CONFERENCE BOARD OF THE MATHEMATICAL SCIENCES

REPORT OF THE SURVEY COMMITTEE

VOLUME V

UNDERGRADUATE MATHEMATICAL SCIENCES IN UNIVERSITIES, FOUR-YEAR COLLEGES, AND TWO-YEAR COLLEGES, 1975-76

JAMES T. FEY
DONALD J. ALBERS
and
JOHN JEWETT
with the technical assistance of
CLARENCE B. LINDQUIST

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PREFACE

This volume is a repetition, with some modifications, of two earlier surveys conducted by the Conference Board of the Mathematical Sciences in 1965 and 1970. The 1965 survey was an expansion of a study done by Clarence B. Lindquist five years eariler for the U. S. Office of Education in 1960. Thus, with the publication of the present volume, we now have available a record of undergraduate education in the mathematical sciences based on four successive major surveys conducted at five year intervals.

All of these surveys have sought to gain information on curricular trends by collecting data on enrollments in undergraduate mathematical science courses. Beginning with the 1965 survey, we have presented data on the number, qualifications, and distribution of mathematical science faculty. In succeeding surveys, we have placed greater emphasis on faculty characteristics, mobility patterns, and other information relating to manpower considerations. Volume I, based on the 1965 survey, also included information from a separate survey (actually conducted in 1966) of the mathematical sciences in two-year colleges, and the two subsequent surveys have incorporated data from two-year colleges as an integral part of the total picture. The present survey presents for the first time data on age, race, and sex of mathematical science faculty.

The fundamental nature and purpose of these surveys has largely been determined by the nature of our sponsoring organization. The Conference Board of the Mathematical Sciences is an organization whose members are organizations; the membership in fact includes virtually all of the principal professional societies in the mathematical sciences.[1] Such sponsorship has had

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[1]American Mathematical Society, American Statistical Association, Association for Computing Machinery, Association for Symbolic Logic, Association for Women in Mathematics, Institute of Mathematical Statistics, Mathematical Association of America, National Council of Teachers of Mathematics, Operations Research Society of America, Society of Actuaries, Society for Industrial and Applied Mathematics, The Institute of Management Sciences.

several advantages. It has helped to make possible the objectivity which we have always sought to have as the principal characteristic of our work. The Conference Board has also made it possible to obtain a broad coverage of the mathematical sciences which was feasible only because we have been able to draw freely on the expertise and experience of prominent individuals from all areas represented by the member organizations. On the other hand, restricting our investigations to the mathematical sciences has provided a certain unity and coherence which would have been lacking had the surveys been aimed at a wider range of disciplines.

The Conference Board surveys, representing a long term effort to provide a comprehensive background of information about the mathematical sciences, serve several distinct purposes. First, they provide a backdrop against which the results of ad hoc surveys can be viewed in proper perspective. Second, the prior availability of certain data can on occasion obviate the need for hurried surveys done on a crash basis. Finally, the continuous monitoring of trends by successive surveys is the only way in which the actual existence of suspected changes can effectively be confirmed or denied. For example, the 1965 survey gave the first concrete evidence that the shortage of mathematicians was coming to an end; the 1970 survey provided the first measurements of the then explosive growth of statistics and computer science; the present survey shows that the two-year college segment of the system has become by some measures comparable in size to that portion included in four-year institutions, and also has documented the first demonstrable increase in teaching loads.

There are still, however, important gaps in our knowledge about the mathematical sciences. Since the present survey has been restricted to undergraduate programs, we have been unable to provide needed data bearing directly on graduate education and research. This has the effect of limiting our understanding of important aspects of the professional life of those teaching in universities as well as making it impossible to provide the factual data needed in connection with manpower questions. Especially at a time when there are basic issues in graduate education needing to be resolved, it would be extremely helpful to have from some source a study of graduate education in the mathematical sciences of the same comprehensive nature as the survey done by the Conference Board in 1966, a survey that we have failed to repeat only because of our inability to secure the necessary funding.

Because the process of graduate education in the mathematical sciences is structurally different from the customary patterns in the natural sciences, it is essential that such a study be done on a disciplinary basis.

A second major deficiency in our understanding is our virtually complete lack of knowledge about the subsequent careers of mathematical science graduates at all degree levels. The only subclass about which there is anything approaching adequate understanding is composed of those going into college teaching. The collection of such information has been a very difficult problem. Despite the obvious relevence of such questions to the formulation of educational policy, the promising beginning represented by Volume III of the Survey Committee's report has not been followed up. As far as we can discover, information is no more complete for other scientific disciplines than for ours. Because of the proclivity of scientists, even at the doctoral level, to switch fields after graduation, a study of career patterns is one which might be done most effectively if conducted for a group of related disciplines.

The present survey has depended on the efforts of many people, not the least among whom were the many department chairmen who undertook to complete our lengthy questionnaire. We were fortunate in securing the services of Dr. Clarence B. Lindquist of the U. S. Office of Education, who supervised the editing of questionnaires and the tabulation of data, and especially of Professor James T. Fey of the University of Maryland, who was the executive secretary for the project. Dr. Fey is the principal author of most of the present volume and deserves the main credit for shaping a vast amount of data into an orderly whole. We are grateful to Professor Donald J. Albers of Menlo College who, in addition to providing insight and advice regarding two-year colleges, wrote much of the material in Chapters 5 and 6. We are indebted to Dr. Truman Botts, the Executive Director of the Conference Board, for his tact, patience, and administrative skill. We have profited greatly from his comments and advice in connection with the conduct of the survey as well as the interpretation of the data. Mrs. Patricia Hughes deserves our special thanks for her careful typing of the entire report. Finally, we are especially grateful to the National Science Foundation for its support of the present project and for its foresight in realizing that the information developed will have not only immediate value but longer term value as well.

December 1976 John Jewett

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INTRODUCTION

The Survey Committee, in publishing the results of its investigations, has always felt its fundamental responsibility to be the neutral presentation of a factual background for use by those in education and government who make decisions about the mathematical sciences, the fundamental premise being that informed decisions are likely to be superior to decisions based merely on hearsay or wishful thinking. Beginning with Chapter 1, the present volume maintains that posture, attempting to describe only what our data say without assuming the more interpretive role of making subjective assertions about what the data mean. In this short introductory chapter, we will try to suggest something of the significance of our most salient results without, however, presuming to offer any recommendations for specific actions which the mathematical community should take.

Anyone engaged in planning regarding mathematical sciences in higher education must make assumptions as to the numbers of enrollments to be expected in mathematical science courses. One of the most suggestive findings of our surveys is the relatively constant relationship between college enrollments and enrollments in mathematical science courses. If we compute the ratio of the number of enrollments in undergraduate mathematical science courses to the number of full-time-equivalent students in four year institutions, we obtain .32 in 1960, .31 in 1965, .30 in 1970 and .30 in 1975. For two-year colleges, the corresponding ratios are .37 for 1966, .38 for 1970, and .36 for 1975. The constancy of this ratio over a period which saw profound changes in all aspects of education in the mathematical sciences suggests that future mathematical science enrollments may well be more closely tied to general college enrollments than is commonly believed.

The percentage of high school graduates continuing to college, after rising steadily over a long period of time, has recently ceased to increase and has begun to oscillate gently about what may be a new equilibrium value. Therefore, the prime determinant of future mathematical science enrollments, especially in four-year institutions, may be the size of the 18-21 year age group. But the 18-21 year age group, which numbered 16.2 million in 1974 (up 40 percent from ten years earlier), will fall to 15.8 million in 1984 and to slightly over 14 million in 1988. These figures represent people who have already been born and do not, therefore, involve any prediction of the birth rate. It is perhaps worth noting in this connection that a preliminary report from the U. S. Office of Education shows that enrollments for the fall of 1976 (including part-time and non-degree students) increased less than one percent over the preceding year.

The periodic nature of the Conference Board surveys together with their consistent methodology makes them particularly suited to the observation of trends in the data. The most conspicuous trend was not unexpected -- an abrupt halt to the exuberant growth of the sixties. The mathematical science faculties in four-year institutions remained constant in size from 1970 to 1975; overall mathematical science enrollments for the first term increased only eight percent -- from 1,386,000 to 1,497,000. Even in those segments of the community where growth continued, growth from 1970 to 1975 was at a slower pace than in preceding years.

First we single out for special consideration four broad trends, not direct corollaries of the above, and all to a certain extent unanticipated in 1970.

1. Changes in student-faculty ratios. From data of our survey, we can compute the ratio of undergraduate mathematical science enrollments to full-time-equivalent faculty. For four-year institutions this ratio increased from 79 in 1970 to 86 in 1976. In two-year colleges the increase was from 104 to 123. This is corroborated by somewhat less solid data about teaching loads reported below, and is consistent with data from the National Center for Educational Statistics indicating that (for all fields) the ratio of full-time-equivalent students to full-time-equivalent faculty increased from 14.9 to 16.3 between 1970 and 1975, ending a long period of stability of this ratio.

2. Decline in upper division mathematics enrollments. Our data indicate that, after increasing 29 percent from 1965 to 1970, enrollments in upper division mathematics fell from 229,000 in 1970 to 155,000 in 1975, a decline of 32 percent. Among the subjects whose 1975 enrollments were less than half of their 1970 enrollments were theory of numbers, courses in history, logic and foundations, advanced geometry courses, topology, real variables, and complex variables. The fact that courses in differential equations, advanced calculus, and linear and matrix algebra did not fare as badly

suggests that the enrollment decline was not primarily due to a decrease in enrollments by engineers and scientists. Upper level courses enrollments increased by 10,000 in computer science and by 7,000 in statistics, but these increases taken together are smaller than the 19,000 student decrease in courses in linear and matrix algebra. This argues against the decrease in upper mathematics courses being attributable primarily to a shift of interest from mathematics to other areas within the mathematical sciences.

We can only conclude that the enrollment decline is due to a drastic decrease in the number of students majoring in mathematics (including prospective high school teachers). This conclusion is confirmed by U.S.O.E. data showing that the number of bachelor's degrees granted in mathematics and statistics fell from 25,000 in 1970-71 to 20,000 in 1975-76. That worse may be in store is suggested by the American Council of Education survey of entering freshmen which shows that the number of entering freshmen who consider themselves probable majors in mathematics and statistics fell from 52,000 in 1970 to 19,000 in 1975.

What is described above refers only to the fairly recent past and to the immediate future. It may well be that mathematics will follow the physical science which have experienced a period of stability following an earlier period of decline. It can be argued, probably with some justification, that the decline in mathematics majors has been caused in large measure by students' (false) perceptions of declining job opportunities for bachelor's level graduates. If this is true, a natural correction can be expected, as has actually happened in engineering.

3. <u>Declines in graduate programs.</u> Since this subject is not within the scope of our survey, we can present no new data. However, we can observe that data from the American Mathematical Society [S,T] have shown a slight decline in number of Ph.D.'s granted in the mathematical sciences and a substantial decline for pure mathematics both in numbers of Ph.D.'s and in graduate enrollments. These trends can be expected to continue during the next five years and may well lead to a precarious balance between decreased supply and decreased demand for new Ph.D.'s for a short period about 1980. There may be some hope that changes being discussed in graduate education leading to broader relevance of doctoral programs and to greater emphasis on the master's degree might serve to extend this equilibrium somewhat beyond 1980.

Unfortunately, our lack of detailed quantitative knowledge about graduate education in the mathematical science precludes any more detailed analysis.

4. Growth of the Mathematical Sciences in Two-Year Colleges. Over the last five years, not only the rate of growth but also the total amount of growth in two-year colleges has exceeded that in the four-year segment. Mathematical science enrollments increased by 290,000 in two-year colleges compared to an increase of only 111,000 in four-year institutions. Since the four-year mathematical science faculty did not increase in size from 1970 to 1975, the increase of approximately 1,500 full-time-equivalent faculty members in two-year institutions represented the only growth in the system except for a significant increase in computer science faculty. Moreover, the data from the present survey show that at least for the mathematical sciences the two-year colleges have become comparable in size to four-year institutions. In 1975 there were 874,000 course enrollments in undergraduate mathematical science courses in two-year colleges compared to 1,497,000 in four-year institutions. In mathematics courses at the level of calculus and below, there were approximately 830,000 course enrollments in two-year colleges compared to 1,090,000 in four-year institutions. In terms of full-time-equivalent faculty slightly over 7,000 were in two-year institutions and 18,000 in four-year institutions.

In addition to these four trends, it seems worthwhile to mention our results on faculty age distributions and on tenure and faculty mobility prior to discussing some of the trends that were mainly confined to certain types of institutions. The age distributions of mathematical science faculty in four-year institutions give some clue as to the number of vacancies to be created by deaths and retirements. We estimate that only five percent of the mathematical science faculty are 60 or over, another five percent are between 55 and 59, and eight percent between 50 and 54. This indicates that in the critical period between 1980 and 1985, the number of retirements from the faculty of four-year institutions will be less than 200 per year with under 300 retirements per year to be expected from 1985 to 1990. During the eighties, few if any additional new positions can be expected to be added as a result of enrollment increases.

The median age of mathematical science faculty in four-year institutions was approximately 39 years with 54 percent of the faculty under 40. It is perhaps surprising that the age distribution for faculty members in statistics departments, which have been growing more rapidly, is virtually identical to that for all mathematical science faculty. The computer science faculty is not much younger, its lower median age of 37 occurring primarily because the age distribution is somewhat truncated above, with only three percent of faculty being 55 or over. It is also surprising that the junior college faculty is slightly older than the faculty in four-year institutions. Our data indicate that the percentage of four-year faculty with tenure has risen to 72 percent with five percent of the total 1975 faculty having been granted tenure in the preceding year, at an average age of 35. This corresponds roughly to every sixth non-tenured faculty member being granted tenure, which suggests fairly rapid change in the direction of an almost completely tenured faculty. In this connection, it is interesting to note that 71 percent of the 3,364 non-doctorates on four-year college faculties have tenure, a percentage essentially equal to that of doctorate faculty. This means that the replacement of non-doctorate faculty by doctorate holders, a process that provided over 500 jobs a year for young Ph.D.'s between 1970 and 1975, cannot be expected to continue at anything like the former rate since there now appear to be fewer than 1,000 non-tenured non-doctorate faculty members left in four-year institutions.

Our data on faculty mobility in four-year institutions for the single year 1975 confirm a death and retirement rate of approximately one percent. Of those who left for other reasons during this year, about two-thirds or 540 went to positions in other four-year institutions. This represents an internal mobility rate of only three percent, which is surprisingly low. Approximately 200 left for non-academic positions. The sources of new faculty were preponderantly the traditional ones of graduate schools and other colleges and universities. Perhaps the most interesting results of our mobility data involve the small magnitude of some other flows. From our data we can conclude that the number of doctorate faculty who left four-year colleges and universities for two-year colleges in 1975 is almost certainly smaller than 100 and probably less than 50; the flow in the opposite direction appears to be even smaller. In contrast to 1970, we could find very little evidence of faculty members returning to graduate study.

We now turn our attention to trends characteristic only of particular types of institutions or particular types of departments, and consider in turn universities, public four-year colleges, private four-year colleges, and two-year colleges.

Universities. Declining upper division mathematics enrollments were most pronounced in universities, where such enrollments declined 41 percent (from 114,000 to 67,000) between 1970 and 1975. This more than offset modest increases in calculus and precalculus courses so that the total undergraduate mathematics enrollments in universities actually declined by about four percent. Our data indicate that the full-time mathematics faculty in universities declined from about 6,200 to about 5,400. There were also declines in part-time faculty and in numbers of graduate assistants. This decrease in faculty size must imply a gradually aging and presumably less innovative faculty as well as a dearth of tenure opportunities for younger scholars. The faculty appeared to have slightly higher teaching loads; expected teaching loads of six hours or less were reported by only 26 percent of responding departments in 1975 as compared to 48 percent in 1970. The most typical teaching load seems to have crept upwards from six hours to seven or eight hours.

As commonly conceived, the distinguishing characteristic of a university among the totality of educational institutions is its concern for expanding the frontiers of knowledge and for transmitting specialized knowledge at an advanced level. If graduate programs in mathematics are contracting, advanced course enrollments declining, and teaching loads increasing, then university mathematics departments must to a certain extent be losing their special character.

University statistics and computer science departments showed more vigorous growth. The faculty of computer science departments increased by 299 full-time professors from 688 to 987, while part-time faculty decreased from 300 to 133. It seems reasonable to assume that many of the part-time faculty who were in effect replaced by full-time professors held joint appointments with other departments. Curiously enough, our data indicate that enrollments in elementary computer science courses[1] taught by university mathematical science departments showed little if any increase from 1970 to 1975, although advanced undergraduate courses in computer science increased from 15,000 course enrollments in 1970 to 25,000

[1]Specifically, courses 51, 52 and 53 of Appendix E.

in 1975. Although enrollment in undergraduate statistics courses increased from 49,000 in 1970 to 67,000 in 1975, the faculty of university statistics departments appears to have remained essentially constant in size.

Public Colleges. Between 1970 and 1975, a dramatic change has occurred in the formal qualifications of mathematical science faculty in public four-year colleges. The number of full-time faculty with doctorates increased from 2,866 to 4,536 while the number of faculty without doctorates decreased from 3,114 to 1,609. Thus in the five year period, the percentage of doctorate holding faculty increased from 47 percent to 74 percent. Expectations of research have also increased; the percentage of departments stating some expectation of research increased from 38 percent in 1970 to 64 percent in 1975. Moreover, among those willing to state an expected rate of publication, the average expected rate increased from two papers every five years to four.

While faculty qualifications and research expectations in public colleges have been becoming more like those in universities, other aspects have been moving in the opposite direction. The number of mathematical science enrollments per full-time-equivalent faculty member increased from 78 in 1970 to 87 in 1975; the percentage of departments reporting expected teaching loads of 12 hours or more increased from 53 percent in 1970 to 78 percent in 1975. Moreover, as we indicate below, this increased load has become increasingly composed of courses of a lower, even remedial, level and courses whose orientation is determined more by student needs and demands than by mathematical structure. Increases in computer science and statistics enrollments were more striking in public colleges than in universities or in private colleges. Computer science enrollments in public colleges increased from 17,000 in 1970 to 31,000 in 1975 and statistics enrollments more than doubled from 22,000 to 45,000. The bulk of these increases was in introductory courses. The decline in upper division mathematics courses was 23 percent, not as sharp a decrease as in universities.

The most interesting curricular trends in public four-year colleges, as reflected by enrollments, could be observed in courses below the level of calculus. Courses in intermediate algebra and courses below this level can be thought of, at least for the moment, as "remedial courses". Enrollment in such courses in public colleges increased from 68,000 in 1970 to 97,000 in 1975 or 43 percent, this increase lending support to the frequently expressed opinion that the mathematical preparation of freshmen has been declining. Courses in college algebra, trigonometry and combinations of these subjects (such as elementary functions) can similarly be lumped together as "precalculus courses". In public colleges enrollments in these courses declined by 39 percent from 126,000 in 1970 to only 77,000 in 1975. Finally one can define a category of "elementary service courses" comprised of courses oriented more or less to major interests of the students in fields other than mathematics. Among such courses we include mathematics for liberal arts, finite mathematics, mathematics of finance, business mathematics, and mathematics for elementary school teachers. Enrollments in such courses increased by 55 percent from 94,000 to 146,000. Put another way, the percentage of all undergraduate enrollments which were in precalculus courses decreased from 26 percent to 14 percent between 1970 and 1975 while the percentage in remedial courses increased from 14 percent 17 percent and the percentage in elementary service courses went up from 19 percent to 26 percent.

It is interesting and important that none of these three large scale trends was evident either in universities or in private colleges. It is difficult to tell whether the public colleges were acted on by forces which did not affect either universities or private colleges or whether they were more responsive to forces which acted more universally.

<u>Private Colleges</u>. The percentage of private four-year college faculty who held doctorates increased from 42 percent in 1970 to 69 percent in 1975. Otherwise, the private colleges showed fewer signs of change than did other types of institutions. A modest increase in faculty size almost covered a modest enrollment increase. Teaching loads, typically 12 hours although smaller at most prestigious colleges, did not appear to rise. Declines in upper class mathematics enrollments (24 percent) were not as great as in universities, and increases in computer science and statistics enrollments, although larger than in universities, were not as great as in public colleges.

