinking. They give me many ideas I wouldn't have otherwise gotten. But we don't feel pressured from anyone. We're glad to have help and the recommendations guide us and give support when we want to make changes.

One experienced chairman did reflect what he felt might be happening in some schools and offered a thoughtful suggestion:

Sometimes one gets the feeling that CUPM feels this is the way things ought to be (prescriptive). For new departments with no experience (beginning a major, for example), they might be inclined to follow the recommendations slavishly. I'm not at all sure that this is good. I think CUPM might say once in awhile, just for emphasis: 'Use your own judgment.' Anyone with experience would. The recommendations are too didactic for inexperienced people, I'm afraid.

In summary, the investigator concluded from all the comments made by all the chairmen that they were receptive to any national recommendations, particularly those from CUPM, and that they would use them as a guide to their thinking about curricular changes. There was some feeling that the CUPM panels were not completely aware of the problems of the smaller colleges, but this did not dampen the overall enthusiasm of the chairmen for the recommendations and their positive attitude toward the work of CUPM. If anything, they seemed to look with more favor and appreciation on the work of this group than on that of any others that have preceded it. They were definitely aware of CUPM, and they anticipated further CUPM activity.

This general overview of the reactions to the recommendations leads us now to a more detailed discussion of these reactions. It seems appropriate also to note those reservations about the recommendations that were held by the interviewees. With this background we can then analyze the actual effect of the recommendations on the curricular changes which have occurred.

Reactions to and Reservations
about the Recommendations

Most of the specific reactions to the recommendations were made by the interviewees with respect to their own institutions, and this seemed to be a realistic approach. One chairman summed up the situation very well when he said:

We look at our school (its size, students, staff, etc.) and think of it as something a little bit special. The recommendations were realistic as far as general recommendations can be. But every school has to see them in light of their particular situation.

Perhaps the comment heard most often by the investigator in this regard dealt with the inability of the department to implement the recommendations due to the size of the school. This was not surprising in light of the number of schools with student enrollments less than 1000. And of course, with size immediately came staffing problems. "The size of the school requires that one consider the background of the staff before merely adding a lot of new courses." Ultimately, the reactions seemed to center on the students to be taught. There was genuine feeling that some of the recommendations were not appropriate for the student bodies of a number of the colleges. A small sample of the comments expressing reactions to and reservations about the recommendations follows:

CUPM has not considered all of the different types of undergraduate programs. Smaller colleges cannot give the wide variety of courses recommended. Also, students may not come as well prepared to smaller colleges.

Some recommendations are not realistic for a small department, where staff and equipment are lacking. They may be basically good in general but totally unrealistic practically.

We've been aware of the recommendations. We felt the program was geared to some private institution or an institution that can be a little more selective than we can be. We have not had enough students who could begin where CUPM begins. We are changing our program slowly, but it is going to take a little doing.

You could easily be discouraged reading the recommendations and realizing you couldn't do anywhere near the minimum set up for college programs. There are many two or three man departments that are functioning and trying to do good jobs with what they have in students and staff.

The recommendations seem stiff for small colleges. This is true for both students and staff, particularly the staff who may not be able to teach the work recommended.

We do not try to offer as rich a selection as CUPM recommends, but this is because we are small and at times unqualified to give courses due to staff deficiencies. We have to pick what seems to fit the particular school and students.

Sometimes the recommendations are difficult to follow because of financial problems.

Having expressed these reservations about the recommendations, a number of the interviewees went on to comment on how they might effectively implement the recommendations, at least in part. A word heard many times by the investigator in this connection was "spirit." The interviewees seemed in complete agreement with the direction and "spirit" of the CUPM recommendations, whereas they could not accept them totally for a variety of reasons. Several of the chairmen indicated that while the courses offered in their departments were not as strong or as deep as those recommended by CUPM, they nevertheless followed the spirit of the recommendations. Others admitted to

a toning down of courses, both in content and coverage, while keeping the overall CUPM recommended course organization. One chairman stated:

We usually have one course instead of the recommended two in certain areas, and we go as far as possible with the help of teacher aids. In reality we may have possibly one and one-quarter or one and one-half courses in a single course rather than the two full courses.

Another suggested:

Some recommended courses cannot be given as courses, but the concepts are explored in independent study. For a small school, we are doing all that we can, considering our staff and enrollment and limited course offerings. We are doing most of the things suggested in one way or another!

Still another reacted in this way:

Let us be realistic and do only 75 per cent of the recommendations if that is what seems appropriate for the students and the staff of our college.

In summary, all of the comments above (which are indicative of many others received) indicate that in a majority of the colleges in Maryland, there was general agreement with the recommendations and their spirit, but reservations concerning their total implementation. These reservations stemmed from realistic appraisals of each institution, its size, student body, staff and financial status. The chairmen seemed in agreement that all of these must definitely be taken into consideration before trying to implement any curricular changes, and that these changes would be in the spirit of the CUPM recommendations.

The above reactions dealt with the more peripheral matters of implementation of the recommendations. It seems appropriate to turn now for a brief look at some of the reactions to and reservations concerning the course content, organization and level of rigor of the CUPM recommended courses. There were three comments which seemed to be directed to the overall recommendations. One interviewee stated his views this way:

I feel that these CUPM recommendations were all well and good, but a person needs a certain amount of maturity before they can absorb some of the concepts. The terminology can be so sophisticated as to lose the students (or things can be so intuitive as to lose the effect of the organization of the concepts). Maybe a happy medium needs to be struck in the level of rigor demanded.

In a similar vein, another chairman commented:

We need to be practical, including techniques and theory. The recommendations seem to tend toward the theoretical and to diminish or eliminate computational areas. I think that techniques are still needed.

Another criticized the recommendations in this comment:

CUPM is not oriented toward the general students and their needs. It needs a little 'humanity' mixed in, in order to encourage people to do more mathematics, not to scare them off with too much rigor early in the game. The American system of education gives rise to this humanitarian viewpoint.

The reactions to the recommendations for teacher training were generally very positive, with the chairmen expressing the feeling that they were realistic and reachable goals. There were almost no reservations expressed concerning the Level III recommendations; but several people did comment on Level II, expressing the feeling that these were less realistic than the others and inappropriate to

the needs for junior high school mathematics teachers in the State.

One interviewee specifically stated:

It seems to me that for junior high work, a student who has had one good year of college mathematics could do very well. We could look for some positive results rather than have nothing at all.

There were more comments directed toward the Level I recommendations, expressing the realistic concern that, because of the state certification requirements of two mathematics courses for elementary teachers, only two courses were planned in an already very full program. What was asked for was a revision of the recommendations to suggest what might be the content of these two courses, with a third elective course as a possibility.

There were few specific reactions to the recommendations for pre-graduate mathematical study, but there seemed to be agreement on the part of those few who did react that these recommendations were unrealistic (perhaps less so than the original set, but still so to a certain extent). One chairman noted:

The pre-graduate school recommendations seem even more unrealistic since many institutions do not offer even a master's degree as strong as the undergraduate program recommended.

Since so few schools really made any effort to design a specific pre-graduate school program, it was reasonable to expect only a minimum amount of reaction to these recommendations. Therefore, it seems inappropriate to generalize upon the limited reactions or reservations in this area.

There was a variety of comment dealing with specifics of the general curriculum in mathematics. Several comments dealt with the recommended calculus sequence and the time allotments for particular topics. Another concerned itself with the nature of Mathematics 2P; the respondent did not favor the discrete probability approach, preferring one which uses calculus. Still another commented on the lower level courses:

CUPM needs to rethink the earlier levels (lower courses). Mathematics departments also need to rethink this level and consider those students who want a 'casual' exposure to mathematics, which might grow into a deeper and broader interest. Enthusiasm is the key here, not rigor.

With all the reactions (at least partially negative) and reservations expressed or summarized above, one could easily raise the question of how much effect these recommendations could have had on chairmen who expressed so many doubts and concerns. However, it must be remembered that the overall reaction to the recommendations was positive, and that what were expressed in the way of reservations seemed to be, in a sense, constructive criticisms of something considered basically good. With this in mind, it seems appropriate now to turn to the analysis of the effect of the recommendations, to see how much direct effect they had on the departments as they made curricular changes.

The Effect of the Recommendations upon the Department and its Curriculum

During the course of each interview the discussion ultimately led to a consideration of the most important questions: Have you

used the CUPM recommendations, and how would you assess their effect on your thinking about curricular revision? The answer to the first part was affirmative in almost every case, although the degree of use varied. Perhaps the most usual reaction was similar to this comment made by one chairman:

We pay careful attention to several things. The recommendations give good direction and guidelines in the thinking about what the mathematics program should be, but we still use our own professional competencies and backgrounds to temper the recommendations. It is an interaction of all these things.

The key word in so many responses was guideline, and this did not seem surprising when the investigator reflected on the numerous comments which had been made concerning size and staff problems. There seemed to be almost complete agreement that the recommendations had to be used, not as prescriptive rules to follow, but as guides or suggestions to be considered in the context of the individual institutions, their student bodies and staff. Some interviewees accepted the recommendations more completely than other respondents, but all seemed positive in their approach to the use of the recommendations. It was particularly interesting to hear a few chairmen comment in the spirit of this remark made by one interviewee:

Professional mathematicians as we have here on the staff are in the same mainstream of mathematics as the members of the CUPM panels, so we are up on what is going on and what areas need strengthening in our own program, specifically what is needed for graduate work.

The investigator did not construe this remark to be at all disparaging of the CUPM work, but rather one of keen pride that this department was of an academic and professional level comparable

to CUPM. This situation, however, seemed not to exist very often, for more often were heard such comments as:

I like to have the recommendations around to see what the possibilities are; then when I have taken a good hard look at them, I feel perfectly free to reject them. I don't feel guilty in omitting something just because it's a national recommendation. I am glad they are there because they include things I would not have thought of or considered necessarily.

This comment seems representative of more that were made by the chairmen when they considered specifically how they used the recommendations in thinking about curricular revision.

There was, however, another use of the recommendations which is worthy of mention. It appears that, regardless of the specific reservations that the chairmen might have about the recommendations, they found them very useful as supportive documents when they had to discuss and defend curricular changes in academic councils and with deans. One chairman put it this way:

Teachers need the support of an organization like CUPM; if you were going to the curriculum council or the dean, you have a lever, a national weighty group to back up your personal recommendations. We're in the midst of a curriculum revision and we may need to insist on certain programs with CUPM backing.

Another interviewee stated his feelings succinctly in these words:

The recommendations are good help when working with administrators. They enable you to get done that which you probably would have done anyway!

Thus it appears that the CUPM recommendations are used, as guidelines and as levers, to promote and stimulate thought and action in curriculum change.

In attempting to assess the effect of the recommendations on their professional thinking, a number of chairmen quickly pointed

to direct influences. Several reported that the recommendations for the general curriculum were used as a basis for recent curricular revision. They were quick to point out that they had not been able to incorporate all of the courses in the suggested depth, but they definitely had relied on the recommendations during the revision. Another chairman indicated the CUPM influence was present when his department was establishing a major. He reported that, "rather than duplicate our own undergraduate program, we used the CUPM recommendations in planning our new program, as a guide." Still another chairman was very positive in attributing direct influences to CUPM. He described his situation in these words:

When we set up our original major program several years ago, we studied the CUPM recommendations and came up with a reasonable program for the students here. This program was taken to the New York meeting of CUPM to get reactions. We got favorable reactions and felt that we had moved in the right direction. Interaction and criticism from CUPM helped us to analyze the program and to develop it.

Several of the interviewees were specific in the ways that the CUPM recommendations had had a direct influence on them. Three commented that they incorporated linear algebra earlier in their program as a result of the general curriculum recommendations. Another indicated that the establishment of a sequence of probability and statistics courses was a direct result of the recommendations, as was the retention of a geometry course. Several chairmen stated that they had rethought and restructured the courses for elementary teachers in light of the recommendations for Level I. All these comments and others from about one-third of the participating schools indicated to the investigator that the CUPM recommendations had had some

direct influence on the thinking and planning for curricular revision in the Maryland colleges. What was equally important was the fact that four other chairmen indicated that they would be using the recommendations in the future, in effecting further revision. One in particular was in the midst of moving toward a full mathematics major and was already giving the CUPM publications careful scrutiny. There can be no doubt that there has been and will be direct influence from CUPM on the mathematics curricula in the colleges of this state.

The remarks of a larger group of interviewees indicated another important level of influence--the indirect but positive effect of the recommendations via several sources. At least seven different sources of stimuli for change were mentioned by the chairmen who went on to indicate that they felt CUPM was in the background of each of these sources. Several people mentioned the National Science Foundation summer and academic-year institutes as having been very effective in updating staff members. One chairman spoke of these institutes:

CUPM has had an indirect effect here. Many of our staff have attended NSF institutes or taught in them, and have come back with new ideas and modern approaches to mathematics teaching, as well as to what to teach and what should be offered. The effect of CUPM on the NSF institutes has been strong, I think, so we benefit from these indirectly.

Another interviewee credited the Maryland School-College Mathematics Association with giving him new ideas about the preparation of elementary teachers. He realized that the MS-CMA had in turn been greatly affected by CUPM and thus saw another indirect influence.

One chairman of a growing and changing department admitted that he often used catalogs from similar colleges throughout the state as guides to curricular change, and indicated that, since a number of these colleges had been influenced by CUPM and had implemented some of the recommendations, he too was affected indirectly by CUPM.