<u>Two-Year Colleges</u>. We have already identified the continued growth of the mathematical sciences in two-year colleges as one of four particularly noteworthy trends. It remains to trace the characteristics of that growth. The data presented in Chapter 5 show

that from 1970 to 1975 part-time enrollment grew much faster than full-time enrollment. It is also known that occupational and technical programs experienced especially rapid growth as compared with programs which parallel those offered in four-year institutions. These trends are reflected in the data we have collected concerning mathematical science faculty as well as mathematical science enrollments. The full-time mathematical science faculty in two-year colleges increased 22 percent from 4,879 in 1970 to 5,944 in 1975 while the part-time faculty increased 54 percent from 2,213 to 3,411. The formal qualifications of full-time faculty improved. It now appears that approximately 11 percent of full-time faculty hold doctorates, about half of these being in mathematics education. The qualifications of part-time faculty declined, probably as a result of the necessity of hiring 54 percent more part-time faculty from a pool that had not greatly enlarged.

Mathematical science enrollments in two-year colleges increased by 50 percent to 874,000 between 1970 and 1975. The pattern of this growth is interesting in its overall resemblance to the change in lower division enrollments already observed in public four-year colleges. Remedial courses increased from 33 to 40 percent of all mathematical science enrollments; precalculus courses went from 21 percent to 17 percent; while elementary service courses levelled off at around 30 percent of the total load. Enrollments in statistics courses went up significantly from 16,000 to 27,000 from 1970 to 1975. However, computer science enrollments declined from 13,000 to 10,000. This indicated decline is mysterious in view of the substantial increase in the availability of computers and the general increase in enrollments in elementary computer science courses in four-year colleges during the same period. What is perhaps more noteworthy is that statistics courses account for only three percent and computer science courses only about one percent of the total junior college mathematical science enrollments. Since explanations of these phenomena in terms of offerings by non-mathematical science departments, lack of faculty expertise or the nature of two-year college students are not convincing, it is reasonable to surmise that the next five years may see tremendous growth in these areas in two-year colleges.

Chapter 1

PURPOSES AND PROCEDURES OF THE STUDY

In United States colleges and universities, departments in the mathematical sciences provide instruction that is a fundamenta component of undergraduate education for students with extremely diverse educational interests and career goals. To help these departments, campus administrators, and national organizations in planning appropriate and effective programs, the Conference Board of the Mathematical Sciences (CBMS) has conducted a sequence of in-depth surveys describing current practices and trends in undergraduate mathematics education -- curricula, enrollments, instructional practices, and faculty characteristics.

Background and Purpose

The present study, based on questionnaire data collected from over 250 mathematical science departments in 1975-76, is a direct successor to three earlier studies conducted at five year intervals beginning in 1960-61. The first, by Clarence Lindquist for the U. S. Office of Education (USOE), surveyed graduate and undergraduate mathematical programs in four-year institutions [A]. In 1965-66 the CBMS Survey Committee repeated the undergraduate portion of the Lindquist study while expanding its coverage to include basic facts about faculty in the mathematical sciences [B]. The report of that 1965-66 survey also included data from a separate but related survey of two-year colleges, conducted in 1966-67. Then in 1970-71 the CBMS Committee conducted a comprehensive survey of two-year and four-year mathematical science programs and faculty characteristics [C].

The practices of each two-year college, four-year college, and university reflect unique institutional goals, traditions, and boundary conditions. But response to previous CBMS reports indicates the value of national perspective in making decisions regarding such questions as

--What new courses or major programs should be developed and what traditional courses or programs should be dropped?

--What are enrollment trends in various mathematical sciences specialties? What do these trends suggest about employment prospects and advising for undergraduates?

--What types of faculty expertise should be sought?

--What are emerging patterns of instructional staff utilization and how do they affect economic factors such as class size and faculty load?

In addition to these perennial broad concerns, individual CBMS surveys have focused on specific issues of timely importance such as

--What is the impact on undergraduate programs of changing secondary school mathematics curricula?

--How are technological innovations such as calculators and computers influencing curricula and enrollments?

--How have changing college admission standards affected the offerings and standards of mathematics departments?

--What are the age, education, and tenure profiles of mathematical science faculties, and how do they influence long term employment prospects for mathematics graduate students?

The present survey addressed each of these issues, as well as many others of current interest to the mathematical community.

Methodology

The balance of this chapter describes the sampling procedure, response patterns, and methods of estimation used in the 1975-76 study.

Sampling Procedure. The most interesting results of surveys repeated at regular intervals are patterns of change. To establish valid trends in undergraduate mathematics education, the sampling procedure of the 1975-76 survey followed, as closely as possible, that of the 1970-71 study.

The U. S. National Center for Education Statistics (NCES) report of 1974 opening Fall enrollment [D] listed 3,017 institutions of higher education. Of these, 478 graduate or special professional schools offer no systematic undergraduate mathematics instruction. Thus the population for the survey included the remaining 2,539 institutions of higher education in the 50 states and the District of Columbia. To obtain reliable data while imposing on a minimum number of respondents, the survey questionnaire was sent to a stratified random sample of 424 institutions.

In choosing the sample, institutions were stratified according to control and type:

A. Control
   1. Public
   2. Private

B. Type*
   1. University
   2. Four-year college or four-year branch of a university.
   3. Two-year college or two-year branch of a university or of a four-year college.

Then within each control/type category institutions were grouped into 212 zones of approximately equal total enrollment. The procedure for zone formation resulted in valuable additional stratication of the sample, generally placing institutions of similar size and geographical location in the same zone. From each zone two institutions were selected at random for the sample.

The zone formation method, equalizing total zone enrollments led to different sampling ratios for different size institutions.

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*The list of responding institutions, given in Appendix B, is probably the most effective elaboration of these institution type definitions.

Within each control/type category larger institutions tended to be in zones with few members. Thus they were more likely to be sampled than colleges or universities in zones formed from many small institutions. Table 1.1 gives the number of institutions in each category of the population and the sample.

Table 1.1

SAMPLING AND RESPONSE IN MATHEMATICS DEPARTMENTS

Control/Type	Population	Sample	Respondents	Rate of Response
1. Public Universities	95	48	36	75%
2. Private Universities	65	28	15	54%
3. Public Colleges	407	86	50	58%
4. Private Colleges	862	98	62	63%
5. Public 2-Year Colleges	897	146	81	55%
6. Private 2-Year Colleges	213	18	11	61%
	2,539	424	255	60%

After sample institutions were chosen, appropriate questionnaires were sent to heads of all mathematical science departments listed under the sample institutions in the 1976 Mathematical Sciences Administrative Directory [E]. Every university and four-year college in the sample had a mathematics department, so for these schools the sample of mathematics departments had the same structure as the sample of institutions. Mathematics programs in two-year colleges are often under the direction of broad departments or divisions such as Mathematics and Engineering, Mathematics and Physical Science, Mathematics and Natural Science, or Mathematics and Computer Science. Questionnaires for two-year colleges were addressed to the person in charge of the mathematics program.

In the 424 sample institutions there were 48 separate departments of computer science, 32 separate departments of statistics, and 25 other special mathematical science departments such as operations research, applied mathematics, or mathematics education. Questionnaires were sent to each of these departments. Table 1.2

shows the distribution of computer science, statistics, and other mathematical science departments in the sample.

Table 1.2

SAMPLING AND RESPONSE IN COMPUTER SCIENCE, STATISTICS, AND OTHER MATHEMATICAL SCIENCES

Control/Type	Institutions in Sample	Departments in Sample	Departments Responding
Computer Science			
1. Public Universities	48	34	16
2. Private Universities	28	8	2
3. 4-Year Colleges	184	6	5
4. 2-Year Colleges	164	0	0
Statistics			
1. Public Universities	48	21	12
2. Private Universities	28	6	3
3. 4-Year Colleges	184	5	2
4. 2-Year Colleges	164	0	0
Other Mathematical Sciences			
1. Public Universities	48	14	3
2. Private Universities	28	8	3
3. 4-Year Colleges	184	3	3
4. 2-Year Colleges	164	0	0

The sample and response sizes indicated in Table 1.2 are very small for reliable extrapolation to national figures, except in two special categories of departments. The number and distribution of responses seemed to justify inclusion of the categories "university computer science departments" and "university statistics departments" in subsequent analyses (combining public and private universities). Information from other types of institutions and other mathematical science departments was pooled with the appropriate mathematics department figures, making the resulting "composite departments" comparable to comprehensive mathematical science departments at other institutions.

Estimation Procedures. To facilitate interpretation of the data and comparison with results of preceding surveys, data presented in this report are estimates of national totals for institutions of higher education rather than totals for responding institutions or estimates of the sample. To arrive at national estimates it was necessary to multiply response totals by appropriate weighting factors to compensate for sampling and non-response. Sampling rates and response rates were different for each type of institution and each type of mathematical science department, so the weighting factors were determined separately for each of these groups and for each survey question.

Since sampling was accomplished by selecting two institutions each from zones including several institutions, the natural procedure for creating national estimates from responses would be

1) $$\text{Zone Data Estimate} = \frac{\text{Number of institutions in zone}}{\text{Number of respondents in zone}} \times \text{Response Data}$$

2) $$\text{Control/Type Category Data Estimate} = \text{Sum of Zone Data Estimates}$$

Because the number of respondents in each zone was 0, 1, or 2, this method of weighting seemed dangerously sensitive to non-responses. Thus in practice the responses from similar zones were clustered before extrapolation to national estimates.

For example, the Fall 1975 national enrollment in mathematics for elementary school teachers was estimated to be 79,000 students. Calculation of this estimate began with data from public universities. The 95 institutions in this control/type category were partitioned into 5 clusters according to total enrollment.

Cluster	Number of Institutions	Average Enrollment
A	14	39,000
B	15	28,000
C	20	22,000
D	22	18,000
E	24	10,000

Of the 24 institutions in cluster E, 6 were in the sample, 3 of these responded to the survey and provided the requested data on mathematics enrollments. For the question on mathematics for elementary school teachers the 3 institutions reported Fall 1975 enrollments of 590. Thus the estimate for all institutions in cluster E was calculated as (24/3) x 590 = 4,720. Similar estimates for each of the other clusters were summed to get a nationa figure for public universities. Then the procedure was repeated for private universities, public and private four-year colleges, and public and private two-year colleges.

Accuracy of Enrollment Estimates. Confidence in the results of any questionnaire survey depends on the quality of the sample, the rate of response, and, most important, on the extent to which respondents are representative of the population as a whole. In designing the survey sample, the number of institutions chosen in each control/type category was determined by the desire to have 95% confidence that absolute error in estimates would not exceed 4.5%. Several empirical tests of the estimation procedure confirm that the precision requirement has been met. For example, it is known that total Fall 1974 enrollment in the 897 public two-year colleges was 3,273,265 [D]. The estimation procedures described above, when applied to known enrollments of respondent two-year colleges, led to an estimated national figure of 3,399,504, an over-estimate of 3.9%. The complete set of such estimation checks appears in Table 1.3.

Table 1.3

COMPARISON OF ESTIMATED AND ACTUAL DEGREE CREDIT ENROLLMENTS IN ALL INSTITUTIONS

Control/Type	Estimated Enrollment	Actual Enrollment	Error
1. Public University	2,014,661	2,006,723	+ .4%
2. Private University	713,751	695,583	+2.6%
3. Public Four-Year College	2,655,810	2,625,266	+1.2%
4. Private Four-Year College	1,335,225	1,284,302	+4.0%
5. Public Two-Year College	3,399,504	3,273,265	+3.9%
6. Private Two-Year College	114,875	111,585	+2.9%

In a few cases respondents were not uniformly distributed throughout the sample. For example, in one cluster of 101 public colleges the eight responses were from institutions about 50% larger than the cluster average. In this case appropriate adjustment in weighting factors led to better estimates.

Given the above checks on estimation procedures, one might still quite reasonably ask 'Do the patterns of mathematics enrollments and faculty characteristics in non-respondent institutions differ in significant ways from those completing the survey questionnaire?' Responses were received from mathematical science departments in 10% of all U. S. institutions of higher education, institutions which have 20% of all higher education enrollments. However, the overall questionnaire response rate was only 60% of the sample (as low as 54% for private universities).

In contrast to more common opinion surveys, the CBMS questionnaire asked each responding department to assemble, often from disparate sources, detailed information about its program and staff. Comments from many respondents suggest that timing of the survey (calling for Fall data well after the Spring semester had begun) made completion of the questionnaire particularly troublesome. This factor in low response does not seem likely to have caused distortion in the actual respondent data.

In every control/type category response rates for the 1975-76 survey were lower than in previous CBMS efforts. But this decline seems consistent with an acknowledged pattern in all survey research -- as individuals and institutions face sharply increased numbers of such survey requests, more and more become non-respondents. Again, this factor does not seem to undermine, in any obvious way, the data patterns established by actual respondents.

The most reliable check on validity of response data is to sample the non-respondents and compare the results of this collection with the original respondents. The survey committee identified fourteen non-respondents institutions, concentrating on control/type categories and geographical regions notable by under-representation in the respondents, and mailed special requests for response to the mathematical science departments in those institutions. Ultimately, ten of these non-respondents did complete the questionnaire and the findings were compared with estimates based on the first collection of responses. In general the original estimates were supported, but wherever this second round suggested modification of estimates or cautions on interpretation, the results have been included.

Structure of the Report

Universities, four-year colleges, and two-year colleges are increasingly part of higher education systems with complex interrelationships of instructional program, course enrollments, and faculty characteristics. Changes in any aspect of one institution have implications for and are often caused by changes in the others. The survey data and analyses of this study are presented in two main parts: Part I, devoted to universities and four-year colleges, and Part II, to two-year institutions. However, there are frequent cross-references, and clear understanding of undergraduate education in the mathematical sciences requires careful consideration of the entire document.

Chapter 2

ENROLLMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCE COURSES: UNIVERSITIES AND FOUR-YEAR COLLEGES

This chapter reports estimated national enrollments in university and four-year college mathematical science courses for Fall 1975. The data are compared and contrasted with results of previous CBMS surveys and enrollment patterns elsewhere in higher education, especially in the increasingly important two-year college sector, to establish and explain trends and to make tentative predictions of enrollment profiles that affect mathematical science program and manpower planning.

Summary of Major Results

In the five year period from Fall 1970 to Fall 1975 undergraduate mathematical science enrollments in universities and four-year colleges increased from 1,386,000 to 1,497,000 or about 8%. This continues the pattern of growth begun as early as 1960, but at a greatly reduced rate. The distribution of mathematical science enrollments differs strikingly from that observed in previous CBMS undergraduate surveys.

-- The 8% increase in mathematical science enrollments is less than the 11% growth in overall university and four-year college enrollments; the mathematics increase was concentrated in four-year colleges.

-- Enrollments in pre-calculus and calculus courses increased by 12% to 1,089,000 with much of the increase concentrated in courses serving fields that traditional have not been heavy users of mathematics.

-- Enrollments in upper division mathematics courses -- those commonly taken by majors in mathematics, physical science, or engineering -- <u>declined</u> by over 32% between 1970 and 1975. This decline represents a loss of nearl

74,000 enrollments in courses such as advanced calculus, linear and modern algebra, geometry, and foundations of mathematics.

-- Computer science course enrollments increased by 24% to 112,000; statistics course enrollments increased by 53% to 141,000. Together these topic areas now account for nearly 17% of all mathematical science enrollments, even excluding courses taught by departments such as business, engineering, or the social sciences.

The balance of this chapter presents more detailed survey data, elaborating the main trends described above, as well as important background information useful for interpretation of the changes observed. In reading the chapter one should keep in mind that _reported enrollments are estimated national totals for universities and four-year colleges_, unless specifically noted otherwise.

Impact of Two-Year Colleges. Although university and four-year college mathematical science enrollments increased slowly from 1970 to 1975, the growth in two-year colleges was dramatic, up 50% to 874,000. _Two-year colleges now account for 37% of all mathematical science enrollments in higher education_, a fraction that is up from 30% in 1970 and 25% in 1966. Chapter 5 of this report describes in detail the patterns of mathematical science enrollments in two year colleges. But there will be frequent reference to that information in this chapter on four-year institutions, since it is vital to understanding of the total undergraduate situation.

General Enrollment Trends in Higher Education

Since 1960, increases in mathematical science enrollment have closely matched overall increases in higher education enrollment. This global pattern held true from 1970 to 1975, but the distribution of higher education enrollments to various fields of study has changed significantly in that time period, with noticeable impact on demand for mathematical science courses. The data in Tables 2.1 - 2.6 describe changes in overall enrollment patterns of higher education which help explain the marked changes in mathematics.

Table 2.1 documents the continuing growth of two-year colleges. Their impact on undergraduate enrollment patterns is under scored by the data on first time undergraduate enrollments in Table 2.2 which shows that from 1965 to 1975 growth in freshman enrollment has concentrated in the two-year colleges.

Table 2.1

FULL-TIME EQUIVALENT*, DEGREE-CREDIT**, UNDERGRADUATE ENROLLMENTS IN ALL HIGHER EDUCATION (In Thousands)

Type of Institution	1965	Change	1970	Change	1975
Universities and Four-Year Colleges	3435	+33%	4576	+11%	5065
Two-Year Colleges	610	+85%	1127	+38%	1554

Source: NCES. Projections of Education Statistics to 1984-85 [F], and unpublished NCES data for 1975.

*Full time equivalent (FTE) enrollment is the sum of all full-time enrollments and one-third of all part-time enrollments.

**Non-degree credit enrollments in two-year colleges account for over 900,000 full time equivalent students. In four-year institutions the number of such students is negligible.

Table 2.2

FULL-TIME EQUIVALENT FIRST TIME UNDERGRADUATE ENROLLMENTS FOR UNIVERSITIES, FOUR-YEAR COLLEGES, AND TWO-YEAR COLLEGES (In Thousands)

Type of Institution	1965	Change	1970	Change	1975
Universities and Four-Year Colleges	966	+ 9%	1051	+ 3%	1079
Two-Year Colleges	309	+60%	493	+ 6%	525

Sources: NCES. Projections of Education Statistics to 1984-85 [F], and unpublished NCES data for 1975.

Though mathematical science course enrollments are clearly a function of overall undergraduate enrollments, they are also sensitive to societal factors which influence student interest in the various undergraduate programs. Whether due to diminished public regard for science and technology, changing post-college job opportunities, or other factors, a smaller percentage of college students are majoring in mathematical science, physical sciences, and engineering than was the case ten years ago. Table 2.3 shows the decline in freshman preference for such majors.

Table 2.3

PROBABLE MAJORS OF ENTERING FRESHMEN
IN ALL HIGHER EDUCATION

Subject Area	1966	1970	1975
Biological Sciences	10.9%	12.9%	17.5%
Business	14.3%	16.2%	18.9%
Education	10.6%	11.6%	9.9%
Engineering	9.8%	8.6%	7.9%
Humanities and Arts	24.3%	21.1%	12.8%
Mathematics and Statistics	4.5%	3.2%	1.1%
Physical Science	3.3%	2.3%	2.7%
Social Sciences	8.2%	8.9%	6.2%
Other Technical*	2.2%	3.7%	8.6%
Other Non-Technical	9.9%	9.4%	9.5%
Undecided	1.9%	2.2%	5.0%
Total Number of Full Time Freshman	1,163,123	1,617,324	1,760,502

Source: American Council of Education. _The American Freshman: National Norms for Fall_ [G], [H], [I].
*Including computer science.

The decline in potential mathematics and statistics majors among the freshman class represents a loss of about 32,000 students between 1970 and 1975. Furthermore, these data on probable major fields of freshman are leading indicators, not yet fully reflected in the mathematics enrollment data which follows. The sharp recent decline suggests the strong possibility of further significant enrollment losses in advanced mathematics courses over the next few years.

Undoubtedly many of the lost mathematics and statistics majors have gone to computer science -- a major choice that was not offered in the 1966 or 1970 ACE survey questionnaires and was included under 'other technical' in the 1975 report. Enrollment data on computer science major courses presented later in this chapter and preliminary ACE data elaborating the technical category suggest that the number of potential computer science majors among 1975 freshmen does not exceed 7,500. However, another survey by the College Entrance Examination Board indicates that computer science/systems analysis is nearly as popular as mathematics among freshmen choosing a major field of study.[R]

Table 2.4 shows the distribution of potential mathematics majors among freshmen at universities, four-year colleges, and two-year colleges. It shows that the declining interest in mathematics and statistics is affecting all types of institutions, though two-year colleges don't offer the advanced courses which have mathematics majors as their chief clientele.

Table 2.4

PERCENT AND NUMBER OF FRESHMAN PROBABLE MATHEMATICS AND STATISTICS MAJORS IN UNIVERSITIES, FOUR-YEAR COLLEGES, AND TWO-YEAR COLLEGES

Type of Institution	1966	1970	1975
Universities	4.5% [15,600]	3.9% [15,600]	1.6% [6,400]
Four-Year Colleges	6.0% [31,600]	4.3% [27,600]	1.5% [9,300]
Two-Year Colleges	1.9% [5,500]	1.6% [9,200]	.4% [3,000]
All Institutions	4.5% [52,700]	3.2% [52,400]	1.1% [18,700]

Source: ACE. <u>The American Freshman</u>: <u>National Norms for Fall</u> [G], [H], [I].