Still another area of indirect influence was mentioned by one interviewee who stated that he consciously chose textbooks which had been written in the spirit of CUPM (or at least which indicated such a direction in the preface). In this way, he felt he was very much influenced by CUPM, albeit indirectly.

Several other chairmen stated that they had gained new insights and ideas from meetings where representatives of CUPM had spoken and/or discussed the recommendations. But perhaps the greatest number of respondents indicated indirect influences via the graduate schools where they or their staff had recently studied. They felt a definite tie with CUPM here since they saw the recommendations originating from and already in effect at the universities. From their academic experiences they brought to their own campuses fresh ideas and a new awareness of the developments in collegiate mathematics.

All these comments led the investigator to conclude that there also had definitely been an indirect influence from CUPM which was reflected in the curricular revision which had gone on during the five year period of this study.

It was interesting to hear several chairmen comment that they had devised the basis for their present curriculum before

reading the CUPM recommendations, and that upon seeing them, they were pleased to see that their thinking agreed in essence with that of the CUPM panels. One might be able to conclude from this "pleasure" that there was acceptance of the CUPM suggestions, indeed a strong tie with them for future use. Although obviously there was no influence here, the recommendations were considered valuable and were given special comparative study. Such a reaction gives further credence to the investigator's summary of basic attitudes toward CUPM work.

Although it would be pleasant to report that all schools felt either direct or indirect influence from CUPM, such was not the case. Two respondents indicated that they honestly could see no real effect on their thinking as a result of reading the recommendations. One stated his views:

I'm not sure that any of the changes that have taken place here have been due to the recommendations. To have the recommendations is not a bad idea for they at least get people thinking about things--they get some new ideas. They are, however, informal stimuli to thought, etc.

This chairman perhaps did not consider this "informal stimulus" to be an indirect effect, when in actuality it might well have been just that. The other respondent expressed his feelings in these words:

I have been following what has been done by CUPM all along and I can't say that we have made an abrupt change from one thing to another. I feel we have through the years been trying to improve our offerings and to meet the abilities of students as they came along, regardless of the recommendations.

These views are certainly not really negative toward the work of CUPM, but are honest appraisals of the thinking going on in two departments.

Perhaps, however, a third chairman really summed up the total CUPM effect in these thoughtful words:

There would have been some changes in curriculum without CUPM, but the changes would not have been nearly as far and as widespread as they are now. NSF had a big effect too, but CUPM has had an overall general effect which is just as positive, though not as easily pinned down.

Before considering the final section of this chapter, it seems appropriate at this point to include the reactions to one of the other CUPM publications--the Basic Library List [3]. It was interesting to the investigator to note that, whereas the highest number of chairmen reporting familiarity with one of the sets of recommendations was seventeen, nineteen declared awareness of this adjunct publication. Furthermore, the reaction to it was universally favorable. A number of chairmen reported that the list had been used as a basis for evaluating their library holdings. Most indicated at least some attempt to fulfill the basic list wherever possible and appropriate. Several comments about the library list follow:

The CUPM Library List was very valuable. We were very happy to have it. We have used it extensively and are now close to the recommended basic list. They should continue to revise it, every two years.

Someone has done a lot of thinking on the library list. We don't have that much time available, so the list has been very helpful to us. We have used it extensively here.

We went down the Basic Library List and saw that we had a book equivalent to the recommendations or we decided that there was no need for it since no one would read it. We didn't order a book for prestige purposes. We did make an effort to fill in, to see where we were weak. We used it as a guide. We gave it to our librarian to check our collection against it.

I've used the Basic Library List as a guide, because we have a very limited budget; I wouldn't say I felt restricted to this at all. The way I feel about it, these are people who are knowledgeable in the field, people who have spent a good deal of time working on this, and it would be very foolish of me not to take advantage of it and use it.

It appears to the investigator that this publication has received widespread use and much positive reaction throughout the state. As several chairmen commented, a revision of the list does seem needed, to update it since 1965.

The Role of CUPM in the Future

Toward the end of each interview, after general attitudes, specific reservations and the analysis of the effect of the recommendations had been discussed, the investigator asked the interviewee: In what direction do you think CUPM should move now? Are there areas of concern to you that you would like to receive help with from CUPM? These questions elicited a variety of responses. Three chairmen requested help with the freshman level courses, basing their desire on the annual difficulties they had had in trying to find out what mathematics the entering students had studied. They would like to know generally what to expect from entering students and looked to CUPM to make such a national study and perhaps even some recommendations for the twelfth-year course for high schools.

Another chairman expressed a desire to see more detailed recommendations for an applied mathematics program, since a large part of his department's work must be in this area.

Two related problems were raised by two interviewees. One asked:

What do we do with secondary school teachers who need undergraduate courses but who can't get credit for anything but graduate courses in mathematics?

He asked for some definitive suggestions for a worthwhile in-service program which would up-date mathematical backgrounds of teachers and still be of a level to meet state certification requirements. A similar issue was raised by another chairman who suggested that CUPM should look into the programs for master's degrees in mathematics. He wished to see recommendations for these graduate programs which would correlate realistically with the recommended undergraduate programs.

One of the most prevalent comments was an outgrowth of the reservations held by a number of people concerning the recommendations. Those individuals who teach in small colleges were quite vocal in their concern that the CUPM recommendations were not designed for small (two to four man) departments. The investigator soon sensed an air of frustration, even a little bitterness, as these people urgently requested help. The following sample of comments indicates their feelings:

The recommendations were not made for two-man departments; they forgot us!

Another set of recommendations needs to be written similar to the general recommendations, but at a slightly less rigorous level to guide smaller colleges.

CUPM needs to consider schools which are not university calibre but which are training mathematicians as best we can. We need help too, appropriate to our situation.

My general feelings are that national recommendations think primarily about the best prepared students. These don't deal with the world in which I operate. The best I can do is to pick off the best that we can use and forget the rest. After all, our graduates are worthwhile too and need good programs too! We all serve a very important function.

The many comments like those above from the smaller colleges clearly indicated to the investigator that these chairmen would very much welcome and appreciate what they would consider to be more realistic recommendations from CUPM regarding appropriate curricula for the small mathematics department.

Still another area of concern was expressed by a chairman when he said:

CUPM should look closely and be concerned with the general liberal arts student who may take perhaps one year of mathematics. What is a meaningful program?

This person went on to raise an interesting point for future thought when he suggested:

Maybe CUPM should look at the recommendations and ask what happens to the students out of such programs in ten years. Will they still know mathematics and its foundations?

Although for the most part the interviewees were aware of the recent CUPM concentration on the preparation of college mathematics teachers, there was still some vocal concern that CUPM was not really getting to the heart of the matter--the teaching act itself. One respondent suggested that CUPM could perhaps prepare some supplementary materials and hints on how to teach various mathematical concepts. He felt that these would be very beneficial to teachers in small schools where there may be no one with whom to talk, to confer or to share teaching ideas. Another of the interviewees seemed very

concerned with this whole problem of teaching mathematics and made some very interesting observations. In order to present the full flavor of his comments, his remarks on this issue are quoted in their entirety below:

CUPM needs to take a look at the teaching of mathematics, at the undergraduate and graduate school levels, by lecture. I think reform is good, particularly for the colleges that need to modernize. But there is this greater problem. What they need more is a good setting for learning. CUPM assumes that the colleges know what to do with the updated courses once they are put into college programs. Probably most of the CUPM panels don't know or don't consider this problem. They are more interested in mathematical research than in problems of teaching mathematics. Lecturing is easy. Questioning and discovery are hard.

Have we considered what goes on in the classrooms where we want all this new curriculum (as recommended by CUPM) taught? Have the panel members themselves considered how they teach all this mathematics?

I have no objections to the proposals. My objections lie with the pedagogical idea that we teach by lectures, not seminars; that students cannot read! Let them effect this reform in curriculum--I'm all for it--but this is not looking at the teaching.

Is it true that the undergraduate is unable or unwilling to read, and therefore that the instructor should place a book on the blackboard at a faster rate than the student can follow, always?! On their own they learn mathematics, but the classes are lost. The subject matter isn't the problem. It is the structure of the classes which does not help the student learn. The student learns often in spite of that, under the pressure of exams and because of his own initiative. One can learn a lot from any type of method, but he can learn more by seminars and the tutorial method.

Whether CUPM could provide help on any or all of these problems, or whether it even should be involved with them is beyond the scope of this discussion. What does seem quite clear to the investigator is that CUPM has had a definite effect on collegiate mathematics in Maryland in a variety of ways, some direct, some indirect, and some very difficult to assess with any precision.

Furthermore, the attitudes toward the work of this national group were favorable as is borne out not only by the earlier comments made by the chairmen, but also by their expressions of hope for continued help in the future. It appears that it is to CUPM, more than any other single national group, that the chairmen look for guidance and help in a variety of curricular matters.

In this chapter an analysis of the effect of the CUPM recommendations on the Maryland colleges was presented, including general attitudes toward the recommendations, specific reactions to and reservations about the recommendations, and direct and indirect effects of the recommendations on the curricular changes which occurred during the five year period of the study. Also included was a discussion of the role of CUPM for the future, as expressed by the interviewees. In the final chapter a summary of the entire study will be presented together with an assessment of the recommendations and some observations for future consideration, both by the Maryland colleges and by CUPM.

CHAPTER V

SUMMARY, CONCLUSIONS AND OBSERVATIONS

The Problem

It was the purpose of this research to study the mathematics curricula of the colleges in the State of Maryland

- (a) to determine what the mathematics curriculum of each undergraduate colleges was five years ago;
- (b) to determine what the mathematics curriculum of each college is at present;
- (c) to determine any trends in the development of the collegiate mathematics curricula in the State;
- (d) to determine what influences the recommendations of the Committee on the Undergraduate Program in Mathematics (CUPM) had on the collegiate mathematics curricular changes:
 - (1) in the program for the general curriculum in mathematics;
 - (2) in the program for the training of teachers of mathematics;
 - (3) in the program for the preparation for graduate study in mathematics.

Related to the problem was the attempt to determine the academic, professional and experiential backgrounds of the faculty members in the departments of mathematics in the colleges of Maryland.

The Procedures

In order to obtain the necessary information for an analysis of the effect of the CUPM recommendations, the investigator interviewed the chairman of each mathematics department, tape recording the entire discussion for later transcription. The catalogs of each school, both for 1962-1963 and 1967-1968, were also collected and studied. The data sought were:

- (1) brief background about the institution and the mathematics department;
- (2) background information about the person being interviewed and the other members of his department;
- (3) the changes in the mathematics curriculum in the college since September, 1962;
- (4) the present mathematics curriculum, degree or major requirements, and textual materials employed;
- (5) the factors, as perceived by the interviewee, which influenced the curricular changes, particularly the effect of the CUPM recommendations;
- (6) the feelings about the CUPM recommendations held by the interviewees.

Twenty of the twenty-one four-year colleges offering a major or concentration in mathematics agreed to participate in the study,

which had been given backing by the Maryland School-College Mathematics Association.

After all interviews were completed, the investigator then made a detailed analysis of the changes in the collegiate mathematics curricula. The transcripts of all the interviews were also carefully studied to determine the total effect of the CUPM recommendations on the participants as they saw it and communicated it.

A summary of the findings, conclusions and observations will be sent to each participating school for their study and consideration.

Because of the subjective nature of the study, certain assumptions had to be made at the outset to undergird the investigation of the problem. These were:

- (1) People responding to the questions in the interview would be honest in reporting factual data and in discussing the changes in collegiate mathematics curricula and the influence of CUPM on these changes.
- (2) The chairmen of the collegiate mathematics departments throughout the State would be knowledgeable about the changes in their departments and the factors influencing these changes.
- (3) The catalogs of the colleges in the State of Maryland would report reasonably accurately the course offerings and requirements in the mathematics curricula of the colleges.

As the study progressed it became evident to the investigator that these assumptions were well-founded, for he consistently felt

that he received from knowledgeable, professional individuals honest and candid comments to all his probing questions. While maintaining an objective approach to the recommendations himself, he felt that the participants provided willingly a wealth of subjective information for comparison and analysis.

The report of the entire study was prepared and was divided into five chapters. In the first chapter the investigator outlined the problem, its design and significance. In the second chapter the development of CUPM and its recommendations were presented. Chapter Three dealt with the participating schools and the changes in their mathematics curricula. The effect of the CUPM recommendations on the curricular changes was discussed in Chapter Four; this chapter also included the views of the participants concerning the recommendations and the future role of CUPM. Chapter Five presented a summary of the study together with conclusions and observations drawn from the study.

Major Findings and Conclusions

The study revealed that, for the five year period (1962-1967) under consideration, there had been considerable curricular change. There had been a definite and marked increase in the amount and depth of linear algebra being offered by the mathematics departments. This change was almost matched by the increasing offerings in real and complex analysis. Expanded interest in abstract algebra was reflected by the increase in the offerings of a second course in the area. To a lesser degree there had been a move toward more logic,

geometry (especially for prospective teachers), numerical analysis, topology, and computer science. On the other hand there seemed to have been a slight decrease in the offerings in probability and statistics, and in the areas of applied mathematics, but no reasons for this decrease were forthcoming from the chairmen interviewed.