Changes in expressed preference for undergraduate majors are also reflected, with some time lag, in distribution of earned bachelor's degrees. These patterns are shown in Table 2.5.

Table 2.5

EARNED BACHELOR'S DEGREES FOR SELECTED FIELDS
(In Thousands)

Subject Area	1960-61	1965-66	1970-71	1975-76*
Humanities and Related Fields	52	87	140	147
Social Sciences and Related Fields	136	226	382	412
Business and Management	56	64	116	134
Natural Sciences and Related Fields**	114	126	172	198
-Biological Sciences	16	27	36	47
-Computer Science	-	-	2	5
-Engineering	36	38	50	47
-Mathematics and Statistics	13	20	25	20
-Physical Science	15	17	21	20

Source: NCES. Projections of Education Statistics to 1984-85 [F].
*Projected
**Includes agriculture and health fields in addition to those listed below.

Traditionally, engineering students have been a major clientele for calculus and post-calculus mathematics courses. As Table 2.6 shows, engineering enrollments slumped between 1970 and 1973, and the engineers taking upper level mathematics courses in 1975 were drawn primarily from the small entering freshman classes of 1970-73.

With freshman and total engineering enrollments now back to 1970 levels, there is reason for optimism about future demand for mathematical science courses from this sector of the undergraduate student body.

Table 2.6

FULL-TIME UNDERGRADUATE ENGINEERING ENROLLMENTS
(In Thousands)

	1965	1970	1971	1972	1973	1974	1975
Freshmen	80	72	59	52	52	63	75
All Engineering	220	232	211	195	187	201	231

Source: Engineers Joint Council. Engineering and Technology Enrollments [J].

In summary, between 1970 and 1975 enrollments in all higher education increased by 16%, but only 11% in universities and four-year colleges. Furthermore, first time enrollments increased by 4%, only 2.7% in universities and four-year colleges. As indicated by earned degrees and expressed preferences of freshmen choosing major areas of study, the demand for mathematical science instruction serving majors in the physical sciences and engineering has held stable; education and the humanities have declined, while growth has been concentrated in biological sciences and business. We have, however, no firm information regarding possible changes in mathematical science requirements for majors in these fields.

Mathematical Science Course Enrollments

In Fall 1975 there were 1,497,000 university and four-year college enrollments in undergraduate mathematical science courses. The distribution of these enrollments among various types of institutions, levels of study, and mathematics, statistics, or computer science topics is indicated by Tables 2.7 - 2.11.

The graph of Figure 2.1 and elaborating data in Table 2.7 describe broad enrollment trends since Fall 1960. Throughout that period mathematics courses below calculus, calculus, computer science, and statistics have experienced steady growth of enrollment -- exceeding the rate of growth for all higher education enrollment. The notable exception to this growth is the sharp drop in advanced mathematics courses between 1970 and 1975, over 32%.

Figure 2.1

MATHEMATICAL SCIENCE ENROLLMENTS IN
UNIVERSITIES AND FOUR-YEAR COLLEGES, 1960-1975

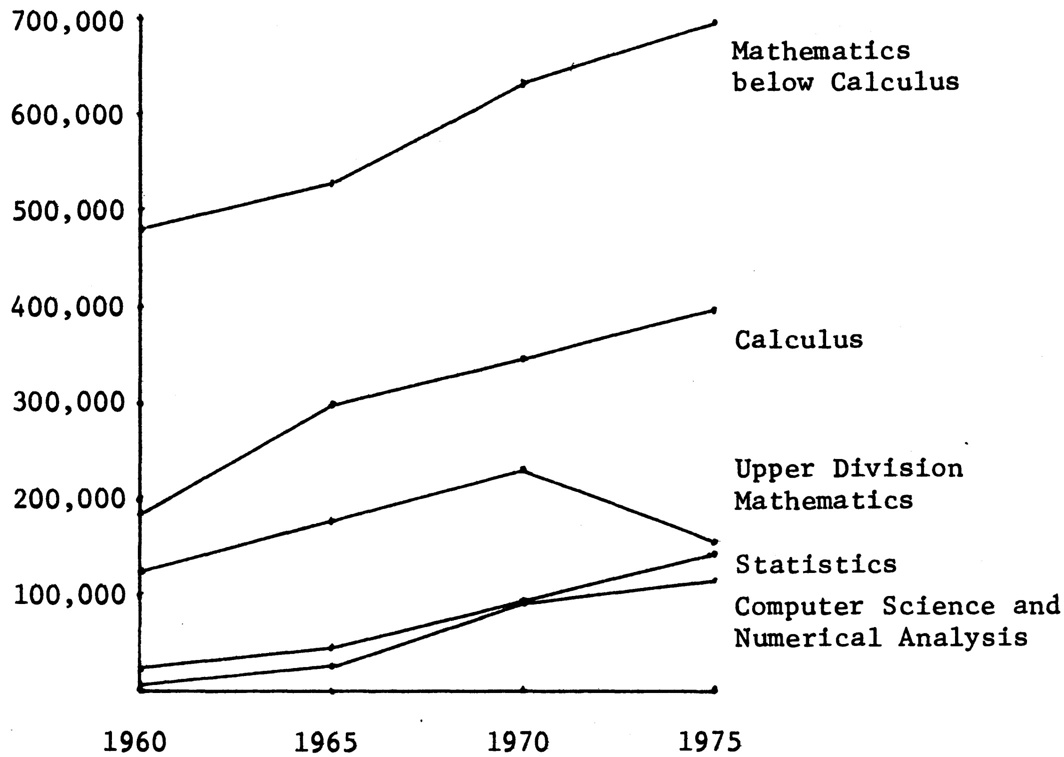


Table 2.7 also reveals trends in the relative importance of various levels and special topic areas in the overall instructional program of mathematical science departments. In 1960 mathematics courses below calculus (55%) and calculus (25%) accounted for 80% of all mathematical science enrollments. Upper division mathematics comprised 16%, statistics 3%, and computer science only 1% of mathematical science enrollments. By 1975 the picture had changed substantially. Courses below calculus had dropped to 45% of total mathematical science enrollments while calculus remained stable at 27% and upper division mathematics fell to 10%. Statistics (9%) and computer science (7%) had increased their share of the market to 16%. Table 2.8 gives more detail as to where growth and decline have occurred, and Appendix E gives the data for each course on the questionnaire. There are several general observations and explanations suggested by the data.

Table 2.7

UNDERGRADUATE MATHEMATICAL SCIENCE COURSE ENROLLMENTS
IN UNIVERSITIES AND FOUR-YEAR COLLEGES
(In Thousands)

Level	Fall 1960-61	Change	Fall 1965-66	Change	Fall 1970-71	Change	Fall 1975-76
Below Calculus	480	+29%	527	+20%	630	+10%	692
Calculus	184	+60%	295	+17%	345	+15%	397
Upper Division Mathematics	122	+46%	178	+29%	229	-32%	155
Computer Science and Numerical Analysis	7	+257%	25	+260%	90	+24%	112
Statistics	23	+87%	43	+114%	92	+53%	141
Total Mathematical Science Enrollments	744	+44%	1068	+30%	1386	+8%	1497

Table 2.8

TOTAL ENROLLMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCE COURSES IN UNIVERSITIES AND FOUR-YEAR COLLEGES
(In Thousands)

Subject	Fall 1960-61	Fall 1965-66	Fall 1970-71	Fall 1975-76
1. Miscellaneous Remedial Courses	8	8	4	6
2. High School Geometry	5	2	3	2
3. Elementary Algebra	10	12	25	26
4. Intermediate Algebra	33	46	50	81
5. General Mathematics (operations, skills, etc.)	40	21	19	26
6. Business Mathematics, Mathematics of Finance, etc.	17	21	18	47
7. Liberal Arts Mathematics (structure, logic, sets, etc.)	36	87	74	103
8. Mathematics for Elementary School Teachers	23	61	89	68
9. College Algebra, Trigonometry, Mathematical Analysis	235	262	301	259
10. Finite Mathematics	1	7	47	74
11. Analytic Geometry, Calculus	184	295	345	397
12. Differential Equations	29	31	31	29
13. Theory of Equations	5	1	1	na
14. Linear and Matrix Algebra	4	19	47	28
15. Modern Algebra	11	20	23	13
16. Theory of Numbers	2	3	4	1
17. Mathematics for Secondary School Teachers	5	5	7	3
18. Advanced Calculus	17	20	20	14
19. Advanced Mathematics for Engineers and Physicists	10	12	12	9
20. Miscellaneous Applied Mathematics	9	9	8	9
21. History, Logic, and Foundations	5	7	18	5
22. Advanced Geometry	8	12	13	5
23. Topology	1	3	5	1
24. Real Variables	1	3	11	6
25. Complex Variables	4	6	7	4
26. Miscellaneous Undergraduate Mathematics	11	27	22	28
27. Numerical Analysis	3	5	11	8
28. Computing and Related Mathematics	4	20	79	104
29. Probability, Statistics	23	43	92	141
Total	744	1,068	1,386	1,497

It is remarkable that enrollments in courses below calculus increased by 10% from 1970, while the number of first time students in universities and four-year colleges increased only 2.7%. The 60% increase in intermediate algebra might be explained in part by widespread reports of declining mathematical preparation and abilities among entering freshmen. The increase in business mathematics parallels increases in the number of entering freshmen who plan to major in business administration. The sharp increase in finite mathematics probably represents mathematics departments reaching out to better serve students in biological, social, and management sciences. If one looks in detail at the computer science and statistics enrollments (See Appendix [E]) this pattern of service in non-traditional topic areas is confirmed. Nearly 68% of computer enrollments and 70% of statistics enrollments are in introductory level courses.

Declining enrollment in mathematics for elementary school teachers was to be expected, in view of the general decline in numbers of education majors. The drop in college algebra/trigonometry is probably a direct consequence of declining numbers of undergraduate mathematics majors, because the engineering and physical science audience for these courses has remained stable since 1970. The alternative explanation that students enter college with preparation that enables them to move directly into calculus was not supported by informal observations from survey respondents.

Because university and college calculus offerings have recently been substantially reorganized and diversified, it is difficulty to get a clear understanding of sources for the 15% increase in calculus enrollments. Mathematics majors appear to have declined in number since 1970; engineering and physical science majors are about the same level as in 1970. Since the new course title 'Calculus (biological, social, and management science)' was responsible for 89,000 enrollments in Fall 1975, it appears that these disciplines are providing the new audience for calculus.

Nearly all lower division mathematics enrollment changes must be viewed with one eye on the two year college data, since we observed earlier that more and more first time students are entering two year schools. But inspection of Table 2.9 reveals changes in two-year colleges that often parallel the university and four year college situation.

Table 2.9

LOWER DIVISION MATHEMATICS ENROLLMENTS IN
FOUR-YEAR AND TWO-YEAR INSTITUTIONS
(In Thousands)

Topic	Four-Year 1970	Four-Year 1975	Two-Year 1970	Two-Year 1975
Remedial Mathematics*	101	141	191	245
Business Mathematics	18	47	33	79
Liberal Arts Mathematics	74	103	57	72
Mathematics for Elementary Teachers	89	68	25	12
Finite Mathematics	47	74	12	12
College Algebra/Trigonometry	301	259	124	149
Calculus and Analytic Geometry	345	397	68	73

*Courses 1 through 5 in Table 2.8.

Of the many changes in undergraduate mathematics enrollments since 1970, the most striking is the precipitous drop in enrollments in upper division courses. Given the earlier evidence of decline in mathematics majors, it might be surprising that the course enrollments didn't drop even more sharply. But the numbers are discouraging enough:

- -linear and matrix algebra down from 47,000 to 28,000 or 40%.
- -modern algebra down from 23,000 to 13,000 or 43%.
- -advanced calculus down from 20,000 to 14,000 or 30%.
- -history, logic, and foundations down from 18,000 to 5,000 or 72%.
- -advanced geometry and topology down from 18,000 to 6,000 or 67%.

The only advanced course to come close to holding its own was differential equations, down only from 31,000 to 29,000.

The drop in upper division mathematics enrollments has particularly serious implications for support of mathematical science faculties. It is these courses that demand highly qualified faculty and many more faculty per course than do lower division courses with high student/teacher ratios. Only computer science and statistics have continued to experience enrollment growth in upper level courses. For computer science the increase was about 10,000; for statistics 7,000 (See Appendix E).

Table 2.10 indicates the different profiles of mathematics enrollments in universities, public four-year colleges, and private four-year colleges. The table shows clearly that since 1970 university mathematics enrollments have remained nearly constant, the sharp drops in advanced courses being offset by increases elsewhere. While university statistics enrollment increased by 37%, the numerical analysis and computing growth was only 7% or about the same as overall university enrollment increases. Public four-year colleges had substantial enrollment growth in pre-calculus courses (14%) and calculus (15%), decline in upper level mathematics (-23%), and dramatic increases in computer science (82%) and statistics (105%). Private college enrollment changes were slightly different, with pre-calculus up 3%, calculus up 48%, upper level mathematics down 24%, computer science up 25%, and statistics up 38%.

Mathematical Science Courses Taught in Other Departments

The information presented above has been restricted to enrollments in undergraduate mathematical science courses taught within mathematical science departments. This includes courses taught by departments of mathematics, statistics, and computer science, but not courses taught by departments specializing in such fields as business or engineering.

From the very beginning of its work the Survey Committee has been interested in mathematical science courses taught outside mathematical departments. In the 1965-66 survey sufficient information was collected to demonstrate the widespread existence of this phenomenon, at least in universities. The 1970-71 survey tried to get quantitative information on the enrollments in such courses by asking mathematics department chairmen to estimate the annual enrollment in mathematical science courses taught outside their departments.

Table 2.10

MATHEMATICAL SCIENCE ENROLLMENTS AT SELECTED LEVELS IN UNIVERSITIES, PUBLIC AND PRIVATE FOUR-YEAR COLLEGES
(Enrollments in Thousands and as % of Total)

	Universities		Public Colleges		Private Colleges	
	1970	1975	1970	1975	1970	1975
Below Calculus	224(36%)	243(30%)	293(58%)	333(58%)	113(43%)	116(39%)
Calculus	185(29%)	193(30%)	99(20%)	114(20%)	61(23%)	90(30%)
Upper Division Mathematics	114(18%)	67(11%)	65(13%)	50(9%)	50(20%)	38(13%)
Numerical Analysis and Computing	57(9%)	61(9%)	17(4%)	31(5%)	16(6%)	20 (7%)
Statistics	49(8%)	67(11%)	22(4%)	45(8%)	21(8%)	29(10%)
Totals	629	631	496	573	261	293

Total 2.11

ESTIMATED ENROLLMENTS IN MATHEMATICAL SCIENCE COURSES TAUGHT OUTSIDE MATHEMATICAL SCIENCE DEPARTMENTS IN UNIVERSITIES AND FOUR-YEAR COLLEGES
(In Thousands)

	Biol. Science	Physical Sciences	Engi- neering	Agri- culture	Educa- tion	Business Admin.	Social Sciences	Other specify	Totals
Probability	L*		1			L		L	1
Statistics	2	2	2	1	7	49	32	7	102
Calculus or Diff. Equations	L	L	4	1	L	4	2		11
Advanced Math for Engineers/Physics		1	3					L	4
Computer Science and Programming	L	1	15		L	19	1	5	41
Numerical Analysis		1	2					L	3
Optimization and Linear Programming		L	2		L	4	L	L	6
Biomathematics	L		L				L		L
Mathematics of Finance, etc.						7		L	7
Other: specify	L	L	L	L	L	3	L	1	5
Totals	2	5	29	2	8	86	35	13	180

*L means less than 500

In 1970 the estimated number of enrollments in undergraduate mathematical science courses taught outside mathematical science departments was 119,000 in the Fall term. These enrollments, about 9% of the mathematical science department figure, were concentrated in statistics (taught in engineering, education, business, and social science departments) and computer science (taught in engineering and business departments). In fact, outside enrollments in statistics were estimated as 67% of those within mathematical science departments, and outside computer science enrollments were estimated as 40% of those within mathematical science departments.

The 1975-76 survey questionnaire again asked respondents to estimate outside enrollments in mathematical science courses. The results, extrapolated to national estimates for the Fall semester, are given in Table 2.11. In considering the implications of this information it is important to keep in mind that the enrollment figures are national estimates based on educated guesses made by responding department chairmen. The similarity of Table 2.11 and the estimates in 1970-71 suggests some confidence in the overall pattern of the estimates, but absolute numbers are necessarily soft.

The estimated 180,000 enrollments represent a 53% increase over 1970, substantially greater than the overall growth rate for mathematical science enrollments in regular mathematical science departments. Together these enrollments equal 12% of mathematical science department enrollments. However, as in 1970, the enrollments are concentrated in computer science (mainly taught in engineering and business administration departments) and in statistics (mainly taught in business administration and social science departments). The growth of these outside computer and statistics enrollments since 1970 roughly parallels substantial increase within mathematical science departments (See Table 2.8).

Bachelors Degrees in Mathematics

For mathematics departments surveying the enrollment data reported in this chapter the most ominous finding must be the sharp decline in upper division mathematics courses. Though some of this decline might be explained by the decline in feeder freshman engineering classes of 1971-73, much of the enrollment drop is clearly the result of sharp reductions in the numbers of students

Table 2.12

BACHELOR'S DEGREES IN MATHEMATICAL SCIENCES BY SPECIAL AREA IN UNIVERSITIES AND FOUR-YEAR COLLEGES 1974-75

Type of Institution	Mathematics	Computer Science	Statistics	Actuarial Science	Applied Math.	Secondary Teaching	Other
Universities	5,561	2,601	378	70	185	963	86
Public Colleges	6,586	801	136	0	288	3,083	41
Private Colleges	5,566	234	56	0	413	732	37
Totals	17,713	3,636	570	70	886	4,778	164

choosing mathematics as a major. Table 2.3 documents this change by listing expressed preferences of entering freshmen. Analysis of the data of Table 2.12 on actual bachelor's degree awards in mathematics during 1974-75 gives a more definite but equally discouraging picture.

The national estimate of 27,800 bachelors degrees in mathematical science that this table yields is about 6.5% greater than NCES reported figures. The 24,000 exclusive of computer science is 34% greater than the 18,000 freshmen of 1975 who report plans to major in mathematics, suggesting that mathematics departments have only begun to see the decline in their upper division offerings. It is impossible to estimate changes in the distribution of mathematical science majors among various special sub-fields, since comparable data were not collected in earlier CBMS surveys. However, computer science, which is a separate category in NCES reports, has grown from no majors in 1965 to its present share of at least 13%. It seems likely to continue that growth, with statistics departments also attracting an increasing share of the undergraduate majors.

Chapter 3

MATHEMATICAL SCIENCE FACULTY IN UNIVERSITIES AND FOUR-YEAR COLLEGES

This chapter describes the number, educational qualifications, and selected personal characteristics of mathematical science faculty in universities and four-year colleges during Fall 1975. It also indicates instructional and research responsibilies of these faculty and patterns of movement into and out of academic positions between 1974 and 1975. The data are compared with enrollment and faculty information from previous CBMS surveys and other surveys of all higher education to help explain and predict patterns in mathematical science manpower utilization and needs.

Summary of Major Results

In Fall 1975 there were 16,863 full-time and 3,598 part-time faculty. This compares with 17,043 full-time and 2,830 part-time faculty in 1970, and it represents an abrupt halt to the roughly 1,000 per year growth in faculty throughout the 1960's. Furthermore, the patterns of faculty qualifications, institutional responsibilities and mobility have changed markedly since 1970.

-- The number of mathematical science enrollments per full-time-equivalent faculty member increased from 77 in 1970 to 83 in 1975, an 8% increase.

-- The decline in full-time mathematical science faculty was confined to university mathematics departments, whereas computer science experienced substantial gains and statistics more modest ones.

-- The fraction of mathematical science faculty holding doctoral degrees increased sharply between 1970 and 1975, particularly in four-year colleges where the fraction is now over 70%.

-- The median age of mathematical science faculty is approximately 39 years with fewer than 5% over 60. Overall, 72% of these faculty members hold tenure.

-- Women comprise only 10% of mathematical science faculties, and racial minorities about 7%, mostly Orientals.

-- There is a clear trend toward increased credit hour teaching loads, use of large-scale teaching methods, and higher research expectations of mathematical science faculty in all types of four-year institutions.

Many of the patterns cited above were also observed in two-year colleges. The major differences whereas the FTE faculty in two-year colleges increased by 26% (most in part-time positions), college mathematical science enrollments per FTE faculty increased from 104 in 1970 to 123 in 1975 (18%). Further details on the two-year college situation are given in Chapter 6. The overall trends in mathematical science faculty numbers, qualifications, personal characteristics, and responsibilities in four-year institutions are elaborated in subsequent sections of the present chapter.

General Trends in Higher Education Faculty

Changes in the numbers, qualifications, personal traits, and teaching loads of mathematical science faculty are clearly influenced by pressures on all of higher education. As data in Chapter 2 show, the number of students enrolled in four-year institutions grew much more slowly between 1970 and 1975 than during the 1960's -- approximately 11%. Furthermore, there has been substantial change in student academic preferences, noticeably away from physical sciences and mathematics. Combined with increasing constraints of funding for higher education, these pressures have led to reallocation of faculty resources that has hit hard at "slow or no-growth" areas.

Table 3.1 compares growth in higher education enrollment and faculty (all fields) from 1965 to 1975. There is a trend for enrollments to grow faster than faculty, a pattern that contrasts with the situation in mathematics for 1965-70 but not for 1970-75. While there is no regular comprehensive survey of higher education faculty educational qualifications, personal characteristics, and teaching responsibilities, the data of Tables 3.2 - 3.4 give a reasonably current profile of the overall situation. These data

Table 3.1

FULL-TIME-EQUIVALENT* ENROLLMENTS AND FACULTY FOR
ALL HIGHER EDUCATION
(In Thousands)

	1965	1970	1975
FTE Enrollment	4671	6721	8289
FTE Faculty	317	452	508**
Students/Faculty	14.7	14.9	16.3**

Source: NCES, Projections of Education Statistics to 1984-85 [E] and unpublished NCES data for 1975.
*Full-time plus one-third of part-time.
**Projected

Table 3.2

HIGHEST EARNED DEGREES OF FULL- AND PART-TIME FACULTY
IN ALL FIELDS OF UNIVERSITIES AND COLLEGES

Institutions/Degree Type	1966	1972
Universities		
Doctoral	54%	50%
Masters	28%	34%
Professional	11%	9%
Bachelors	7%	7%
Colleges		
Doctoral	38%	40%
Masters	52%	51%
Professional	2%	5%
Bachelors	7%	4%

Sources: NCES, Numbers and Characteristics of Employees in Higher Education, Fall 1966 [K] and Alan E. Bayer, Teaching Faculty in Academe, 1972-73 [L].

Table 3.3

AGE DISTRIBUTION OF FACULTY IN UNIVERSITIES AND FOUR-YEAR COLLEGES IN 1973

	Universities		4 Year Colleges	
	Men	Women	Men	Women
30 or Less	4.9%	10.8%	7.1%	10.6%
31-35	15.0%	14.7%	17.3%	12.7%
36-40	15.7%	12.6%	16.7%	14.7%
41-50	30.0%	25.6%	29.4%	28.6%
51-60	22.1%	24.1%	18.5%	19.6%
over 60	9.2%	9.6%	7.0%	8.6%

Source: Alan E. Bayer, Teaching Faculty in Academe, 1972-73 [L].

Table 3.4

NUMBER OF HOURS PER WEEK OF SCHEDULED TEACHING IN UNIVERSITIES AND FOUR-YEAR COLLEGES, 1973*

Number of Hours	Universities	Four-Year Colleges
None or No Response	7.3%	6.1%
1-4	17.6%	9.1%
5-8	32.2%	17.6%
9-12	25.3%	39.6%
13-16	9.0%	17.5%
17 or more	8.6%	10.1%

Source: Alan E. Bayer, Teaching Faculty in Academe, 1972-73 [L].
*Percents are weighted averages of percents given for men and women.

provide a useful backdrop for interpretation of the status and recent changes in characteristics of mathematical science faculty.

Numbers of Mathematical Science Faculty

From 1970 to 1975 the number of full time mathematical science faculty in universities and colleges declined about 1%, to 16,863; the part-time faculty (not including graduate assistants) increased 27% from 2,830 to 3,598. The distribution of changes in faculty numbers is indicated in Table 3.5. Most striking is the drop in both full-time (-6.5%) and part-time (-11%) university faculty positions.

Table 3.5

FULL-TIME AND PART-TIME MATHEMATICAL SCIENCE FACULTY
IN UNIVERSITIES AND FOUR-YEAR COLLEGES*

Type of Institution	1965-66	1970-71	1975-76
Universities			
Full Time	4,730	7,623	7,124
Part Time	698	1,009	900
Public Colleges			
Full Time	3,426	6,068	6,160
Part Time	360	876	1,339
Private Colleges			
Full Time	2,597	3,352	3,579
Part Time	693	945	1,359
Total			
Full Time	10,753	17,043	16,863
Part Time	1,751	2,830	3,598

*Not including graduate teaching assistants.

Counting each part-time faculty member as the equivalent of one third of a full time faculty member (as done in previous CBMS and NCES survey analyses), the number of mathematical science enrollments per FTE faculty has increased by 8%, reversing the decrease that took place between 1965 and 1970.

The changes in enrollment, faculty, and enrollments per FTE faculty have not affected all types of institutions or mathematical science departments the same. As mentioned above, university mathematical science departments had the only absolute decline in numbers of faculty. But within universities the apparent loss was concentrated in mathematics departments, not computer science and statistics departments. In university mathematics departments the data indicate that full-time-equivalent faculty <u>declined</u> by 802 or about 12%. The computer science and statisitcs FTE faculty increased by 31% and 3% respectively -- most in the category of full-time faculty members.

The surprising decline of faculty numbers in university mathematics departments is probably attributable in part to the formation on new departments of computer science and statistics with a resulting transfer of mathematics faculty members to the newly formed departments. However, the indicated decrease being larger than the increases in the numbers of computer science and statistics faculty, cannot all be explained by reorganization. Therefore we conclude that, as is supported by anecdotal evidence, there has been a genuine decline in the number of university mathematics professors, but probably not as large a decline as shown in Table 3.5.

In universities, and to less extent in public colleges, much of the mathematics instruction in pre-calculus courses is the responsibility of teaching assistants. Tables 3.7 and 3.8 show that since 1970-71 changes in the number and distribution of teaching assistants were similar to changes in senior faculty. University mathematics and statistics departments now use somewhat fewer TA's, but computer science has had a counterbalancing increase. Private colleges have begun to make substantial use of teaching assistants (including 34% undergraduates), though they still account for only 7% of FTE faculty in those institutions.

The data of Tables 3.5 - 3.8 indicate current status and recent changes in the numbers of mathematical science faculty at universities and four-year colleges. Patterns of mobility within the system and prospects for future growth or decline in these numbers are discussed with more detail in a later section of this chapter.

Table 3.6

MATHEMATICAL SCIENCE ENROLLMENTS PER FTE FACULTY*
IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Type of Institution	1965-66	1970-71	1975-76
Universities	104	79	85
Public Colleges	101	78	87
Private Colleges	90	71	73
All Institutions	99	77	83

*Not including graduate teaching assistants.

Table 3.7

MATHEMATICAL SCIENCE FACULTY IN UNIVERSITIES*

Type of Department	1970-71	1975-76	% Change
Mathematics Departments			
Full Time	6,235	5,405	-13%
Part Time	615	699	+14%
Computer Science			
Full Time	688	987	+43%
Part Time	300	133	-56%
Statistics			
Full Time	700	732	+5%
Part Time	93	68	-27%
Total			
Full Time	7,623	7,124	-7%
Part Time	1,008	900	-11%

*Not including graduate teaching assistants.

Table 3.8

NUMBERS OF MATHEMATICAL SCIENCE TEACHING ASSISTANTS IN UNIVERSITIES AND FOUR-YEAR COLLEGES*

Type of Institution	1970-71	1975-76
Universities	7,055	6,612
Mathematics	5,999	5,087
Computer Science	309	835
Statistics	747	690
Public Colleges	1,804	1,805
Private Colleges	146	559
Totals	9,005	8,976

*A small number, about 6%, are undergraduates and the rest graduate students.

Qualifications of Faculty

As university and four-year college mathematical science faculties grew rapidly throughout the 1960's, the supply of highly trained potential faculty members grew even more rapidly. The yearly production of mathematical science doctorates increased from 596 in 1963-64 to 1,343 in 1968-69 and has held steady since then -- though now about 20% are in computer and information sciences.

The data presented in this section stress formal qualifications of faculty primarily because this is the only easily obtained measure of quality. The adequacy of this measure of quality in mathematical science departments will of course depend on the research, teaching, and service priorities of individual departments.

Tables 3.9 and 3.10 show overall trends in the formal qualifications of mathematical science faculty members. The most striking change since 1970 is the sharp increase in percent of public and private four-year college faculty who hold the doctoral degree, now 74% and 69% respectively. Since university faculties

Table 3.9

EDUCATIONAL QUALIFICATIONS OF FULL-TIME MATHEMATICAL SCIENCE FACULTY IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Type of Institutions	1965	1970	1975
Universities			
Doctorate	3,584 (76%)	6,652 (87%)	6,492 (91%)
Masters	1,084 (23%)	901 (12%)	600 (9%)
Bachelors	62 (1%)	70 (1%)	32 (-)
Public Colleges			
Doctorate	1,237 (36%)	2,866 (47%)	4,536 (74%)
Masters	2,002 (59%)	3,114 (51%)	1,609 (26%)
Bachelors	186 (5%)	88 (2%)	15 (-)
Private Colleges			
Doctorate	890 (34%)	1,400 (42%)	2,471 (69%)
Masters	1,558 (60%)	1,890 (56%)	1,092 (31%)
Bachelors	149 (6%)	62 (2%)	16 (-)

Table 3.10

FIELD OF DOCTORATE FOR FULL-TIME MATHEMATICAL SCIENCE FACULTY IN 1975 FOR UNIVERSITIES AND FOUR-YEAR COLLEGES

Type of Institution	Mathematics	Statistics	Computer Science	Mathematics Education	Other
Universities (6492 doctorates)	69%	14%	8%	2%	7%
Public Colleges (4404 doctorates)	72%	8%	4%	15%	1%
Private Colleges (2471 doctorates)	83%	1%	1%	10%	5%

have apparently declined in numbers since 1970 and those institutions had already essentially totally doctorate faculties, many highly trained mathematical scientists have clearly been moving into four-year colleges, largely as replacements for those holding the master's degree. The exact pattern of this movement of faculty is not clear. Certainly some mathematical science doctorates fail to receive tenure in universities and move to college positions. Others who were in four-year colleges completed their doctoral study and stayed on, while a third group went directly from doctoral study to first appointment in four-year college. A different view of faculty mobility is given in a later section which reports data from another survey question.

Since the increase in doctoral level faculty members has been concentrated in colleges -- where the main responsibility is more often teaching and service than research -- it is interesting to study the areas of specialization of doctorate mathematical science faculty in various types of institutions. The results are probably not surprising. The public colleges, many of which have emerged from teacher education institutions, have the highest fraction of mathematics education doctorates, and all colleges have a low percent of statistics and computer science doctorates. The 1974-75 production of mathematical science doctorates has a profile different from that of all mathematical science faculty given by Table 3.10. A 1976 National Research Council report of doctorate recipients [N] indicates 1149 degrees in mathematical science, of which 174 (15%) were in probability and statistics and 167 (14.5%) were in computer science. These numbers do not include computer science degrees given by engineering departments nor statistics degrees given by biological or social science departments.

In both public and private colleges part-time faculty members have recently grown to account for a significant portion of mathematical science faculties. As Table 3.11 shows, the formal qualifications of these faculty are typically quite different from those of the full-time faculty.

In considering the implications of this data, it is important to remember that individuals included in the part-time category are in many cases joint appointees -- with part-time affilation in a mathematical science department. This probably helps explain the high percent of doctorates among statistics, computer

Table 3.11

EDUCATIONAL QUALIFICATIONS OF PART-TIME MATHEMATICAL SCIENCE FACULTY
IN UNIVERSITIES AND FOUR-YEAR COLLEGES -- 1975

Type of Institution	Mathematics	Statistics	Computer Science	Mathematics Education	Other
Universities (doctorate %) 900 (65%)	476(52%)	175(89%)	129(67%)	26(31%)	94(99%)
Public Colleges (doctorate %) 1339 (17%)	937(18%)	58(10%)	89(3%)	231(19%)	24(33%)
Private Colleges (doctorate %) 1359 (43%)	1006(33%)	5(-)	50(10%)	45(71%)	253(83%)

science, and "other" classifications. It is also probably related to the recent overall growth of part-time faculty appointments and the decline of full-time mathematics faculty in universities.

Previous CBMS surveys have investigated the number of doctorates per institution, usually finding doctorates concentrated in the large universities. In the 1975-76 survey, among 173 responding four-year institutions only 8 had no mathematical science doctorates on their faculty, and these were small, special-focus schools.

Age, Tenure, Sex, and Racial Composition of Mathematical Science Faculty

The period of swift growth in the number and educational qualification of university and college faculties has led to significant change in the age distribution and tenure status of faculties. This in turn leads to changes in the job market for graduate students, sending delayed reactions throughout higher education enrollment and staffing. More recently, colleges and universities have been under strong pressure to increase the numbers of women and various racial minorities in their senior faculties.

Tables 3.12 - 3.17 describe the 1975-76 tenure, age, sex, and racial profiles of mathematical science faculties in universities and four-year colleges.

During the 1960's teaching faculties and production of mathematical science doctorates to fill faculty positions both grew rapidly. Thus it is not surprising that the median age of full time mathematical science faculty is only 39 years. Furthermore, fewer than 5% of these faculty are over 60 years old. Assuming a death and retirement rate of 1% per year, replacement will demand about 170 full-time mathematical science positions each year, compared to current production of well over 1,000 mathematical science doctorates.

Comparing information in Tables 3.12 and 3.3 confirms a finding of earlier CBMS surveys that mathematical science faculty tend to be much younger on the average than the total higher education faculty.

Table 3.12

AGE DISTRIBUTION OF FULL-TIME MATHEMATICAL SCIENCE FACULTY
IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Type of Institution	<30	30-34	35-39	40-44	45-49	50-54	55-59	≥60
Public Universities (5671 faculty)	12%	22%	22%	15%	11%	8%	5%	5%
Private Universities (1453 faculty)	9%	22%	22%	15%	14%	9%	6%	3%
Public Colleges (6160 faculty)	8%	24%	20%	18%	10%	9%	5%	6%
Private Colleges (3579 faculty)	4%	20%	26%	16%	10%	10%	7%	7%
All Institutions (16863 faculty)	10%	22%	22%	16%	11%	9%	5%	5%

Leveling enrollments and a preponderance of young faculty suggest long-term stability in mathematical science departments. This prospect is confirmed by the tenure data given in Table 3.13. The overall tenure rate of 72% in mathematical science departments is substantially higher than the 1973 national average of 57% for public higher education and 51% for private higher education overall (though in the intervening years these percents may have increased by as much as 10-15%). As with age, the tenure profiles of all four types of institutions are remarkably similar.

Table 3.13

TENURE STATUS OF MATHEMATICAL SCIENCE FACULTY IN UNIVERSITIES AND FOUR-YEAR COLLEGES

	Tenured Ph.D.	Tenured non-Ph.D.	Non-Tenured Ph.D.	Non-Tenured non-Ph.D.
Public Universities	69%	4%	25%	2%
Private Universities	57%	10%	28%	5%
Public Colleges	56%	18%	20%	6%
Private Colleges	45%	25%	24%	6%
All Institutions	62%	10%	24%	4%

Since computer science and statistics are the likely areas of future growth within the mathematical sciences, it is particularly timely to assess the age and tenure status of faculty in these areas. The data are given in Table 3.14. It is mildly surprising that these faculty members are only slightly younger than overall mathematical science faculty and the tenure ratio is only slightly lower than that for universities where most reside.

Because mathematical science departments, like all universit and four-year college departments, are facing pressure to maintain non-tenured faculty positions for continued faculty revitalization, the survey committee inquired about the number and age of mathematical science faculty granted tenure during 1974-75.

Table 3.14

AGE AND TENURE STATUS OF COMPUTER SCIENCE AND STATISTICS FACULTIES IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Type of Department	<30	30-34	35-39	40-44	45-49	50-54	55-59	≥60
Computer Science								
Tenured	7%	9%	15%	14%	9%	8%	3%	-
Non-Tenured	11%	12%	6%	4%	1%	-	-	-
Statistics								
Tenured	-	10%	15%	16%	11%	9%	7%	3%
Non-Tenured	11%	16%	2%	-	-	-	-	-

The data in Table 3.15 reveal a consistent pattern of roughly 5% of mathematical science faculty gaining tenure in the past year. The average tenure age of 35 again suggests long term stability for mathematical science faculties.

Table 3.15

PERCENT AND AVERAGE AGE OF MATHEMATICAL SCIENCE FACULTY GRANTED TENURE DURING 1974-75 IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Type of Department	% Granted Tenure	Average Age at Tenure
University		
Mathematics	4%	36
Computer Science	7%	34
Statistics	6%	35
Public Colleges	4%	36
Private Colleges	5%	35

One of the main goals of equal employment opportunity affirmative action programs in higher education has been to increase representation of women and racial minorities on faculties. Table 3.16 compares the percent of women in mathematical science faculty with the percent of women in all higher education.

Table 3.16

PERCENT OF WOMEN IN FULL-TIME MATHEMATICAL SCIENCE AND ALL FULL-TIME FACULTY FOR UNIVERSITIES AND FOUR-YEAR COLLEGES

Type of Institution	Mathematical Science (1975)	All Disciplines (1974)
Public Universities	7%	19%
Private Universities	7%	16%
Public Four-Year Colleges	13%	24%
Private Four-Year Colleges	10%	26%
All Institutions	10%	24%

The fact that women comprise a smaller fraction of faculties in mathematical science than in other disciplines is not at all surprising. It is difficult to determine whether the situation is changing, since comparable data were not collected in previous CBMS surveys. However, comparison of Tables 3.17 and 3.3 suggests trends.

In both universities and four-year colleges women are somewhat more concentrated in lower age groups. Furthermore, the age profile of women mathematical scientists on higher education faculties peaks much lower than that of women in other disciplines.

The racial distribution of U. S. mathematical science faculties has traditionally been heavily Caucasian. Orientals, Hispanics, and Blacks have made up a very small fraction of mathematical science faculties. Among the faculty members described by institutions responding to the 1975 CBMS survey, nearly 93% were Caucasian, 5% Oriental, 1% Hispanic, and 1% Black. Since

Table 3.17

DISTRIBUTION OF FULL-TIME MATHEMATICAL SCIENCE FACULTY IN UNIVERSITIES AND FOUR-YEAR COLLEGES BY AGE AND SEX

	<30	30-34	35-39	40-44	45-49	50-54	55-59	≥60
Universities								
Men [6661]	11%	22%	23%	15%	11%	8%	5%	5%
Women [463]	24%	19%	9%	12%	13%	9%	6%	8%
Four Year Colleges								
Men [8554]	7%	24%	22%	18%	10%	8%	5%	6%
Women [1185]	11%	16%	14%	14%	11%	18%	7%	8%

the sample numbers in each minority classification are very small, it is dangerous to use these figures to estimate national totals of Oriental, Hispanic, or Black mathematical science faculty, but it seems safe to say that there are probably fewer than 250 in each of the last two categories.

The current under-representation of minorities on mathematical science faculties is certainly a direct consequence of the student racial distribution in graduate preparation programs. For instance, in 1974-75 only 9 U. S. citizen Blacks earned doctorates in the mathematical sciences and only 16 Blacks overall. In that same year only 5 U. S. citizen Hispanics earned mathematical science doctorates and only 35 Hispanics overall [M].

Faculty Utilization

During the rapid growth of mathematical science undergraduate major programs, graduate programs, and faculty research activity throughout the 1960's there were tendencies to reduce faculty teaching loads, increase use of large scale teaching methods, and increase expectations of faculty research productivity, With mathematics major enrollment now declining and faculty size stabilizing it is interesting to inspect recent changes in the utilization and productivity expectations of mathematical science faculty.

Data presented in Table 3.6 shows that the ratio of mathematical science enrollments to FTE faculty increased by nearly 8% between 1970 and 1975. Tables 3.18 - 3.23 provide information suggesting ways that this increased student load has been handled.

Based on Table 3.18 it appears that since 1970 university and public college credit hour teaching loads have increased noticeably. No departments reported normal teaching loads of less than 6 hours per week, and the average load increased from 7.2 hours to 11.9 hours in public colleges. The private college teaching load remained relatively stable between 1970 and 1975.