From all that he could observe, the investigator concluded that the spirit in which the mathematics courses were taught was a modern one, and that in most cases the staff was reasonably well prepared academically to teach the courses in the modern curricula. These courses were generally not as rigorous or as deep, however, as those recommended by CUPM, and usually employed less sophisticated and rigorous textbooks.

With regard to the three types of programs given special consideration in this study, it was found that offerings of courses listed in the general curriculum proposal had increased in number over the five year period, as had the courses and requirements for teacher training. Less change seemed to have occurred in the Level I area than in Level III, while Level II, as a distinct program, was almost nonexistent. It also became evident to the investigator that very few colleges prepare students in any special way for graduate work in mathematics, due primarily to the size of the institution and the number of majors in each program. Hence, no conclusions could be drawn about the changes in the offerings in the pre-graduate program.

The study also revealed that there was a universal positive attitude toward the CUPM recommendations, each chairman expressing the feeling that there was value to be gained from having them.

A number of reservations about the recommendations were expressed, however, the major one being that CUPM had not considered the smaller institution and its problems. There was no feeling on the part of any participant that he was pressured to adopt or implement the recommendations, but in almost every instance the interviewee stated that he had used the recommendations as guidelines, choosing from them the most appropriate elements in light of his particular students and staff. Often he used the recommendations as a lever when dealing with administrators concerning curricular changes.

From all that was heard and observed, the investigator concluded that the CUPM recommendations did have an effect on the collegiate mathematics departments in Maryland. The effect seemed to be more indirect, informal and sometimes incomplete than direct and formal. In only a few instances in large schools could one see the recommendations fully implemented. In most other cases, the schools seemed to have incorporated as much of the recommendations as seemed realistic for their situation. Certain courses had been put into the curricula as a result of the recommendations, but more often the changes had been brought about through an eclectic process, employing knowledge gained from National Science Foundation Institutes and graduate schools, broad reading of a variety of curricular publications including other schools' catalogs, textbook approaches and comments, and attendance at meetings where the CUPM recommendations were discussed. All these stimuli to thinking seemed to have a tie with CUPM and hence showed an indirect influence from this organization. The participants suggested a number of areas which CUPM

might choose to explore; their hope is for continued CUPM activity and revision of present documents. There was no totally negative attitude expressed toward CUPM or its work by any participant; on the contrary, in spite of the reservations and occasional frustrations expressed by the chairmen, the overwhelming feeling seemed to be that CUPM had done a good job, that it perhaps had overshot the mark at times, but that it should continue to provide much needed guidance to the undergraduate college mathematics program.

Observations and Recommendations

It appears to the investigator that, while the colleges in Maryland are doing an adequate or better job of training beginning mathematicians for a variety of occupations, this work will become increasingly difficult in the years ahead. Many of the departments are small, both in staff and students, and this creates a number of problems. To alleviate further frustration and limited program offerings, several neighboring colleges might well consider joining forces, to provide a single, comprehensive and strong department which is economically feasible. This seems particularly appropriate for consideration by the smaller private colleges, many of which are or soon will be in serious financial difficulties. The advantages to such a proposal seem obvious but they must, of course, be contrasted with the disadvantages which are also inherent in such an arrangement.

Regardless of any departmental reorganization that might occur, it appears that more offerings in probability and statistics are definitely needed in most of the colleges. This growing area of

mathematics cannot be ignored, any more than computer science can be, at this time in our nation's growth. A reassessment of the total mathematics curriculum should be made by each college to determine how such offerings can be effected.

Turning now to the work of CUPM, it appears to the investigator that one difficulty in communication needs to be alleviated as soon as possible. The study revealed that all too often the recommendations for particular programs got to the departmental chairman's desk and remained there, so that no other staff members were aware of what CUPM was doing in their specific area of interest. A broader mailing list might relieve this problem, as would an appeal to the recipient to pass the materials along to other concerned individuals. Furthermore, it appears that not all publications are received; for example, the 1966 revision of the teacher training recommendations was not in the hands of a number of chairmen. Also, several chairmen asked for materials which they were not aware had already been published (for applied mathematics and for elementary teacher education). It is also clear that at times the recommendations are not read carefully or thoroughly. Perhaps a well-written, tabular summary could be included in each document to provide an overview of the contents for quick reading and easy reference.

Aside from these more mechanical problems, it appears to the investigator that CUPM is in an excellent position at this time to be of great assistance to many mathematics departments as they are being developed or expanded. To this end, it seems worthwhile

to recommend several areas which require immediate consideration if CUPM is to take full advantage of its present favorable status:

1. Recommendations for several alternate curricula should be drawn up for the small college mathematics department. These should make clear that they represent not an ideal curriculum but only a start towards one. A variety of suggestions for textual materials, time schedules, and major requirements should also be included to help the new departments get a good start, in a realistic manner.
2. Reconsideration of the Level II recommendations for teacher training should be undertaken, in light of the national trend away from junior high schools. Surveys of present teacher shortages might suggest that a less-expansive minimal program (as compared with the present Level II) be recommended in lieu of no training at all.
3. Recommendations for a twelfth-year senior high school program should be drawn up, with several alternatives and tracks possible, so that some reasonable correlation between the pre-college and college mathematics programs can be effected.
4. Recommendations for a realistic master's degree program in mathematics should be considered, in an attempt to correlate with the present undergraduate

programs. Such recommendations should be periodically revised and upgraded as undergraduate programs continue to improve. Also, suggestions for a worthwhile in-service program for teachers should be drawn up, with an eye to meeting state certification requirements.

5. A variety of short publications dealing with the teaching of specific mathematical concepts should be considered by CUPM, to provide a service to those teachers who would like to do a good job in their classrooms in the CUPM spirit. Written by master teachers who have demonstrated special skills in this area, these publications could go far to improve undergraduate mathematics education. A broader consideration of teaching might also be helpful to the CUPM panels as they strive to create realistic recommendations for undergraduate colleges.
6. The Basic Library List and other similar publications should be revised and updated every two years to keep them in tune with the many developments in the constantly growing field of mathematics.

In conclusion, one cannot escape the fact that collegiate mathematics must continue to change to keep pace with the changing world. The Committee on the Undergraduate Program in Mathematics has, in at least one state and probably throughout the nation as well, served a very worthwhile purpose of guiding change. In fact, it appears that this organization has had more overall, longrange effect

on collegiate mathematics curricula than any other single national group. It has raised our sights and brought the mathematics teaching profession together for meaningful discussions. It can and should continue to be a strong, viable force in the uncertain future.

APPENDIX A

UNIVERSITY OF VIRGINIA
SCHOOL OF
ENGINEERING AND APPLIED SCIENCE
THORNTON HALL
CHARLOTTESVILLE

DEPARTMENT OF
APPLIED MATHEMATICS
AND
COMPUTER SCIENCE

June 15, 1967

Mr. James E. Lightner,
Morrison Tower,
196 West 11th Ave.,
Columbus, Ohio 43210.