Table 3.18

EXPECTED TEACHING LOAD OF FULL-TIME FACULTY IN MATHEMATICS DEPARTMENTS IN UNIVERSITIES AND FOUR-YEAR COLLEGES*

Teaching Loads	Universities 1970	Universities 1975	Public Colleges 1970	Public Colleges 1975	Private Colleges 1970	Private Colleges 1975
Less than 6 hours	8%	-	-	-	-	-
6 hours	40%	26%	3%	1%	-	4%
7-8 hours	32%	39%	5%	5%	-	2%
9 hours	8%	21%	14%	1%	7%	6%
10-11 hours	5%	5%	25%	14%	17%	18%
12 hours	7%	10%	35%	57%	60%	56%
More than 12 hours	-	-	18%	21%	16%	14%

*Data are percent of all mathematics departments having the given teaching load, not numbers of faculty.

Though the data in Table 3.18 are percents of all mathematics departments reporting various average teaching loads, there was only a slight trend for faculty in larger or research-oriented institutions to have smaller teaching responsibilities. Furthermore, teaching loads were generally the same for all tenure track faculty ranks, the main exceptions being reduced loads for administrators. The teaching loads in computer science and statistics departments were, as in 1970, generally lower than in mathematics departments -- probably reflecting the predominant research and service functions of such departments and the fact that most are located in research oriented universities which have lowest teaching loads overall. Though it appears that computer science and statistics teaching loads have increased since 1970, the percents are based on small numbers of departments in the universe and responding, so a shift of one or two departments produces large percent changes.

Table 3.19

TEACHING LOADS OF FULL-TIME FACULTY IN COMPUTER SCIENCE AND STATISTICS DEPARTMENTS

Teaching Loads	Computer Science 1970	Computer Science 1975	Statistics 1970	Statistics 1975
Less than 6 hours	17%	14%	44%	17%
6 hours	46%	34%	28%	45%
7-8 hours	27%	19%	12%	11%
9 hours	-	14%	8%	17%
10-11 hours	7%	14%	8%	5%
12 hours	3%	5%	-	5%
More than 12 hours	-	-	-	-

The effective teaching load of full-time faculty members is also affected by class size, style of instruction employed, and use of teaching assistants. The survey questionnaire asked respondents to report course enrollments and number of teaching sections. From this data we have calculated average class size for several of the most common undergraduate courses. Though data for comparison with previous years are unavailable, individual departments might find interesting comparisons with their own class size numbers.

The 1965 CBMS survey noted substantial increase from 1960 in the use of large lecture systems of instruction. By 1970 some

Table 3.20

AVERAGE CLASS SIZE IN SELECTED MATHEMATICAL SCIENCE COURSES
IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Course Title	Public University	Private University	Public College	Private College
8. College Algebra and Trigometry	43.3	35.3	34.1	29.1
14. Math. for Elem. Sch. Teachers	30.5	30.5	28.8	28.1
17, 18. Calculus	38.2	37.5	27.7	26.0
23. Advanced Calculus	23.6	15.5	16.8	12.8
24. Elementary Statistics	36.7	38.8	28.7	25.8
51. Introduction to Computing	29.8	43.4	30.7	29.0

Table 3.21

PREVALENCE OF INSTRUCTIONAL METHODS OTHER THAN SMALL SECTIONS
IN UNIVERSITY AND FOUR-YEAR COLLEGE MATHEMATICAL SCIENCE DEPARTMENTS

	University Mathematics		Computer Science		Statistics		Public Colleges		Private Colleges	
Method of Instruction	1970	1975	1970	1975	1970	1975	1970	1975	1970	1975
Large Lectures	56%	56%	77%	50%	40%	68%	17%	38%	12%	22%
Organized Independent Study	24%	12%	51%	22%	18%	21%	22%	19%	51%	20%
Television	6%	10%	2%	11%	9%	-	10%	3%	4%	-
Audio-Tutorial	NA	4%	NA	-	NA	-	NA	9%	NA	9%
Programmed	9%	6%	3%	-	2%	-	7%	7%	10%	9%
Computer Assisted	5%	6%	11%	11%	11%	5%	2%	3%	2%	5%
Computer Managed	NA	-	NA	-	NA	-	NA	3%	NA	-
Self-Paced	NA	22%	NA	17%	NA	21%	NA	31%	NA	28%

NA Not on the 1970 survey questionnaire.

form of large lecture classes was used in 56 percent of university mathematics department, 77 percent of computer science departments, 40 percent of statistics departments, 17 percent of public college and 12 percent of private college mathematics department. Table 3.21 shows the current prevalence of large lecture instruction and other alternatives to the traditional small section lecture-recitation methods.

Since survey respondents were asked only to check any of the teaching techniques "used to a substantial degree" by their departments, the data of Table 3.21 indicate only roughly the relative frequency of various procedures -- not the number of students involved. The most striking indicated changes are the emergence of "self-paced" and "audio-tutorial" instruction in all types of mathematical science departments (perhaps explaining the sharp drop in "organized independent study") and the increase in the use of large group instructional methods at both public and private four-year colleges.

Changes in format of mathematical instruction generally involve changes in the use of graduate and undergraduate teaching

Table 3.22

LOWER DIVISION MATHEMATICS TEACHING BY TEACHING ASSISTANTS IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Percent of Teaching Done by TA's	Percent of Departments in Given Range: University 1965	University 1970	University 1975	Public College 1975*
0% - 19%	22%	21%	21%	64%
20% - 39%	24%	28%	30%	24%
40% - 59%	30%	37%	32%	9%
60% - 79%	14%	7%	13%	3%
80% - 100%	10%	7%	4%	-

*Comparable data for 1965, 1970 not available.

assistants. Since teaching assistants commonly have major instructional responsibility only in lower division courses, the survey questionnaire asked respondents what percent of this teaching is handled by TA's. The 1975 findings are compared with 1965 and 1970 data in Table 3.22. Changes since 1965 in the fraction of university lower division teaching borne by TA's were slight. However, it appears that public colleges are beginning to make substantial use of TA's. The responses from computer science and statistics departments were really too few and scattered to make reliable estimates of TA roles there. The credit hour teaching loads for TA's in various types of mathematical science departments are given in Table 3.23. The 1975 pattern is very similar to that of 1970.

Along with regular teaching, advising, and administrative responsibilities, mathematical science faculty members are increasingly expected to do research. Table 3.24 shows the pattern of such expectations. Even admitting that these data represent department chairmen's <u>expectations</u> it seems clear that pressure for regular research and publication has increased since 1970 -- particularly in colleges.

Table 3.23

TEACHING LOADS OF TEACHING ASSISTANTS IN
UNIVERSITIES AND FOUR-YEAR COLLEGES

Credit Hour Load	University Mathematics 1970	University Mathematics 1975	Computer Science 1970	Computer Science 1975	Statistics 1970	Statistics 1975	Public College 1975
Less than 4 hours	23%	11%	65%	50%	62%	50%	3%
4 - 5 hours	35%	41%	4%	10%	8%	10%	34%
6 hours	35%	37%	31%	30%	30%	20%	38%
More than 6 hours	7%	11%	-	10%	-	20%	24%

Table 3.24

FACULTY RESEARCH AND PUBLICATION EXPECTED BY UNIVERSITY AND FOUR-YEAR COLLEGE MATHEMATICS DEPARTMENTS

Expectation	Universities 1970	Universities 1975	Public Colleges 1970	Public Colleges 1975	Private Colleges 1970	Private Colleges 1975
Publication at a stated rate	41%	56%	13%	32%	4%	14%
Maintain research activity but no specified rate of publication	53%	40%	25%	32%	24%	34%
No expectation of research or publication	6%	4%	62%	36%	72%	52%
Average rate expected per year, when stated	1.0	1.1	0.4	0.8	0.6	0.5

Faculty Mobility

Throughout the era of growth in mathematical science faculty during the 1960's, each year brought many additions to each department -- some fresh from graduate programs and others changing their institutional affiliations. But the 1970's have been a period of limited growth, increasing tenure, and thus stability of mathematical science faculty. To help in understanding the new dynamics of the academic marketplace, the survey committee asked each responding department to report the source of all faculty members employed for the first time in 1975 and the destination of those who left during that year.

The responses indicate that during 1975 about 1,230 mathematical scientists were appointed to university or four-year college positions and 1,045 left such positions, a net increase of roughly 185. Allowing for the likelihood that department chairmen are better able to describe the source of their new faculty than the destination of those who left, this still suggests a recent increase in mathematical science faculties -- either contradicting data presented earlier in this chapter or indicating a recent improvement in the mathematical science hiring situation.

About one half of the reported mobility involved movement from one academic position to another. Apart from this kind of internal mobility, Table 3.25 shows the details of additions to and subtractions from mathematical science faculties, in comparison with those for 1970.

Table 3.25

CHANGES IN UNIVERSITY AND FOUR-YEAR COLLEGE
FULL-TIME MATHEMATICAL SCIENCE FACULTY

Source/Destination	Doctorates 1970	Doctorates 1975	Non-Doctorates 1970	Non-Doctorates 1975
Additions to Faculty				
From Graduate School	843	426	512	130
From Post-Doctoral Study	87	68	-	-
From Non-Academic Positions	52	46	44	3
From Other Sources	11	-	14	-
	+993	+540	+570	+133
Subtractions from Faculty				
Deaths and Retirements	103	128	89	58
To Non-Academic Positions	55	176	82	32
To Graduate School	49	7	230	21
To Other Positions	54	86	28	15
	-261	-397	-429	-126
Net Changes	+632	+143	+141	+ 7

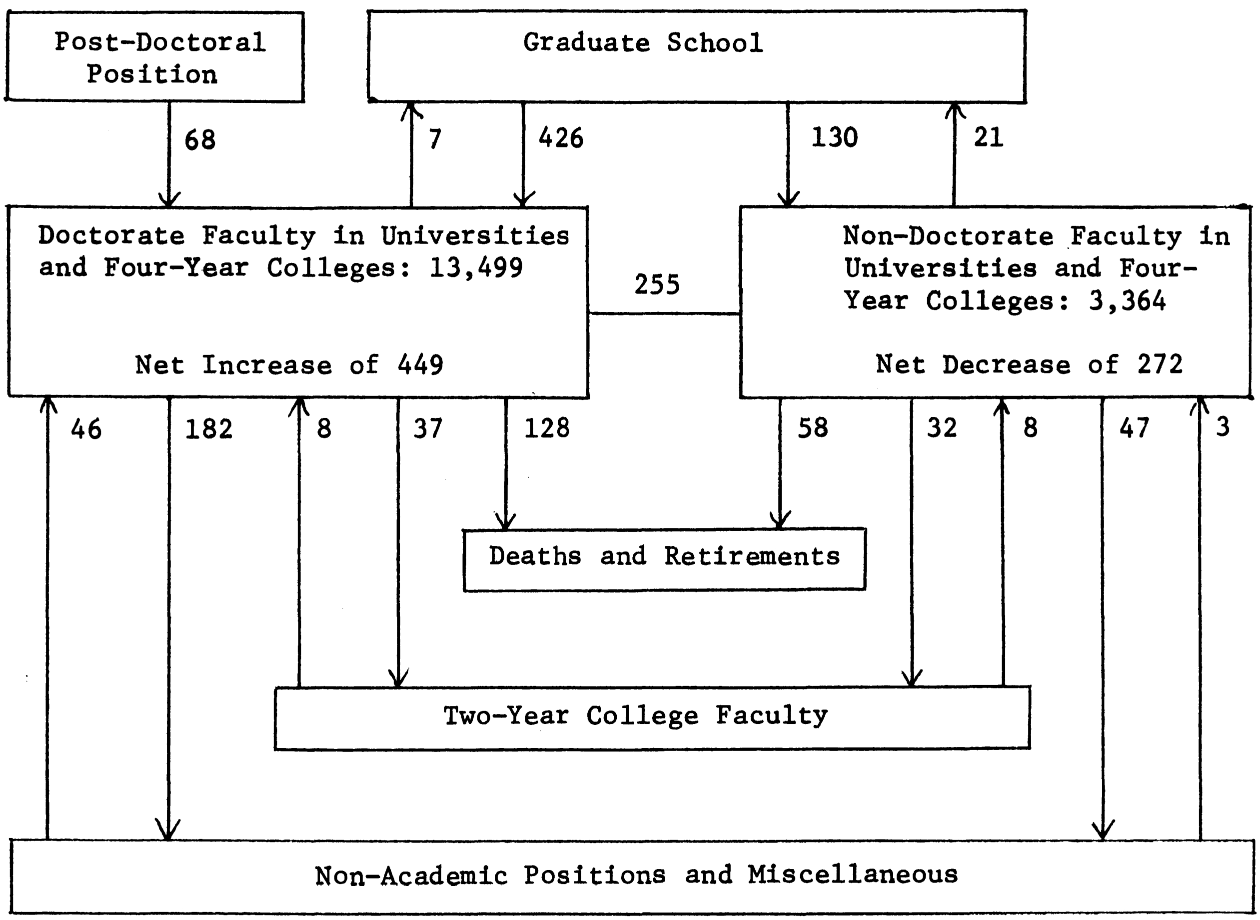
The raw data on which national estimates in Table 3.25 are based were, in many categories, very sparse. So it is dangerous to place great faith in the absolute numbers of faculty additions and subtractions. However, confidence in several broad patterns and trends seems justified.

First, compared with 1970, overall faculty growth has greatly slowed. Additions to faculties still come almost totally from graduate schools; deaths and retirements equalled slightly more than 1% of the total of mathematical science faculty members; there was a noticable increase in the number of mathematical scientists leaving academic positions; but very few left for further graduate study, and there was very little faculty movement between four-year and two-year institutions.

The pattern of university and four-year college faculty mobility is illustrated graphically in Figure 3.1. That flow chart also indicates the roughly 255 faculty members who earned doctorates and remained in four-year positions held prior to completion of that degree. Recall that in many categories national estimates are based on sparse raw data, so it is dangerous to place much faith in absolute numbers -- only the orders of magnitude.

Figure 3.1

FLOW CHART OF FACULTY MOBILITY 1974-75 TO 1975-76
IN UNIVERSITIES AND FOUR-YEAR COLLEGES



CHAPTER 4

MATHEMATICAL SCIENCE STUDENTS, PROGRAMS, AND FACILITIES IN UNIVERSITIES AND FOUR-YEAR COLLEGES

This chapter describes several characteristics of the students, programs, and facilities for undergraduate mathematical science education in universities and four-year colleges. Included are reports of perceived changes in level of mathematical training among undergraduate students, a survey of admission and placement exam practices, new course and degree programs, and patterns of computer and calculator use in mathematical science instruction.

Summary of Major Results

Among the diverse information reported in this chapter several major findings stand out:

--A heavy majority of mathematical science department heads report that mathematical training of undergraduate students has declined recently, and they attribute the decline to poorer secondary school preparation and generally weaker motivation to study mathematics.

--Most recent curricular innovation has focused on computer related courses and courses to serve biological, social, and management sciences.

--Access to computers as support for mathematics instruction is now nearly universal in universities and four-year colleges, but few mathematical science faculty members outside of computer science and statistics actually use the computer in either their research or their teaching.

--Use of electronic pocket calculators currently receives extremely varied acceptance or encouragement in mathematical science instruction.

These findings are elaborated in the balance of this chapter.

Mathematical Training and Ability of Undergraduates

The most hotly debated issue in education at all levels is the cause and meaning of recent declines in student performance on standardized tests, including college entrance examinations. Mathematics is a prominent topic in nearly all such testing, and the school mathematics achievement scores have (if to a slightly less extent than language arts) declined also. The survey committee asked responding mathematical science department heads whether they saw changes in the mathematical training and ability of their undergraduates and, if so, to conjecture causes. Over 75% of the respondents reported a recent decline of student training and ability. The most common explanations were:

poorer secondary school preparation,
lower college admission standards, and
student lack of interest in or motivation to study mathematics

There were a substantial number of respondents who felt that student mathematical training has recently improved. Most, but not all of these were from private institutions, suggesting a pattern observed elsewhere that 'the best have gotten better, but the balance weaker'.

Earlier data suggested recent changes in the enrollment patterns of students and the doctoral research training of faculty. Thus it might be that the perceived student ability decline is to some extent due to the changing audience for mathematical science courses and the rising expectations of faculty.

Entrance and Placement Examinations

If student mathematical training is declining, there are two obvious ways for mathematics departments to respond. They can raise admission standards for programs and courses, or they can devise placement and remedial programs to compensate for student deficiencies. Table 4.1 shows that since 1970 there has been a slight increase in the percent of universities requiring an admission examination that includes mathematics; the percent of public colleges requiring such an examination appears to have nearly doubled; and the private college figure has declined slightly.

The most commonly required examinations were the College Entrance Examination Board Scholastic Aptitute Test and the American Colleg Testing examination. Unfortunately, the report that an admission examination is required says nothing about the standard of performance required for actual entrance to the university or college.

Table 4.1

PERCENT OF UNIVERSITIES AND FOUR-YEAR COLLEGES REQUIRING ADMISSIONS EXAMINATIONS INCLUDING MATHEMATICS

Type of Institution	1960	1965	1970	1975
Universities	68%	90%	63%	70%
Public Four-Year Colleges	55%	80%	35%	60%
Private Four-Year Colleges	91%	96%	91%	83%

Table 4.2 shows that there has been a recent increase in the use of placement examinations for entering students. In contrast to admissions testing, the placement exams are most commonly local exams. They focus on knowledge of algebra and trigonometry and are used most often to determine in which mathematics course a student should enroll.

Table 4.2

PERCENT OF UNIVERSITIES AND FOUR-YEAR COLLEGES USING PLACEMENT EXAMINATIONS IN MATHEMATICS

Type of Institution	1960	1965	1970	1975
Universities	68%	50%	57%	74%
Public Colleges	59%	50%	68%	72%
Private Colleges	48%	39%	37%	53%

The exception to this pattern is the advanced placement testing program. Nearly all institutions have programs of advanced standing in mathematics, in which an entering student, on the basis of high school record or examination, may enroll in a course more advanced than usual for entering freshmen. In the great majority of these schools calculus is the course for which college credit may be entered on the student's record. But a substantial number allow credit for college algebra and/or trigonometry.

The survey indicated mathematical science departments response to lower student entering abilities through answers to two other questions. First, the enrollment data in Chapter 2 showed a large increase in general mathematics and intermediate algebra (high school level) between 1970 and 1975. Second, in a question about undergraduate program innovations, many departments reported providing new courses or tutorial work to meet broadened admissions policies. In most types of institutions the pace of innovation to meet these needs has quickened in the last five years (See Table 4.3).

Course and Program Innovations

The enrollment patterns of Chapter 2 may, in several important cases, be interpreted as consequences of demand for greater mathematical science training by academic disciplines that have not been traditionally heavy users of mathematics, statistics, or computer science. To confirm and better understand these explanatory conjectures, the survey committee asked mathematical science departments to describe their recent course and program innovations. The quantitative results are given in Table 4.3 along with comparable data from two earlier surveys.

Overall the rate of innovation is greater in universities and public colleges than in private colleges. The lone exception is in courses appropriate for computing and data processing, where private colleges and public colleges both appear to be catching up with universities, which had a head start. Most other new courses have been aimed at the burgeoning audience of students of biological social, and management sciences. The basic freshman program and programs for prospective teachers appear to have received less attention recently.

Table 4.3

PERCENT OF UNIVERSITY AND FOUR-YEAR COLLEGE MATHEMATICS DEPARTMENTS REPORTING INNOVATIONS IN UNDERGRADUATE PROGRAMS

Type of Innovation	Universities 1960-1965	Universities 1965-1970	Universities 1970-1975	Public Colleges 1960-1965	Public Colleges 1965-1970	Public Colleges 1970-1975	Private Colleges 1960-1965	Private Colleges 1965-1970	Private Colleges 1970-1975
Introduced new degree programs	31%	42%	28%	32%	41%	38%	20%	30%	22%
Provided new courses appropriate for the biological and medical sciences	27%	28%	58%	18%	42%	52%	12%	34%	27%
Provided new courses appropriate for the social and management sciences	59%	53%	66%	28%	54%	62%	27%	51%	48%
Provided new courses appropriate for the physical sciences and engineering	68%	32%	46%	33%	38%	40%	30%	30%	28%
Provided new courses appropriate for computing and data processing	64%	54%	42%	50%	59%	72%	27%	36%	60%
Provided new courses or tutorial work to meet broadened admissions policies	-	28%	44%	-	36%	52%	-	36%	33%
Significantly altered the program for freshman year	56%	41%	22%	59%	49%	28%	58%	55%	28%
Introduced or substantially altered a program for the undergraduate preparation of secondary school teachers of mathematics	46%	35%	12%	56%	48%	30%	38%	36%	14%
Introduced or substantially altered a program for the mathematics preparation of elementary school teachers	41%	21%	38%	62%	53%	40%	39%	42%	22%
Introduced other innovations	20%	30%	22%	31%	12%	8%	22%	19%	17%

Respondents were asked to elaborate on their yes/no answers about various types of curricular innovation. The most frequently mentioned type of change, in all types of institutions, was introduction of some program for remediation of entering student weakness. The various efforts included mixtures of self-pacing, programmed instruction, tutoring, multi-media instruction, and special summer programs for disadvantaged students. Clearly the problems caused by poor mathematical skills of entering students are focus of major attention in mathematics departments. But there is little consensus on the most effective way to meet the challenge.

Somewhat surprisingly, the second most frequently mentioned focus of program innovation was in preparation of elementary school teachers. In many four-year colleges the mathematics requirements appear to have increased recently (though this contradicts popular impressions). Another common aspect of these changes is to mix mathematics and methodological preparation in laboratory learning environments.

Many mathematics departments described new degree programs, minors, or single courses giving a more applied flavor to the traditional undergraduate experience. Very often these overtures were directed toward biological and social science, notably economics.

Use of Computers and Calculators

Between 1960 and 1970 virtually all undergraduates in universities and over 90% in four-year colleges gained access to computers for mathematical science study -- either directly or through a computer terminal. Enrollments in computer science courses increased rapidly, but use of computers by mathematics faculty in their research and teaching remained low. By 1975 access seems to have become nearly universal, but use of computers in mathematics teaching and research had increased only modestly.

The 1975 survey questionnaire provided more details on patterns of computer use than any previous CBMS survey. As Table 4.4 shows, mathematics department access to computers is high, and in most institutions the access is in mathematics department space or at least in the same building. For roughly half of the mathematics departments computer usage is free of charge; in most other

Table 4.4

ACCESS, FUNDING, AND USE OF COMPUTERS FOR MATHEMATICAL SCIENCE TEACHING AND RESEARCH IN UNIVERSITIES AND FOUR-YEAR COLLEGES, 1975

	Universities	Public Colleges	Private Colleges
Access to computer or terminal	100%	98%	92%
In department space	49%	56%	44%
In department building	18%	21%	31%
Other	33%	22%	25%
Funding			
Free of charge	43%	50%	64%
Department budget	47%	28%	17%
Project-by-Project	6%	8%	2%
Other	4%	14%	17%
Percent of mathematics faculty making substantial use of computer			
In research	15%	10%	10%
In teaching	20%	25%	35%

institutions usage is charged to a general department budget. Remembering that universities gained computer facilities earliest, followed by public colleges and, most recently, private colleges, there is an ominous pattern suggesting that the longer a computer is available, the more likely is its use to be charged against a department's budget.

In every type of institution the computer is not used for research by any large portion of the faculty. This is not surprising in the colleges which are less research oriented. What is mildly startling is the fact that more private college faculty use computers in teaching than do faculty of public colleges or universities. However, over two thirds of mathematics departments of each type require computer use in some of their courses. The courses most often mentioned as involving computer use were calculus, numerical analysis, and statistics. Not surprisingly, use of computers for research and teaching was much greater in departments of computer science and statistics. About 60% of the statistics faculty make substantial use of computers in their work.

While access to and use of computers in mathematics instruction has been increasing steadily for the past 15 years, the powerful scientific hand calculators burst on the scene in about 1973 and immediately raised several issues of instructional policy. The CBMS survey could not examine calculator usage in depth, but we did obtain interesting responses to the basic questions: are there courses taught by your department in which the use of a pocket calculator is recommended for (a) homework? (b) taking exams? The results are given in Table 4.5.

Table 4.5

PERCENT OF MATHEMATICAL SCIENCE DEPARTMENTS RECOMMENDING HAND CALCULATOR USE IN SOME COURSES

	Homework		Examinations	
Type of department	Yes	No	Yes	No
University				
Mathematics	28%	72%	18%	82%
Computer Science	6%	94%	6%	94%
Statistics	74%	26%	58%	42%
Public College	45%	55%	33%	67%
Private College	59%	41%	50%	50%

The temptation to speculate on reasons for the wide differences of opinion regarding the appropriate role of hand calculators is nearly irresistible. It is not surprising that even in mathematics departments the course in which calculator use is most frequently approved is elementary statistics. In two-year colleges there is much more widespread approval of the use of hand calculators for both homework and examinations (See Table 5.7 and 5.8).

Chapter 5

MATHEMATICAL SCIENCE OFFERINGS, ENROLLMENTS, AND INSTRUCTIONAL PRACTICES IN TWO-YEAR COLLEGES

This chapter reports estimated national enrollments in two-year college mathematical science courses for Fall 1975. The data are compared and contrasted with results of previous CBMS surveys in 1966 and 1970 and with general enrollment trends in two-year colleges.

Summary of Major Results

From Fall 1970 to Fall 1975 mathematical science course enrollments in two-year colleges increased from 584,000 to 874,000 or nearly 50%. This increase is not as great as the 60% growth in overall two-year college enrollments, but it is greater than the 38% growth rate of degree-credit students in two-year colleges. The main patterns of change in mathematical science enrollments are similar to those of four-year institutions -- less growth in courses leading to education, mathematics, physical science, or engineering majors and greatest growth in courses that are at a remedial level or that serve students heading for occupational, technical, or business programs.

--Enrollments in arithmetic increased by 86% to 67,000.

--Enrollments in elementary (high school level) algebra increased by 103% to 132,000 and intermediate algebra (high school level) increased by 75% to 105,000.

--Taken together high school level arithmetic, algebra, intermediate algebra, and geometry courses now account for 36% of all two-year college mathematics enrollments, compared with 26% in 1966 and 29% in 1970.

--Together, calculus and analytic geometry enrollments increased only slightly, by 7% to 73,000, with calculus increasing by 21% and analytic geometry decreasing by 70%.

--Mathematics of Finance and Business Mathematics enrollments increased by 139% to 79,000.

-- The new course title "Use of Hand Calculators" was estimated to cover 4,000 course enrollments, but still fell behind the 5,000 student total for "Slide Rule"!

Detailed course enrollment data and trends are presented in later sections of this chapter, following background data on the overall two-year college enrollment situation. In reading the chapter one should keep in mind that reported enrollments are estimated national totals for two-year colleges, unless specifically noted otherwise.

General Information about Two-Year Colleges

At the time of the 1960 Lindquist survey of collegiate mathematics programs [A], two-year college enrollments constituted only 15 % of all undergraduate enrollments. A solid majority of two-year students were then in full-time programs leading to a bachelor's degree after transfer to some appropriate four-year school. In 1975 the situation was much different. As Table 5.1 shows, two-year colleges now enroll nearly 3,900,000 students. Over half are studying part-time; the full-time equivalent enrollment is 39% of all undergraduate enrollment; students in non-degree credit programs, such as those leading to specific occupational training certificates, comprise over a third of the two-year college FTE students; and over 50% of all college freshmen enroll in two-year colleges. Furthermore, two-year colleges are now predominantly public, with only 4% of two-year students in the mostly small private colleges.

As relatively new institutions, the two-year colleges find their curricular emphases and student body still taking shape. The fluidity of the two-year college scene is also influenced by the ease of entry, exit, part-time study, and community education* involvement that are increasingly basic commitments in the community college concept.

Table 5.1 underscores these emerging characteristics of two-year colleges. While undergraduate enrollment in universities and four-year colleges has leveled off recently, two-year college

*Community education, people participating in non-credit activities sponsored by a college, was estimated at 1,337,267 in Fall 1975 by the American Association of Community and Junior Colleges [P].

Table 5.1

TRENDS IN TWO-YEAR COLLEGE ENROLLMENTS
(In Thousands)

Type of Enrollment	Fall 1966	Change	Fall 1970	Change	Fall 1975
Total Enrollment*	933	+63%	1517	+60%	2428
Degree Credit*	690	+63%	1127	+38%	1553
Non-Degree Credit*	243	+61%	391	+124%	875
Full-Time	737	+58%	1165	+47%	1707
Part-Time	589	+80%	1058	+105%	2164
First Time Freshmen*	406•	+67%	680	+33%	904
Mathematical Science Enrollments	348	+68%	584	+50%	874
Mathematical Science Enrollments per FTE Student	.37		.38		.36

Sources: NCES. Projections of Education Statistics to 1984-85 [E] and unpublished NCES data for 1975.
*Full Time Equivalent is the sum of full time enrollments and one-third of part-time enrollments.
•Estimated using non-degree credit equal to .35 degree credit.

enrollments have climbed steadily since 1960. The NCES projection [F] indicate that this growth is apt to continue at a slower pace during the next five years. But it is not clear whether the new students will come from a new clientele for higher education (perhaps requiring new kinds of mathematics instruction) or whether the two-year schools will draw students who might in other times have gone as freshmen to four-year institutions. There would be important implications for program development and staffing in mathematics departments -- if only one could see into the future with some certainty.

Since 1970 the greatest growth in two-year colleges has been in non-degree credit and part-time study. The spectacular growth in occupational-technical enrollments, as measured by the non-degree credit enrollments, bears careful watching. It may be that part of the disparity between the overall enrollment growth rate of 60% and the mathematics growth of 50% is a consequence of broad shifts in student preference toward occupational-technical (O-T) programs. Many O-T programs have carried out mathematical instruction 'in house' for some time and will probably continue to do so. And from 1970 to 1975 it is estimated that enrollments in mathematics courses taught outside of mathematics departments in two-year colleges increased by 93%. Two-year college mathematics faculties have traditionally paid little attention to the mathematics service courses required by occupational-technical programs. The fact that for 1970-75 mathematics enrollment increases exceeded overall degree-credit increases (38%) provides some evidence that mathematics faculty are responding to the new service needs of O-T programs. If the two-year college shift away from academic emphasis persists or accelerates in the years ahead, mathematics departments will ignore the important service role at their own peril.

Patterns of Mathematics Enrollments

In Fall 1975 mathematics enrollments in two-year colleges were 874,000, a 50% increase over the enrollment in 1970, which was a 68% increase over the 1966 CBMS survey enrollment estimate. The rate of increase in mathematics enrollments was substantially lower than the 60% enrollment gain for all two-year colleges, but it was greater than the 38% increase in overall degree-credit enrollments. Dividing the mathematics enrollment (874,000) by the total number of full-time equivalent two-year college students (2,428,000) yields a ratio of .36 mathematics enrollments per FTE student. This ratio has been essentially constant since 1966.

Estimated national enrollments for individual mathematics courses in Fall 1975 are given in Table 5.2 where they can be compared with data from 1966 and 1970. There are two important types of baseline measure for judging the magnitude of any enrollment

Table 5.2

DETAILED ENROLLMENTS IN MATHEMATICAL SCIENCE COURSES IN TWO-YEAR COLLEGES
(In Thousands)

Subject	Fall 1966-67	Fall 1970-71	Fall 1975-76
1. Arithmetic	15	36	67
2. High School Geometry	5	9	9
3. Elementary Algebra (H.S.)	35	65	132
4. Intermediate Algebra (H.S.)	37	60	105
5. College Algebra	52	52	73
6. Trigonometry	18	25	30
7. College Algebra and Trigonometry, combined	15	36	30
8. Elementary Functions	7	11	16
9. Mathematics for Liberal Arts	22	57	72
10. General Mathematics	17	21	33
11. Finite Mathematics	3	12	12
12. Mathematics of Finance	4	5	9
13. Business Mathematics	17	28	70
14. Mathematics for Elementary School Teachers	16	25	12
15. Technical Mathematics	19	26	46
16. Technical Mathematics (calculus level)	1	3	7
17. Analytic Geometry	4	10	3
18. Analytic Geometry and Calculus	32	41	40
19. Calculus (mathematics, physics, and engineering sciences)	8	17	22
20. Calculus (biology, social, and management sciences) (New Course)	NA**	NA	8
21. Differential Equations	2	1	3
22. Linear Algebra	1	1	2
23. Differental Equations and Linear Algebra, combined (New Course)	NA	NA	L*
24. Elementary Statistics	4	11	23
25. Probability (and statistics)	1	5	4
26. Programming of Digital Computers	3	10	6
27. Other Computer Science Courses	2	3	4
28. Use of Hand Calculators (New Course)	NA	NA	4
29. Slide Rule	3	9	5
30. Other Courses	5	5	27
Total	348	584	874

*L denotes enrollment less than 500.
**NA denotes "not available".

change. First are the 1970-1975 composite growth rated of 50% in mathematics and 60% in all two-year college enrollment. Second, and perhaps most significant, is the percent of all mathematics enrollment concentrated in each course. For instance, in Fall 1975 the course 'Math for Liberal Arts' had an estimated national enrollment of 72,000 two-year college students. This was an increase of 15,000 or 26% from 1970, but as a share of the market it was a decline from 10% to 8%. Similarly, college algebra enrollment increased by 40% from 1966 to 1975, but as a fraction of all mathematics enrollment it declined from 15% to 8%.

By any measure, the recent mathematics enrollment gains have been most striking in arithmetic (up by 31,000 to 8% of all mathematics enrollment), elementary algebra (up by 67,000 to 15% of the total), intermediate algebra (up by 45,000 to 12% of the total), and business mathematics (up by 42,000 to 8% of the total).

The sharp gains in remedial arithmetic and high school level algebra enrollments are in contrast to much slower growth in precalculus and calculus courses whose share of the total declined from 33% in 1970 to 26% in 1975 (See Table 5.3). The reasons for these shifts in enrollment concentration are probably complex. We have already discussed the apparent growth of non-degree credit enrollments in occupational-technical programs which generally do not demand sophisticated mathematical preparation. But the growth of remedial enrollments is also probably a consequence of declining mathematical training among entering freshmen. Over half of the survey respondents felt that such a decline has occurred recently and evidence from college entrance testing scores and other standardized measures of secondary school performance seem to confirm their judgment. The declining student performance in mathematics (and other school subjects, too) has been variously attributed to 'new math' curricula, television, recent social turmoil, and open admission policies in higher education. The College Entrance Examination Board has appointed an Advisory Panel on Score Declines and the Mathematical Association of America has recently appointed a Committee on the Reported Decline in Preparation of Students for Collegiate Mathematics.

In two-year colleges, as in four-year institutions, enrollments in mathematics for elementary school teachers dropped and enrollments in elementary statistics increased from 1970 to 1975. However, in contrast to the four-year situation, computer related enrollments decreased in two-year college mathematics departments (See Table 2.9 in Chapter 2).

Table 5.3 summarizes broad trends in the course by course enrollment data. It illustrates steady increase in the share of enrollments in remedial work, levelling off in the service course area, and the decline in relative size of pre-calculus and calculus enrollments.

Table 5.3

TOTAL ENROLLMENTS IN MATHEMATICAL SCIENCE COURSES
IN TWO-YEAR COLLEGES, BY LEVEL
(In Thousands)

Level	Fall 1966 Number	Fall 1966 Percent	Fall 1970 Number	Fall 1970 Percent	Fall 1975 Number	Fall 1975 Percent
Remedial (Courses 1-4,10)	109	31%	191	33%	346	40%
Precalculus (5-8)	92	26%	124	21%	149	17%
Calculus (17-21)	46	13%	69	12%	76	9%
Statistics (24-25)	5	1%	16	3%	27	3%
Computing (26-27)	5	1%	13	2%	10	1%
Service Courses (9,11-16,22,24, 25,28,29)	91	26%	182	31%	266	30%

Availability of Mathematics Courses

Of the 1100 public and private two-year colleges in the United States, roughly 60% have total enrollments under 2500 students -- full-and part-time, degree-and non-degree credit. The limited size of many of the community oriented institutions restricts availability of diverse mathematics courses and then

Table 5.4

AVAILABILITY OF MATHEMATICS IN PUBLIC TWO-YEAR COLLEGES

(Percent of Public Two-Year Institutions Offering each course sometime in 1975-76)

Subject	Enrollment Large	Enrollment Medium	Enrollment Small	All Public Two-Year 1970-71	All Public Two-Year 1975-76
1. Arithmetic	90%	75%	42%	43%	51%
2. High School Geometry	84	33	21	29	27
3. Elementary Algebra (H.S.)	97	99	57	59	68
4. Intermediate Algebra (H.S.)	100	92	70	65	76
5. College Algebra	74	69	74	58	73
6. Trigonometry	87	62	56	67	59
7. College Algebra and Trigonmetry	42	52	32	41	37
8. Elementary Functions	30	16	10	21	12
9. Mathematics for Liberal Arts	56	62	64	NA	63
10. General Mathematics	22	22	31	20	29
11. Finite Mathematics	42	40	13	21	20
12. Mathematics of Finance	17	16	16	15	19
13. Business Mathematics	26	56	56	39	54
14. Mathematics for Elementary School Teachers	74	56	37	59	43
15. Technical Mathematics	49	66	61	51	61
16. Technical Mathematics (Calculus Level)	30	23	24	24	24
17. Analytic Geometry	25	16	37	21	32
18. *Analytic Geometry and Calculus	83	62	49	68	53
19. *Calculus (mathematics, physics, and engineering science)	38	62	50	43	52
20. Calculus (biology, social and management science)	66	56	19	NA	29
21. Differential Equations	55	29	27	46	29
22. Linear Algebra	50	36	28	22	31
23. Differential Equations and Linear Algebra	29	13	5	NA	8
24. Elementary Statistics	78	79	24	46	38
25. Probability (and statistics)	33	19	22	NA	22
26. Programming of Digital Computers	57	27	14	32	19
27. Other Computer Science Courses	41	27	16	21	20
28. Use of Hand Calculators	23	20	12	NA	15
29. Slide Rule	19	16	16	30	16

*When one looks at the number of institutions offering either "calculus and analytic geometry <u>or</u> calculus (mathematics, physics, science, engineering) the percents approach 100 in each size category.

enrollments. Table 5.4 shows the percent of two-year colleges now offering each lower division mathematics course. The data are given by institutional size category for 1975, and compared in total with 1970. Information on this question is given only for public colleges because of the extremely small private college sample.

As expected, nearly every course is more readily available in large and medium sized colleges than in small colleges (average total enrollment 1550). Mathematics for elementary school teachers, differential equations, and computer programming are notably less available now than in 1970. The last decline is somewhat puzzling, though perhaps related to the rise in "Use of Hand Calculators" which seems mercifully to be ending the role of "Slide Rule".

Mathematics Courses Taught outside of Mathematics Programs

Earlier in this chapter we noted the phenomenal (124%) growth in non-degree credit occupational-technical enrollments in two-year colleges and suggested that these O-T programs probably include substantial amounts of mathematics instruction not given by the regular mathematics faculty. To get a rough measure of the magnitude of such mathematics offerings outside of mathematics departments or divisions, the survey questionnaire asked for estimates of enrollments in mathematics courses given by other divisions or departments. The estimates are probably not as reliable as other data presented in this report, because respondents did not have direct responsibility for these outside courses. There is some reason to believe that the estimated figures in Table 5.5 are less than actual enrollments in outside courses.

The estimated 178,000 enrollments in mathematics courses taught outside mathematics departments represent a 93% increase over the 92,000 figure in 1970-71. The increase, and nearly all outside mathematics enrollment, is concentrated in business divisions and in computer programming courses taught in various programs. Arithmetic taught in business departments increased from 5,000 in 1970-71 to 15,000 in 1975-76 or 200%; business mathematics was up from 33,000 to 52,000 or 58%; computer programming in business departments was up from 7,000 to 26,000 or 270%; and computer programming in "other" departments was up from 2,000 to 16,000 or 700%.

Table 5.5

ESTIMATED ENROLLMENTS IN MATHEMATICS COURSES TAUGHT OUTSIDE OF MATHEMATICS PROGRAMS IN TWO-YEAR COLLEGES, ALL TERMS ACADEMIC YEAR 1975-76
(In Thousands)

	Enrollment in courses given by division specializing in:					
Courses	Natural Sciences	Occupational Programs	Business	Social Sciences	Other (specify)	Total
Arithmetic	1	9	15	L	2	27
Business Mathematics	-	1	52	L	-	53
Statistics	L	L	7	4	3	14
Probability	L	-	-	-	-	L
Pre-calculus College Math.	12	4	L	1	-	17
Calculus or Diff. Equations	3	1	L	-	-	4
Computer Science & Programming	1	8	26	-	16	51
Other	L	4	3	-	5	12
Total	17	27	103	5	26	178

L = some, but less than 500

The spectacular growth of demand for mathematics courses in areas outside regular mathematics offerings presents a real challenge to two-year college mathematics faculties. While often quick to scorn the substance and quality of such outside courses, mathematics departments have generally shown little interest in providing the courses themselves. Since overall mathematics enrollments have recently increased more rapidly than all degree-credit enrollments, there is reason to believe that mathematics departments have been partially successful in providing necessary service for occupational-technical programs. But there is apparently still a very large and growing untapped market for mathematics instruction.