Dear Mr. Lightner :

Thank you for your letter of June 10 about existing studies of CUPM impact. Your question is one which is best handled by the Central Office of CUPM, Box 1024, Berkeley, Calif. I am sending your letter to them.

Actually I think you will find that little or nothing exists in the way of formal studies of CUPM influence on college mathematics. The difficulty with such evaluations is that colleges, in contrast to public schools, do not adopt or reject a proposed program. They do not go over to CUPM as schools go over to SMSG. They either read a CUPM recommendation, or do not. If they read it, they may be influenced by it, consciously or unconsciously. They may even adopt some parts of it, aware that they are following the CUPM suggestions. Even then, they probably do not say so specifically. I think that few colleges have remodelled their programs to follow CUPM recommendations, or reasonable adaptation thereof, in entirety. It was not to be expected.

There is probably more effect on colleges involved in teacher preparation.

Sincerely,

WLD:vb

COMMITTEE ON THE UNDERGRADUATE PROGRAM IN MATHEMATICS

LINCOLN K. DURST
Executive Director

MALCOLM W. POWNALL
Associate Director

August 3, 1967

Professor James E. Lightner
307 Morrison Tower
196 West 11th Avenue
Columbus, Ohio 43210

Dear Professor Lightner:

I enclose a copy of our report A General Curriculum in Mathematics for Colleges.

This report was submitted to the MAA for referral to the individual sections of the Association for discussion and debate. Each section was asked to report back to CUPM and to the MAA Board of Governors. These reports are not expected to be completed for at least a year or two. Except for this and for a study made a couple of years ago on the possible effect of the CUPM Level I Recommendations we have not attempted to make any statistical evaluation of our efforts. As a matter of fact, we are not authorized to spend any of our NSF funds for such purposes.

Sincerely,

L. K. Durst

LKD/kb
enc.

COMMITTEE ON THE UNDERGRADUATE PROGRAM IN MATHEMATICS

MALCOLM W. POWNALL

Executive Director

GEORGE B. PEDRICK

Associate Director

ROBERT F. JOLLY

Staff Mathematician

S. KATHERINE BLACK

Administrative Assistant

February 28, 1968

Mr. James E. Lightner
112 Anchor Street
Apartment 8
Westminster, Maryland 21157

Dear Mr. Lightner:

Several mathematicians associated with CUPM have mentioned the fact that you have been conducting a study of the influence which our organization has had on the schools. They have felt moved to praise the thoroughness and fairness of your approach to the survey and to express their belief that your results would probably be of great value to CUPM in its continuing efforts to evaluate and improve its effectiveness. I'm sure you will appreciate the fact that self-evaluation is always haunted by the specter of a possibly slanted point of view and our consequent pleasure in learning of the availability of an evaluation by an independent agency.

Accordingly, we shall be very pleased to obtain a copy of your study as soon as it becomes available.

Sincerely yours,

George Pedrick

GP/kb

APPENDIX B

WESTERN MARYLAND COLLEGE

WESTMINSTER, MARYLAND

DEPARTMENT OF
MATHEMATICS

October 10, 1967

Dear Colleague:

I am sure that each of us in recent years has been faced with the problem of determining the most effective, challenging and up-to-date mathematics curriculum for our respective undergraduate institutions. In one effort to help us make wise decisions about various types of curricula, the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America has provided us with a series of recommendations, reflecting the thinking of some of the leading mathematicians and mathematics professors across the country.

As a research project for my doctoral dissertation at The Ohio State University, I have chosen to analyze the effect of certain of the CUPM recommendations on the mathematics curricula of the colleges in the State of Maryland. The study has been approved and is under the direction of my adviser, Dr. Harold C. Trimble. I have also been given encouragement by the officers of the CUPM, who tell me they are not permitted to make such analyses themselves.

In order to ascertain the present status and recent changes in the undergraduate mathematics curricula (particularly three programs: a general major², preparation for graduate study, and training of mathematics teachers), I am requesting an interview of each departmental chairman, which should take approximately one hour. I would plan to tape record our conversation so that I might more clearly recall the nature and tenor of your remarks as they reflect your opinion on the effect of the CUPM recommendations on your department's curriculum over the past five years. All responses will be used anonymously and no specific college's program will be identified in the resulting written analysis. The emphasis will be upon the total state picture, a summary of which will be sent to all participants.

I hope that you will share some of your valuable time with me; I am enclosing a postal card on which you may indicate a convenient date and time for the interview. As soon as I receive your affirmative reply, I will forward to you some specific areas of concern and some informational needs, that you might have an opportunity to think about them before we meet.

Thank you so much for your assistance in what I hope will be a most beneficial study for us all. I look forward to visiting with you on your campus.

Very truly yours,

A handwritten signature in cursive script that reads "James E. Lightner". The signature is fluid and elegant, with a long, sweeping underline.

James E. Lightner
Assistant Professor

JEL:bl1
Enclosure

Maryland School - College Mathematics Association

October 10, 1967

Dear Colleague,

The Maryland School-College Mathematics Association is pleased to endorse the study of the impact of the recommendations of the Committee on the Undergraduate Program in Mathematics (CUPM) being conducted by Professor James Lightner of Western Maryland College. This study should enable all of us to learn a great deal more about the status of teacher training in mathematics for the State of Maryland. We urge you to fully cooperate with this study.

Sincerely,

James Henkelman

James Henkelman, President

Sister Marie Augustine

Sister Marie Augustine, Secretary

WESTERN MARYLAND COLLEGE

WESTMINSTER, MARYLAND

DEPARTMENT OF
MATHEMATICS

Dear Colleague:

Thank you very much for agreeing to assist me in the study of the effect of the CUPM recommendations on the undergraduate mathematics curricula in Maryland. I am looking forward to visiting your campus and talking with you about your past and present curricula; of course, my special concern rests with the reasons for any recent changes, particularly those that can be traced to the CUPM recommendations.

In order to help us both prepare for the interview, may I suggest some areas of the study in which information or your opinions will be sought:

- (1) Some brief factual information concerning your college, the students, the mathematics department, and the departmental instructional staff.
- (2) The basic mathematics program offered through your department; the 1962-1963 and the 1967-1968 curricula with the titles of textbooks used where available; the requirements for the general mathematics major; the reasons for any curricular changes in the last five years.
- (3) The curriculum for the training of mathematics teachers, in 1962-1963 and 1967-1968, with textbooks used; the requirements for various levels of teaching; the reasons for recent curricular changes.
- (4) The curriculum for preparation for graduate study in mathematics, in 1962-1963 and 1967-1968, with textbooks used; the requirements for such programs; the reasons for any recent curricular changes.

It would also be helpful if I might see a catalog for 1962-1963 and 1967-1968 for the exact course descriptions and titles. Finally, if possible, it would be very useful to see any recent final examinations administered for mathematics courses.

Your cooperation and assistance in this project is greatly appreciated. The results will be made available to you for later analysis and information. I look forward to our meeting on _____.

Sincerely,

James E. Lightner
Assistant Professor

JEL:bll

WESTERN MARYLAND COLLEGE

WESTMINSTER, MARYLAND

DEPARTMENT OF
MATHEMATICS

Dear _____

This is just a note of thanks for all your friendly cooperation and kind assistance in my study of the effect of the CUPM recommendations on the undergraduate mathematics curricula in Maryland. Your frank and honest comments about your program as well as the wealth of information you provided me will greatly add to the overall analysis and give me much to work with.

I enjoyed visiting your campus and was particularly pleased to meet and talk informally with you. I hope that such contact can be continued in the future. Again, thank you for all your generous help. It is greatly appreciated. You will be receiving a summary of the findings following the completion of the study, which I hope will be beneficial to us all. Best wishes for a continued profitable year.

Sincerely,

James E. Lightner
Assistant Professor

JEL:b11

APPENDIX C

PARTICIPATING COLLEGES

<u>College</u>	<u>Participant(s)</u>
College of Notre Dame of Maryland	Sister Marie Augustine Dowling
Columbia Union College	E. I. Mohr Marion L. Hartlein Daniel Koval
Goucher College	Dorothy L. Bernstein
Hood College	Phyllida M. Willis
Loyola College	Frederick A. Homann, S.J.
Mount Saint Agnes College	Sister Mary Seraphine Bennett
Mount Saint Mary's College	Thomas D. Ryan
Saint John's College	Samuel S. Kutler Robert L. Spaeth
Saint Joseph College	Sister John Frances Gilman Donald F. Shriner
Washington College	Richard H. Brown
Western Maryland College	Clyde A. Spicer James E. Lightner
Bowie State College	Oberia B. Butler
Coppin State College	John A. Higgins
Frostburg State College	Thomas V. Baucom Walter J. Rissler
Maryland State College	Joel C. Mack
Morgan State College	Walter R. Talbot
Salisbury State College	Frank D. White
Towson State College	Robert D. Beckey
University of Maryland	Leon W. Cohen James Henkelman Guydo R. Lehner
United States Naval Academy	L. H. Chambers Commander William F. Kelly, U.S.N.

APPENDIX D

QUESTIONNAIRE-CHECKLIST

I. The College and the Mathematics Department

College _____

Address _____

College Enrollment _____

Total number undergraduate degrees awarded 1967 _____

Total number undergraduate degrees awarded 1962 _____

Total number Mathematics majors in college _____

Total number Mathematics majors receiving degrees 1967 _____

Number going to graduate school _____

Number entering teaching _____

Number entering industry _____

Others _____

Mathematics Staff: Number full time _____; Part time _____

Academic preparation:

Degree _____ in: Pure Math Applied Pedagog.

_____ Doctorate

_____ Masters + 30

_____ Masters

_____ Bachelors +

_____ Bachelors

Average teaching load per instructor per semester (quarter) _____

Library: Type (general, shared, departmental,
general and departmental) _____

Number of volumes in total math collection _____

Number of mathematics journals currently subscribed
to _____

Are you familiar with the CUPM Basic Library List? _____

Have you read and/or studied the CUPM recommendations for _____

(a) the training of teachers of mathematics? _____

(b) the preparation for graduate study? _____

(c) a general curriculum in mathematics? _____

Name and title of person interviewed _____

II. A General Curriculum in Mathematics

	1962- 1963	Text	1967- 1968	Text
1. Intro. Calc				
2. Math Analys. (1)				
3. Math Analys. (2)				
4. Linear Alg.				
5. Probability				
6. Adv. Mult. Calc				
7. Algebr. Struc.				
8. Prob/Stat.				
9. Numer. Anal.				
10. Geometry				
11. Applied Math				
12. Intro. Real Var. (1)				
13. Intro. Real Var. (2)				
14. Complex Anal.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				
26.				

Minimum requirements for the general major:
1962-1963

1967-1968

Reasons for changes (Effect of CUPM recommendations?)

Recent examinations available for perusal:

III. Training of Mathematics Teachers (Levels I, II, III)

I	1962-	Text	1967-	Text
	1963		1968	
1. Real # (1)				
2. Real # (2)				
3. Conc./Alg.				
4. Inf. Geom.				
5.				
6.				
7.				
8.				
9.				
10.				
II				
1. Elem. Anal. (1)				
2. Elem. Anal. (2)				
3. Elem. Anal. (3)				
4. Abst. Alg.				
5. Geometry				
6. Probability				
7. Intro.to Real Var.				
8. Number Th.				
9. Topology				
10. Hist/Math				
11. Numer. Anal.				
12.				
13.				
14.				
15.				
16.				

III. Continued

III	1962-		1967-	
	1963	Text	1968	Text
1. Elem. Anal. (1)				
2. Elem. Anal. (2)				
3. Elem. Anal. (3)				
4. Abstr. Alg. (1)				
5. Abstr. Alg. (2)				
6. Geometry (1)				
7. Geometry (2)				
8. Prob/Stat (1)				
9. Prob/Stat (2)				
10. Intro. to Real Var.				
11. Number Theory				
12. Topology				
13. Hist. of Math				
14. Numer. Anal.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

Is the language and logic sets included in some one or more of these courses? _____ Where? _____

III. Continued

Requirements for Elementary School Math Teachers (Level I)	
1962-1963	1967-1968

Requirements for Junior High School Math Teachers (Level II)	
1962-1963	1967-1968

Requirements for Senior High School Math Teachers (Level III)	
1962-1963	1967-1968

Reasons for changes (Effect of CUPM recommendations?)

Recent examinations for perusal:

IV. Preparation for Graduate Study

	1962- 1963	Text	1967- 1968	Text
1. Intro. Calc				
2. Math. Anal.				
3. Linear Alg.				
4. Math. Anal.				
5. Adv. Mult. Calc				
6. Probability				
7. Algebr. Strc.				
8. Applied Math				
9. Intro. Real Var. (1)				
10. Intro. Real Var. (2)				
11. Complex Analysis				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				

IV. Continued

Minimum requirements for graduate school preparation:

1962-1963

1967-1968

Reasons for changes (Effect of CUPM recommendations?)