Computer and Hand Calculator Use

The phenomenal growth of the computer industry has affected programs of two-year colleges in at least three major ways. First, computer programming and data processing have become topics of technical training programs. Second, computers are used as an adjunct to regular mathematics instruction in calculus, statistics, and other appropriate courses. Third, computers are sometimes used as a medium or manager of instruction in many different kinds of courses. Since the 1970 CBMS survey, student access to computers in two-year colleges has increased substantally. However, the fraction of two-year college faculty making substantial use of computer facilities in their teaching has remained essentially unchanged since 1970 at 14%. Table 5.6 gives additional details on computer access and use in two-year colleges.

Given the high cost of even small computers, it is no surprise that access to computing facilities is inversely related to institutional size. However, small and powerful hand calculators do not require major financial outlays for students or mathematics departments and their rapid emergence as an adjunct to mathematics instruction is clearly shown in Table 5.7.

The uniform widespread acceptance of hand calculators for both homework and examinations in two-year college mathematics courses in striking, particularly in view of the limited acceptance of calculators by university and four-year college mathematics departments. Though two-year college mathematics enrollment patterns indicate a heavy concentration on remedial basic skill courses like arithmetic and algebra, it appears that teachers are quite willing to allow students the assistance of hand calculators with those skills as they go ahead to learn more substantial mathematical ideas. This conjecture is confirmed by the data indicating courses in which calculator use is recommended, given in Table 5.8.

Table 5.6

COMPUTER ACCESS AND USE IN TWO-YEAR COLLEGES

	Public Colleges			All Colleges	
	Large	Medium	Small	Public	Private
Departments reporting access to computers	98%	71%	50%	57%	36%
Departments reporting some use of computers in courses other than programming	61%	26%	24%	26%	18%
Usage rate = Use/Access	62%	37%	48%	46%	50%
Faculty making substantial use of computers in teaching	25%	17%	14%	15%	NA

Table 5.7

PERCENT OF MATHEMATICS DEPARTMENTS IN TWO-YEAR COLLEGES RECOMMENDING HAND CALCULATOR USE IN SOME MATHEMATICS COURSES

	Public Colleges			All Colleges	
	Large	Medium	Small	Public	Private
Use of Calculators Recommended for Homework	86%	84%	82%	82%	82%
Use of Calculators Recommended for Examinations	67%	64%	75%	72%	73%

Table 5.8

USE OF POCKET CALCULATORS IN MATHEMATICAL SCIENCE COURSES IN PUBLIC TWO-YEAR COLLEGES

	Large Enrollment	Medium Enrollment	Small Enrollment	All Public Two-Year Colleges
Statistics				
% Giving Course	78%	79%	24%	38%
% Using Calculators	42%	45%	24%	29%
Usage Rate = $\frac{\text{\% Using}}{\text{\% Giving}}$	54%	57%	100%	76%
Analytic Geometry and Calculus				
% Giving Course	83%	61%	49%	53%
% Using Calculators	23%	30%	27%	27%
Usage Rate	28%	49%	55%	51%
Technical Mathematics				
% Giving Course	49%	66%	61%	61%
% Using Calculators	25%	27%	26%	26%
Usate Rate	51%	41%	43%	43%
Trigonometry				
% Giving Course	87%	61%	56%	59%
% Using Calculators	45%	14%	16%	17%
Usage Rate	52%	23%	29%	29%

At every level of education, from kindergarten through graduate school, teachers commonly protest against large class size, particularly in mathematics where help with problems of individual learners is often essential. Table 5.9 gives average class size for two-year college mathematics courses that are widely available.

The table reveals that generally large classes are found in large schools, much as in the four-year situation where universities and public colleges had larger class size averages than private colleges. Though many believe that the average class size has increased recently, data necessary for such a comparison were

Table 5.9

AVERAGE CLASS SIZE IN PUBLIC TWO-YEAR COLLEGES

	Very Large Colleges: Average Enrollment = 22,500	Large Colleges: Average Enrollment = 15,700	Medium Colleges: Average Enrollment = 6,500	Small Colleges: Average Enrollment = 2,200
Arithmetic	37	38	31	26
Geometry (H.S.)	34	32	25	29
Elementary Algebra (H.S.)	39	33	32	25
Intermediate Algebra (H.S.)	38	33	30	30
College Algebra	37	31	27	28
Trigonometry	36	30	33	24
College Algebra and Trigonometry	31	37	30	27
Mathematics for Liberal Arts	30	30	28	32
Finite Mathematics	34	28	27	22
Business Mathematics	38	28	29	30
Mathematics for Elementary School Teachers	33	28	24	22
Technical Mathematics	36	30	29	26
Analytic Geometry and Calculus	30	28	26	24
Calculus (mathematics, physical science, engineering)	32	26	21	19
Calculus (biology, social, management science)	36	24	26	27
Linear Algebra	25	20	18	20
Elementary Statistics	31	34	27	25
Overall Average	34	30	27	26

not collected in the 1970 CBMS survey. However, information giver in the next chapter lends support to the conjecture. As a preview we mention only that the average number of students taught per mathematics faculty member has increased from 104 in 1970-71 to 123 in 1975-76.

Instructional Techniques

The vast majority of public two-year colleges are young institutions. They were founded and grew to maturity during a period of spirited educational innovation. Thus their physical facilities, staff, and programs were planned to offer not only alternatives to traditional college curricula, but alternatives to the traditional lecture-recitation system of instruction. The efforts at innovation have generated a new category of educational jargon including modules, audio-tutorial, personalized system of instruction (PSI), learning resource centers, and multi-media instruction. These labels certainly signify different practices in different institutions, but to get a rough idea of how frequently the various alternatives are used in two-year college mathematics teaching, the survey questionnaire asked respondents to indicate which alternatives were used in their department. The results are given in Table 5.10.

Table 5.10

PERCENT OF RESPONDING TWO-YEAR COLLEGES USING ALTERNATIVE INSTRUCTION TECHNIQUES

Technique	Percent Using Technique
Courses by <u>programmed</u> <u>instruction</u>	47%
Organized program of <u>independent</u> study	45%
Audio-tutorial	37%
Modules	37%
Large lecture classes with help sessions	15%
Computer assisted instruction (CAI)	13%
PSI	10%
Courses by television	6%
Large lecture classes with small quiz sections	4%
Courses by film	3%

As in 1970 the most common alternative is programmed instruction. However, the most striking aspect of Table 5.10 is the sudden emergence of a variety of self-pacing methods: Organized programs of independent study doubled in frequency between 1970 and 1975; Audio-tutorial and PSI were not even mentioned in the 1970 questionnaire and in 1975 appear in substantial numbers of institutions; Computer Assisted Instruction has grown in popularity, though still available in only a limited number of schools. Furthermore, over a third of responding two-year college mathematics departments reported some use of modularized instructional techniques.

Admission and Placement of Students

One of the basic purposes of the recent boom in two-year community colleges was to ease entrance to higher education for students whose financial resources or secondary school training would not ordinarily have permitted them to attend a four-year college. Thus it is not surprising that admission examinations are now given by only 42% of all public two-year colleges, down sharply from 81% in 1970. The decrease is even more pronounced in large institutions, where only one in four now give such examinations. Only 45% of the responding private two year colleges reported requiring admission examinations.

Because entering students at two-year colleges bring widely varied background knowledge and abilities, placement of these students in appropriate mathematics courses has become a prime concern of many two-year colleges (See Table 5.11).

Table 5.11

PLACEMENT EXAMINATIONS IN TWO-YEAR COLLEGE MATHEMATICS DEPARTMENTS

Percent of public two-year colleges which administer a placement exam in mathematics	57%
Percent of two-year colleges in which placement exam tests for	
arithmetic	81%
algebra	80%
geometry	19%
trigonometry	25%

The percent of two-year colleges requiring a placement exam in mathematics is up only slightly over the 1970 figure, but the emphasis of placement examination has changed markedly. In 1970 over 40% of such exams tested for knowledge of geometry, and roughly 60% tested for knowledge of trigonometry. It appears that in 1975 the focus of placement testing has shifted to basic skills.

Coordination of Transfer Programs with Four-Year Institutions

For two-year colleges with large degree-credit programs it is important to coordinate program offerings, advisement, and academic standards with the most likely four-year college or university destination of their students. About 70% of public two-year colleges apparently do consult regularly with four-year schools on transfer designated courses. One might hope that two-year and four-year colleges and universities would coordinate other activities such as colloquia, curriculum experiments and the like. However, only 16% of all public two-year colleges reported such activities involving their mathematics faculty with mathematics departments of four-year institutions. This figure is down from 39% in 1970 and suggests a growing estrangement of the two types of institutions -- hardly in the best interest of either.

Chapter 6

MATHEMATICAL SCIENCE FACULTY IN TWO-YEAR COLLEGES

This chapter describes the number, educational qualifications, professional activities, and selected personal characteristics of two-year college mathematical science faculty. It includes profiles of the age, sex, and ethnic composition of these faculty and a flow chart of mobility into, within, and out of two-year college teaching positions.

Summary of Major Results

In Fall 1975 there were 5,944 full-time and 3,411 part-time mathematical science faculty in two-year colleges. Both the number and characteristics of these faculty are substantially changed from 1970.

--From 1970 to 1975 the full-time faculty increased by 22% and the part-time faculty increased by 54%.

--The number of mathematics enrollments per FTE faculty member increased from 104 to 123, an 18% increase.

--The number of full-time two-year college mathematical science faculty holding doctorates more than doubled, to 11% of the total.

--Only 4% of the two-year college mathematical science faculty are over 60 years of age, with the median age 40 years.

--Women now constitute 21% of the full-time faculty and they are concentrated largely in the younger age category.

--About 8% of full-time faculty are minority -- equally divided among Orientals, Hispanics, and Blacks.

--The most common sources of new full-time two-year college mathematical science faculty are graduate school, secondary teaching, and part-time two-year college positions.

The data supporting each of these major findings are presented in greater detail later in this chapter. When interpreting the results one should keep in mind that data are national estimates for two-year colleges based on responses from a stratified sample of 93 institutions. Because private colleges represent only 5% of total two-year college enrollment and the sample of these schools was small, data are often presented for all colleges or for public colleges alone.

General Information on Two-Year College Faculty

The 1975 study of the mathematical sciences in two-year colleges revealed striking recent changes in the number, qualifications, teaching responsibilities, and personal characteristics of the faculty. But proper interpretation of those changes must take into account the overall pattern of faculty growth in two-year colleges. While there is no regular comprehensive survey of two-year college faculty characteristics, the data collected in Table 6.1 give a useful backdrop for mathematical science faculty patterns mentioned above and elaborated in later sections of this chapter. In addition to data supplied by Table 6.1 it is known that in 1974-75 women comprised 32.7% of public and 44.1% of private two-year college faculty [O].

It appears that since 1970 the total faculty in two-year colleges has grown more substantially than has the mathematical science faculty. The growth has been mainly concentrated in part-time faculty appointments which now outnumber full-time positions. If anything, mathematical science departments appear to have resisted the pressure toward greater numbers of part-time faculty, perhaps because the part-time staff of two-year colleges is heavily involved in the varied non-degree credit programs. Not surprisingly, the number of students per faculty member has increased in two-year colleges overall, about 18%, or essentially the increase in student load of the mathemtatical science faculty.

Numbers of Mathematical Science Faculty

The Fall 1970 CBMS survey estimated that two-year colleges employed 4,879 full-time and 2,213 part-time mathematical sciences

Table 6.1

TWO-YEAR COLLEGE FACULTY
ALL FIELDS

Numbers of Faculty and Students[a]	1970	% Change	1975
Faculty (in thousands)			
Full-Time	69	+ 23%	85
Part-Time	40	+143%	97
Full-Time Equivalent (FTE)	82	+ 43%	117
Students (FTE, in thousands)	1518	+ 60%	2428
FTE Students per FTE Faculty	18.5	+ 12%	20.7

Highest Earned Degree[b] (1972-73)	
Doctorate	10%
Master's Degree	74%
Bachelor's Degree or less	16%

Age and Sex[b] (1972-73)	Under 30	31-35	36-40	41-50	51-60	Over 60
Men	6.1%	14.2%	16.7%	36.0%	20.0%	4.8%
Women	13.3%	13.2%	11.4%	34.3%	18.9%	5.9%

[a]Source: 1971 and 1976 Community, Junior, and Technical College Directories, American Association of Community and Junior Colleges.

[b]Source: Teaching Faculty in Academe, American Council on Education(1974).

faculty. By Fall 1975 the full-time faculty had increased 22% to 5,944 and the part-time faculty had increased by 54% to 3,411. Employing the usual estimation procedure that counts part-time loads as one-third of full-time yields a 1975 total of 7,081 full-time equivalent mathematical science faculty members, an increase of 26% over 1970, as compared with no growth at all in four-year institutions. Although 26% is a substantial increase in FTE faculty, in the same time period mathematics enrollments increased by 50%.

The most striking feature of Table 6.2 is the 18% increase in enrollments per FTE faculty member since 1970. Reversing a promising change from 1966 to 1970, it appears that the average two-year college mathematical science faculty member has assumed responsibility for 19 additional students. Typical credit-hour teaching loads have not changed since 1970, so the increase in enrollments must be reflected in greater class size. A similar pattern of increased teaching loads has been observed in universities

Table 6.2

TWO-YEAR COLLEGE MATHEMATICAL SCIENCE
FACULTY GROWTH: 1966-1975

	1966	Change	1970	Change	1975
Faculty Size					
Full-Time	2677	+82%	4879	+22%	5944
Part-Time	1318	+68%	2213	+54%	3411
FTE	3116	+80%	5617	+26%	7081
Mathematics Enrollments (in thousands)	348	+68%	584	+50%	874
Enrollments per FTE	112	- 7%	104	+18%	123

and four-year colleges, prompting the American Mathematical Society Council to express its concern in a "Statement on Teaching Loads and Class Size" in January 1976 [Q].

Educational Qualifications of Mathematical Science Faculty in Public Two-Year Colleges

The enrollment data in Chapter 5 show that teaching responsibilities of two-year college mathematical science faculty are divided among remedial (40% of total enrollment), pre-calculus and calculus (26%), and elementary service courses (30%). Nearly three quarters of all enrollments are below the level of calculus. There is no clear consensus on the appropriate educational and experience preparation for this type of teaching assignment. The data presented in this section stress formal qualifications of two-year college mathematical science faculty -- primarily because they are the only easily obtained measures of quality. Emphasis is on public college data since responses from private colleges were too sparse to produce reliable estimates.

The 1970 CBMS survey report noted significant increases from 1966 in the level of educational qualifications of public two-year college mathematical science faculty. Between 1970 and 1975 there were similar changes

--The number of doctorates is up to nearly 11% of all mathematical science faculty;

--The decline in master's degree holders equalled the doctorate increase and the percent of bachelor's degree holders remained essentially constant.

Table 6.3 gives the details of each pattern.

The apparent sharp drop in two-year college faculty holding master's degree plus one year status has several possible explanations. There is evidence from mobility data presented later, and corroborating AMS survey data, that roughly 40 two-year college faculty members completed doctorates during 1975 -- a pattern which, if extrapolated over the five-year period back to 1970, might account for a quarter of the change. Another factor is the inclusion in the 1975 survey of a new degree category "Master's Degree (special program) to cover such degrees as Master of Arts

Table 6.3

HIGHEST DEGREES OF FULL-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICAL SCIENCE FACULTY

Degree	1970	1975
Doctorate	4.5%	10.8%
Master's Plus 1 Year	46.7%	34.8%
Master's	42.2%	47.4%
Bachelor's	6.6%	7.0%

in Teaching. As Table 6.4 shows, this response covered 10% of two-year college faculty and there is a good chance that many in this category have advanced work in addition to the master's degree.

Table 6.4

EDUCATIONAL QUALIFICATIONS OF FULL-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICAL SCIENCE FACULTY, 1975

Highest Degree	Mathematics	Statistics	Computer Science	Mathematics Education	Other Fields	Total
Doctor's	240	-	-	274	90	604
Master's + 1 yr.	1521	33	19	287	87	1947
Master's	1314	-	28	447	283	2072
Master's (Special Program)	404	-	-	76	101	581
Bachelor's	192	-	-	32	168	392
Total	3671	33	47	1116	729	5596

The data of Table 6.4 are national estimates, in some cells based on very small raw data counts. One must exercise great caution when interpreting the small numbers, but various aggregates of cell entries provide interesting insight into the characteristics of two-year faculty.

Table 6.5 shows that since 1970 the fraction holding their highest degree in mathematics education has dropped from 25% to 20%. Concurrently, the fraction of two-year mathematical science faculty holding higest degree in a non-mathematical field has increased from 9% to 13%.

Table 6.5

FIELD OF HIGHEST LEVEL OF TRAINING OF FULL-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICAL SCIENCE FACULTY, 1970-1975

Field of Highest Degree	1970	1975
Mathematical Sciences	66%	67%
Mathematics Education	25%	20%
Other	9%	13%

From 1970 to 1975 growth in part-time mathematical science faculty (54%) greatly outstripped growth in full-time faculty (22%). Economic uncertainty during this period may be responsible for some of the disparity between growth rates. The generally depressed mathematics job market has focused attention on the increasing use of part-time faculty, making survey of their characteristics particularly timely.

Table 6.6 reveals a general decline in the educational qualifications of part-time faculty. The percent of doctorates is more than cut in half, while the number holding bachelor's degrees has increased to one in six. The total of all master's degrees is up slightly over 1970, with the new category "Master's Degree (spe cial program)" probably accounting for the differences. A more detailed breakdown of the level and major field for the part-time faculty degrees is given in Table 6.7.

Table 6.6

HIGHEST DEGREES HELD BY PART-TIME MATHEMATICAL SCIENCE FACULTY IN PUBLIC TWO-YEAR COLLEGES

Type of Degree	1970	1975
Doctorate	9.5%	3.9%
Master's Plus 1 Year	31.0%	29.9%
Master's	45.5%	49.6%
Bachelor's	14.0%	16.6%

Table 6.7

EDUCATIONAL QUALIFICATIONS OF PART-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICAL SCIENCE FACULTY, 1975

Highest Degree	Mathematics	Statistics	Computer Science	Mathematics Education	Other Fields	Total
Doctor's	61	-	-	25	42	128
Master's + 1 yr.	626	7	3	230	116	982
Master's	761	40	54	359	206	1420
Master's (Special Program)	137	-	-	45	31	213
Bachelor's	351	-	12	46	137	546
Total	1936	47	69	705	532	3289

It is interesting to note that the number of part-time faculty with degrees in non-mathematical fields has declined while among full-time faculty the reverse was noted. A similar reversal can be seen for mathematics education.

Table 6.8

FIELD OF HIGHEST LEVEL OF TRAINING OF PART-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICS FACULTY, 1970 AND 1975

Field of Highest Degree	1970	1975
Mathematical Sciences	62%	62%
Mathematics Education	15%	21%
Non-mathematical Fields	23%	16%

(Columns may not add to 100% due to rounding)

Age, Sex, and Ethnic Group of Public Two-Year College Mathematical Science Faculty

Age distributions are of course very important to anyone attempting to forcast job opportunities in two-year college mathematics faculty. Sex and ethnic-group distributions are basic to assessing the influence of affirmative action legislation on hiring, as well as having intrinsic interest. We begin by considering age distributions.

A brief look at Table 6.9 shows that the two-year college mathematics faculty is young, with nearly half (47%) of the faculty under 40 years, although not as young as faculty in four-year colleges and universities. Given the explosive growth of two-year colleges during the last decade, a young faculty is to be expected. The fact that only 4% of the full-time faculty is 60 or more years of age shows that we can expect only about 50 jobs per year for the next five years due to retirement alone. We shall say more about this when considering faculty employment and mobility in a later section.

Table 6.10, showing a distribution of faculty by degree and age, contains few surprises.

Table 6.9

AGE PROFILE OF FULL-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICAL SCIENCE FACULTY, FALL 1975

	Under 30	30-34	35-39	40-44	45-49	50-54	55-59	And 60 Over
Percent of Total	9%	18%	20%	15%	13%	13%	8%	4%

Table 6.10

DISTRIBUTION BY DEGREE AND AGE FOR FULL-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICAL SCIENCE FACULTY, FALL 1975

	Under 30	30-34	35-39	40-44	45-49	50-54	55-59	And 60 Over
Master's Degree	9%	18%	20%	14%	13%	13%	8%	4%
Doctor's Degree	6%	28%	19%	14%	17%	7%	4%	5%

The survey shows that women now constitute 21% of the full-time faculty, a figure which is consistent with data from the 1975 AMS Survey [M]. The later survey indicates that women as a fraction of full-time faculty grew by 2% in a one year period! It is thus to be expected that the percent of the female faculty under 30 years of age would be large, as indicated in Table 6.11.