Recent examinations for perusal:

APPENDIX E

RANKED 1967 TOTAL COLLEGE ENROLLMENTS

10,300

4,998

4,500

4,200

3,500

1,739

1,050

1,000

900

850

850

838

830

750

750

750

700

610

599

500

300

Median : 850

Mean : 1,929

RANKED 1967 TOTAL UNDERGRADUATE DEGREES AWARDED

1,297

900

685

542

416

350

201

200

184

178

166

130

130

120

96

94

90

80

75

75

55

Median: 166

RANKED 1967 TOTAL UNDERGRADUATE
MATHEMATICS DEGREES AWARDED

67

56

45

27

20

19

13

12

11

8

8

8

7

7

7

6

6

4

3

1

0

Median : 8

Mean : 16

RANKED 1967 NUMBER OF MATHEMATICS GRADUATES
ENTERING VARIOUS FIELDS

Graduate School	Teaching	Industry or Government	Other
23	35	20	53
14	14	19	4
11	11	10	3
4	10	6	1
3	8	4	1
3	8	3	1
2	5	3	1
2	5	3	0
2	5	3	0
2	4	2	0
1	4	2	0
1	3	2	0
1	3	2	0
1	2	1	0
1	2	0	0
0	1	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
Median : 1.5	Median : 4	Median : 2	Median : 0
Mean : 3.5	Mean : 6	Mean : 4	Mean : 3

RANKED 1967 TOTAL FULL-TIME
MATHEMATICS STAFF

82

82

22

11

6

5

5

4

4

4

3

3

3

2

2

2

2

1

1

0

Median : 4

Mean : 13

RANKED 1967 TOTAL MATHEMATICS STAFF
(FULL AND PART-TIME)

85+

82

22

12

8

6

6

6

6

5

4

4

4

4

3

3

3

3

2

0

Median : 5

RANKED 1967 LIBRARY HOLDINGS
IN MATHEMATICS

No. Total Volumes	No. Journals Subscribed To
13,000	200
7,000	72
3,000	19
2,700	16
1,500	15
1,200	10
1,200	8
900	7
750	6
750	6
702	5
700	5
650	5
500	5
500	4
500	4
430	3
150	3
	2
Median : 750	Median : 6
Mean : 2,007	Mean : 21

RANKED NUMBER OF MATHEMATICS COURSES OFFERED
1962-1967

No. in 1962	No. in 1967
62	59
27	30
21	30
20	27
18	24
17	20
17	18
16	17
15	17
14	16
14	16
12	16
12	16
12	15
12	15
11	12
10	11
10	11
5	7
Median : 14	Median : 16

COURSE OFFERINGS FROM THE CUPM GENERAL CURRICULUM

132

School	Number Courses		Math 1,2,4:		Math 3:		CUPM Recommended		Math 5:		Math 6:		Math 2P,7:		Math 8:		Math 9:		Math 10:		Math 11,12:		Math 13:		Comp.Sci.	Number CUPM Courses 1962-3	Number CUPM Courses 1967-8
	Offered 1962-3	Offered 1967-8	Calculus 1962-3 1967-8		Linear Alg. 1962-3 1967-8		Adv.Mult.Calc. 1962-3 1967-8		Alg.Struct.I,II 1962-3 1967-8		Probab./Stat.I,II 1962-3 1967-8		Num. Analys. 1962-3 1967-8		Geometry I,II 1962-3 1967-8		Appl. Math 1962-3 1967-8		Real Var.I,II 1962-3 1967-8		Complex An. 1962-3 1967-8						
A	12	17	*	*	*	*			*	*	*	*	*		*	*			*	*	*	*			6	7	
B	15	16	*	*	*	*	*	*	*	*	*	*	*			*			*	*	*	*	*	*	7	7	
C	12	12	*	*		*			*	*	*	*	*						*	*	*		*	*	5	4	
D	14	17	*	*		*			*	*	*	*	*		*	*	*	*	*	*	*	*			6	6	
E	11	15	*	*		*				*	*	*	*	*	*	*									2	5	
F	12	18	*	*		*			*	*	*	*	*		*	*					*				3	5	
G	27	30	*	*	*	*		*	*	*	*	*	*	*	*	*					*				4	7	
H	10	11	*	*	*	*	*		*	*	*	*	*			*			*		*		*		4	6	
I	17	30	*	*		*			*	*	*	*	*	*	*	*	*				*	*	*	*	4	9	
J	17	20	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	7	10	
K	20	16	*	*	*	*	*		*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	8	8	
L	62	59	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	11	11	
M	14	16	*	*		*			*	*	*	*	*		*	*				*		*	*		3	6	
N	18	27	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	10	10	
O	21	24	*	*	*	*			*	*	*	*	*	*	*	*			*	*	*	*	*	*	7	7	
P	12	16	*	*		*			*	*		*	*	*	*	*			*	*	*		*	*	4	8	
Q	10	11	*	*					*	*															1	1	
R	5	7		*												*									0	1	
S	16	15	*	*	*	*	*		*	*	*	*	*	*		*			*		*	*	*	*	6	6	

An asterisk (*) indicates that the course was offered.

COURSE OFFERINGS FROM THE CUPM TEACHER TRAINING PROGRAM

School	ELEMENTARY EDUC.		SECONDARY EDUCATION														No. Required CUPM Courses			
	Number Courses Required	Number Courses Required	Number Courses Required	Number Courses Required	CUPM Recommended Courses Offered								Electives (2)		Computer Sci.					
	1962-3	1967-8	1962-3	1967-8	Calculus (3) 1962-3 1967-8	Algebra (2) 1962-3 1967-8	Geometry (2) 1962-3 1967-8	Probab./Stat. (2) 1962-3 1967-8	Electives (2) 1962-3 1967-8	Computer Sci. 1962-3 1967-8	1962-3	1967-8	1962-3	1967-8						
A	2	2	12	12	*	*		*	*					*	*	*	*	5	7	
B			12	12	*	*	*	*	*	*		*		*	*	*	*	8	8	
C			8	10	*	*		*						*	*	*	*	*	4	6
D			12	12	*	*	*	*	*	*	*	*	*	*	*	*	*	9	10	
E			10	10	*	*		*	*	*	*	*	*		*	*		5	9	
F	2	2	10	10	*	*		*	*					*	*	*	*	5	7	
G	2	2	9	9	*	*								*	*	*	*	3	3	
H	0	1	6	7	*	*		*							*		*	3	5	
I	2	2	6	6	*	*		*	*	*	*	*		*	*	*	*	4	6	
J	0	0	9	9	*	*		*	*			*		*	*	*	*	6	7	
K	2	2	12	10	*	*		*	*			*	*		*	*		3	8	
L	2	2		9		*		*		*					*	*	*		7	
M	2	2	8	8	*	*		*	*						*	*	*	3	7	
O	2	2	9	10	*	*	*	*	*	*			*	*	*	*	*	7	7	
P	2	2	7	8	*	*	*	*	*	*	*	*	*		*		*	6	8	
Q	2	2	6	6	*	*	*											2	3	
R	2	2																		
S			8	10	*	*		*	*		*	*	*	*	*	*	*	5	8	

An asterisk (*) indicates that the course was offered.

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