The 1975 survey marks the first time that CBMS has tried to gather information on the ethnic composition of two-year college mathematical science faculties. As in four-year institutions, only 8% of the full-time two-year faculty belong to ethnic minorities. For the 670 faculty reported by responding institutions, the ethnic distribution is given in Table 6.12.

Table 6.11

DISTRIBUTION BY AGE AND SEX OF FULL-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICAL SCIENCE FACULTY, 1975

	Under 30	30-34	35-39	40-44	45-49	50-54	55-59	And 60 Over
Men	5%	19%	21%	14%	14%	14%	8%	5%
Women	22%	17%	14%	16%	11%	8%	8%	5%

(Rows may not add to 100% due to rounding.)

Table 6.12

DISTRIBUTION BY ETHNIC GROUP OF FULL-TIME PUBLIC TWO-YEAR COLLEGE MATHEMATICAL SCIENCE FACULTY, 1975

Ethnic Group	Fraction of Total
Caucasian	92%
Oriental	2%
Hispanic	3%
Black	3%

Full description of the age distribution for ethnic minority faculty was not possible, owing to small raw data entries in most cells of the detailed table. But Table 6.13 gives an aggregated distribution showing that minority faculty tend to be somewhat younger than the average two-year college mathematics faculty member.

Table 6.13

AGE DISTRIBUTION OF ETHNIC MINORITIES ON TWO-YEAR PUBLIC COLLEGE MATHEMATICAL SCIENCE FACULTIES, 1975

	Under 35	35-44	45-59	60 and over
Percent of all Minorities	44%	33%	20%	3%

The Mathematical Science Faculty in Private Two-Year Colleges

In Fall 1975 the number of mathematical science faculty in private two-year college was 348, down 17% from 421 in 1970. The number of part-time faculty was 122, down 40% from 205 in 1970. These figures combine to yield a decline in full-time-equivalent faculty from 489 in 1970 to 389 in 1975, a 20% decrease. Over the same time period mathematical science enrollments declined by 10% from 50,000 to 45,000. The total number of existing private two-year colleges and the total number of faculty in private two-year colleges also declined, by 11% and 7% respectively. However, the total number of students in private two-year colleges actually increased by 10% over the same period. These patterns of change are detailed in Table 6.14. As previously noted, private college responses to more detailed faculty questions yielded numbers in sample cells regarded as too small to justify extrapolation to national totals on any fine structure basis.

Faculty Employment and Mobility

This section reports the sources of new full-time faculty members in two-year college mathematics departments for the year 1975-76 and the destinations of those who left two-year college positions at the end of the academic year 1974-75. Combining the two types of information one can estimate the increase in faculty for the year 1975-76 and get another perspective on the characteristics of two-year faculty.

Comparison of Tables 6.15 and 3.24 shows that the sources of two-year college faculty are quite different from those of

Table 6.14

FACULTY AND ENROLLMENTS IN PRIVATE TWO-YEAR COLLEGES

	1970	Change	1971
Mathematics Faculty			
Full-Time	421	-17%	348
Part-Time	205	-40%	122
FTE	489	-20%	389
Total Faculty (All Fields)*	9377	-7%	8677
Mathematical Science Enrollments	50,000	-10%	45,000
Total Enrollments*	134,000	+10%	148,000

*Sources: AACJC. Community, Junior, and Technical College Directory, 1971, 1976 [P].

four-year and university faculty. Nearly one-fifth (19%) of the new two-year faculty in 1975 came from secondary school positions. In 1970 the comparable figure was 17%. It thus appears that high schools are continuing to be a strong source of new full-time two-year college faculty. Data from the 1975 AMS survey [M] confirm this picture, suggesting that almost one-half of current two-year faculty have taught at some time in secondary schools. Graduate school and part-time positions in two-year colleges are the other major suppliers of new two-year faculty. However, the graduate school share of 33% is down from 44% in 1970 and the part-time to full-time share of 16% is up from 4% in 1970.

Of the individuals who left two-year colleges for reasons other than death or retirement, nearly all returned to graduate schools.

The combination of tables 6.15 and 6.16 yields a net gain of 174 full-time faculty for 1975-76. From Fall 1970 to Fall 1975,

Table 6.15

SOURCES OF NEW FULL-TIME MATHEMATICS FACULTY
IN TWO-YEAR COLLEGES, 1975-76

Source	Doctorates Math.	Doctorates Math. Ed.	Master's & Bachelor's	Total
Graduate School	20*	7*	80	107
Teaching in a Four-Year College or University	13*	7*	7	27
Secondary School Teaching			60	60
Part-Time Employment in Institution			53	53
Non-Academic Position	7	7	7	21
Other Sources, or Unemployed		7	47	54
Total New-Year College Faculty	40	28	254	322
Transfers Between Two-Year Colleges				33

*These figures agree very closely with 1975 AMS data [M].

the net gain in full-time faculty was 1065 (See Table 6.2.) Dividing 1065 by 5, we get an average yearly gain of 213 full-time faculty members. The two figures are not incompatible with each other.

Department heads were asked to estimate the number of additional full-time faculty members to be recruited for 1976-77. Their pooled estimate of 201 additional full-time faculty agrees well with the additional full-time figure for 1975-76, calculated in the last paragraph. The department heads are somewhat less optimistic for 1977-78, forecasting only 114 additions.

Professional Activities

In 1975 for the first time, the CBMS survey asked department heads to estimate the professional activity of their full-time mathematical science faculty members. The estimates of membership

Table 6.16

FULL-TIME MATHEMATICS FACULTY LEAVING
TWO-YEAR COLLEGES, 1975-76

Reason for Leaving	Doctorates Math.	Doctorates Math. Ed.	Master's & Bachelor's	Total
Death or Retirement	-	7	80	87
Teaching in a Four-Year College or University	-	-	-	-
Non-Academic Position	-	-	-	-
Secondary School Teaching	-	-	7	7
Returned to Graduate School	-	-	47	47
Other, or Unemployed	-	-	7	7
Total Leaving Two-Year Colleges	-	7	141	148

in professional organizations, given in Table 6.17, agree very closely with data available from at least two of the organizations (MAA and NCTM).

Table 6.17

ESTIMATED MEMBERSHIPS OF FULL-TIME TWO-YEAR COLLEGE MATHEMATICS
FACULTY IN PROFESSIONAL ORGANIZATIONS, 1975-76

Organization	NCTM	MAA	AMS	SIAM	STATE AFFILIATE AMATYC	STATE ORGAN.	CITY ORGAN.	OTHER ORGAN.
Percent of Faculty Belonging	29%	25%	5%	2%	17%	22%	4%	9%

It is clear from Table 6.17 that no single professional organization has captured the interest and loyalty of two-year college mathematics faculty. Of the organizations listed, the first five are known to regularly publish a journal. Even assuming that the memberships of the five are pairwise disjoint, it is then estimated that at least 22% of all full time faculty do not regularly receive a professional journal devoted to mathematics or mathematics education. Additional information on professional activities of two-year college mathematical faculty is given in Table 6.18.

Table 6.18

PROFESSIONAL ACTIVITIES OF FULL-TIME TWO-YEAR COLLEGE MATHEMATICS FACULTY, 1975-76

Activity	Percent of Faculty Engaging in Activity
1. Attendance at at least one mathematics conference per year	47%
2. Taking additional graduate mathematics courses during the year or summer	21%
3. Giving talks on mathematics at conferences	9%
4. Giving talks on mathematics education at conferences	9%
5. Regular reading of journal articles on mathematics	47%
6. Regular reading of journal articles on mathematics education	47%
7. Writing journal articles on mathematics	5%
8. Writing journal articles on mathematics education	5%
9. Writing textbooks	15%

The like responses to 3 and 4, 5 and 6, and 7 and 8 suggest the possibility that mathematics and mathematics education were not separated by respondents.

BIBLIOGRAPHICAL REFERENCES

[A] Lindquist, Clarence B. Mathematics in Colleges and Universities. Washington, D. C.: U. S. Government Printing Office, 1965.

[B] Jewett, John and Clarence B. Lindquist. Aspects of Undergraduate Training in the Mathematical Sciences. Washington, D. C.: Conference Board of the Mathematical Sciences, 1967.

[C] Jewett, John and C. Russell Phelps. Undergraduate Education in the Mathematical Sciences, 1970-71. Washington, D. C.: Conference Board of the Mathematical Sciences, 1972.

[D] National Center for Education Statistics. Fall Enrollment in Higher Education 1974. Washington, D. C.: U. S. Government Printing Office, 1975.

[E] 1976 Mathematical Sciences Administrative Directory. Providence, R. I.: American Mathematical Society, 1976.

[F] Simon, Kenneth A. and Martin M. Frankel. Projections of Education Statistics to 1984-85. Washington, D. C.: U. S. Government Printing Office, 1976.

[G] Astin, Alexander W., Robert J. Panos, and John A. Creager. National Norms for Entering College Freshmen -- Fall 1966. Washington, D. C.: American Council of Education, 1967.

[H] National Norms for Entering College Freshmen -- Fall 1970. Washington, D. C.: American Council of Education, 1970.

[I] Astin, Alexander W., Margo R. King, and Gerald T. Richardson. The American Freshman: National Norms for Fall 1975. Los Angeles: Cooperative Institutional Research Program of the American Council on Education and the University of California at Los Angeles, 1976.

[J] Engineering Manpower Commission of Engineers Joint Council. Engineering and Technology Enrollments. New York: Engineers Joint Council, 1975.

[K] National Center for Education Statistics. Numbers and Characteristics of Employees in Higher Education, Fall 1966. Washington, D. C.: U. S. Government Printing Office, 1967.

[L] Bayer, Alan E. Teaching Faculty in Academe, 1972-73. Washington, D. C.: American Council on Education, 1973.

[M] "Nineteenth Annual AMS Survey." Notices of the American Mathematical Society, Volume 22, Number 6 (October, 1975), pp. 303-308. Additional information provided for CBMS by the AMS office.

[N] Board on Human-Resource Data and Analyses, Commission on Human Resources, National Research Council. Summary Report 1975 Doctorate Recipients from United States Universities. Washington, D. C.: National Academy of Sciences, 1976.

[O] American Council on Education. A Fact Book on Higher Education Third Issue/1975. Washington, D. C.: American Council on Education, 1975.

[P] Drake, Sandra L. (ed). 1976 Community, Junior and Technical College Directory. Washington, D. C.: American Association of Community and Junior Colleges, 1976.

[Q] "Statement on Teaching Loads and Class Size". Notices of the American Mathematical Society, Volume 23, Number 1 (January 1976) p. 76.

[R] "Aptitude Test Scores: Is the Decline Slowing?" The Chronicle of Higher Education. 13 September 1976.

[S] Fleming, Wendell H. "Current Trends in Graduate Education in Ph.D. Granting Mathematics Departments". Notices of the American Mathematical Society, Volume 23, Number 1 (January 1976) pp.109-113.

[T] Fleming, Wendell H. "Report of 1976 Survey of New Doctorates' Notices of the American Mathematical Society, Volume 23, Number 6 (October 1976) pp.318-320.

APPENDIX A
QUESTIONNAIRE FOR FOUR-YEAR INSTITUTIONS

Conference Board
of the Mathematical Sciences

832 Joseph Henry Building, 2100 Pennsylvania Ave., N.W., Washington, D. C. 20037

Telephone: (202) 293-1170

1 February 1976

To: The Chairman of a Mathematical Science Department

The development of sound policies and wise programs in the mathematical sciences, whether by department chairmen, administrators or national organizations, depends on having a base of accurate information on current trends in course offerings, curricula, enrollment, and faculty characteristics, as well as other data. The Survey Committee of the Conference Board of the Mathematical Sciences, whose present members are named below, has as its charge the task of making appropriate surveys of the current state of the mathematical sciences. To date, these surveys have resulted in the publication by CBMS of four reports dealing with undergraduate, graduate, or professional work in the mathematical sciences. We are now seeking your assistance in the task of bringing up to date information on the status of undergraduate programs in the various mathematical sciences.

A pioneer survey of undergraduate programs in mathematics was made by Clarence B. Lindquist of the U.S. Office of Education for academic year 1960-61. Our Survey Committee extended this work with undergraduate surveys for academic years 1965-66 and 1970-71 that are reported in the first and fourth volumes of our series. The present study will give a timely reassessment of undergraduate curricula in the mathematical sciences reflecting and highlighting the many changes that we all believe have taken place over the past five years. The current situation in employment in the mathematical sciences adds urgency to the present study.

The Committee has made every effort to limit this questionnaire to those questions which are of the greatest significance to the mathematical community and whose answers are not easily available from other sources. Your institution has been selected as one of approximately 260 which form a scientifically designed sample of the set of universities and colleges which grant bachelor's degrees and offer a substantial program in the mathematical sciences.

Your assistance in this important work will be greatly appreciated. Please return the filled out questionnaire by 1 March 1976. We shall be pleased, in return, to send you a copy of the resulting printed report.

Sincerely yours,

John W. Jewett
Chairman, CBMS Survey Committee

Survey Committee Members
- Donald J. Albers
- William F. Atchison
- Robert V. Hogg
- John W. Jewett
- Henry O. Pollak
- Gail S. Young

SURVEY OF UNDERGRADUATE PROGRAMS IN THE MATHEMATICAL SCIENCES

1975-76

General Instructions

You are asked to report on programs in the mathematical sciences under the cognizance of your department. If your college or university has on its campus separate departments of mathematics, statistics, applied mathematics, computer science, etc. (as listed in the 1975 Mathematical Sciences Administrative Directory published by the American Mathematical Society), we are sending this same questionnaire to each such department, which is being requested to fill out the entire questionnaire insofar as it is applicable to that department. Do not include data for branches or campuses of your institution that are administratively separate.

Please return completed questionnaire by 1 March 1976 to:

Conference Board of the Mathematical Sciences
2100 Pennsylvania Avenue, N.W., Suite 832
Washington, D. C. 20037

1. Name of your institution: ______________________

Name of your department: ______________________

Plan under which your institution operates:

1. ________ semester
2. ________ quarter
3. ________ trimester
4. ________ four-one-four
5. ________ other (specify) ______________________

II. Approximate enrollment of your branch or campus:

	Undergraduate	Total
Full-time Students		
Part-time Students		

III. Student training and ability

A. We are trying to find out changes in mathematical ability of undergraduates in various categories of institutions. Do you feel that such changes have occurred in your students? _____ Yes _____ No

B. If "Yes", has the change been upwards or downwards?

	training	ability
up		
down		

C. Such changes can be caused by a change in admissions standards or by a change in secondary school preparation or by other factors. In your judgment, what are the causes of the changes in your students?

IV. **Regular Undergraduate Program Courses**

Instructions for preparing of table on pp. 3-7:

a. The courses in column (1) in the following table are listed with typical course titles (which may not necessarily coincide with the titles you use). They are listed in approximate "catalogue order", beginning with remedial and freshman courses and proceeding through to those typically given to upperclassmen, which are grouped by major subject areas for your convenience in locating a listing which is a reasonable approximation for your offering". Additional blank spaces are provided to permit you to write in names of courses which do not fit reasonably under some listed title.

For the purpose of this survey, consider as a single course, instruction in a particular area of mathematics which you offer as a sequence of two or more parts (e.g., calculus). There is a column for indicating the number of sections of a course.

b. For each course in column (1) that is offered, write in column (2) the title(s) of the text(s) used and the name(s) of its author(s). In column (3) write the total number of students who enrolled in (any part of) the course in the fall term of 1975. In column (4) write the total number of sections of the course in the fall term of 1975. For a course not offered in fall 1975 but offered sometime, write "0".

*For purposes of identification with published curricula, certain courses are labelled as follows (but it is not necessary to refer to these sources):

ACM: courses suggested by the Association for Computing Machinery, Curriculum Committee on Computer Science, as listed in Communications of the ACM, March 1968, pp. 151-197.

IV. Undergraduate Courses in Mathematics

Name of Course (or equivalent)	Title and Author(s) of Text	Total No. of Students Enrolled Fall 1975	Total No. of Sections
(1)	(2)	(3)	(4)
1. Arithmetic for College Students			
2. General Math (basic skills, operations)			
3. High School Geometry			
4. Elementary Algebra (H.S.)			
5. Intermediate Algebra (H.S.)			
6. College Algebra			
7. Trigonometry			
8. College Algebra and Trigonometry, combined			
9. Elementary Functions			
10. Mathematics for Liberal Arts			
11. Finite Mathematics			
12. Math of Finance			
13. Business Math			
14. Math for Elementary School Teachers			
15. Analytic Geometry			
16. Other pre-calculus: specify			

IV. Undergraduate Courses in Mathematics

Name of Course (or equivalent	Title and Author(s) of Text	Total No. of Students Enrolled Fall 1975	Total No. of Sections
(1)	(2)	(3)	(4)
17. Calculus (math., phys., & eng. sciences)			
18. Calculus (bio., soc., & mgmt. sciences)			
19. Numerical Analysis			
20. Differential Equations			
21. Linear Algebra			
22. Differential Equations and Linear Algebra			
23. Advanced Calculus			
24. Advanced Differential Equations			
25. Partial Differential Equations			
26. Real Analysis			
27. Complex Variables			
28. Vector Analysis			
29. Advanced Math for Engineers & Physicists			
30. Geometry Survey			
31. Projective Geometry			
32. Topology			

IV. Undergraduate Courses in Mathematics

Name of Course (or equivalent) (1)	Title and Author(s) of Text (2)	Total No. of Students Enrolled Fall 1975 (3)	Total No. of Sections (4)
33. Modern Algebra			
34. Matrix Theory			
35. Combinatorics			
36. Foundations of Mathematics			
37. Theory of Numbers			
38. Set Theory			
39. History of Mathematics			
40. Mathematical Logic			
41. Math for Sec. School Teachers (methods, etc.)			
42. Applied Math. (models)			
43. Biomathematics			
44. Elementary Statistics (no calculus prereq.)			
45. Probability (& Stat.) (no calculus prereq.)			
46. Mathematical Statistics (Calculus)			
47. Probability (Calculus)			
48. Applied Statistical Analysis			

IV. Undergraduate Courses in Mathematics

Name of Course (or equivalent) (1)	Title and Author(s) of Text (2)	Total No. of Students Enrolled Fall 1975 (3)	Total No. of Sections (4)
49. Design & Analysis of Experiments			
50. Statistics, Other (specify)			
51. Intro. to Computing ACM: B-1			
52. Intro. to Computing, II			
53. Computers and Programming ACM: B-2			
54. Intro. to Discrete Structures ACM: B-3			
55. Numerical Calculus ACM: B-4			
56. Intro. to File Processing			
57. Data Structures ACM: 1-1			
58. Programming Languages ACM: 1-2			
59. Computer Organization ACM: 1-3			
60: Systems Programming ACM: 1-4			
61. Compiler Construction ACM: 1-5			
62. Design & Anal. of Computer Algorithms			
63. Artifical Intell. & Heuristic Programming			
64. Automata Theory			

IV. Undergraduate Courses in Mathematics

Name of Course (or equivalent) (1)	Title and Author(s) of Text (2)	Total No. of Students Enrolled Fall 1975 (3)	Total No. of Sections (4)
65. Information Storage and Retrieval			
66. Numerical Analysis (Computer) ACM: 1-8&9			
67. Combinatorics & Graph Theory			
68. Senior Seminar (Mathematics)			
69. Senior Seminar (Statistics)			
70. Senior Seminar (Computer Science)			
71. Indep. Study or Honors (Mathematics)			
72. Indep. Study or Honors (Statistics)			
73. Indep. Study or Honors (Computer Science)			
74. Other: Specify			

V. To what extent are courses in the mathematical sciences (comparable to those listed in Question IV) taught in divisions and departments other than one of the departments in the mathematical sciences. Enter in the relevant boxes an estimate of the total enrollments for the year of either graduates or under-graduate-level courses:

	Enrollment in courses given by division specializing in:							
	Biol. Science	Physical Sciences	Engi-neering	Agri-culture	Educa-tion	Business Admin.	Social Sciences	Other: specify
1. Probability								
2. Statistics								
3. Calculus or Diff. Equations								
4. Advanced Math for Engineers/Physics								
5. Computer Science & Programming								
6. Numerical Analysis								
7. Optimization & Linear Programming								
8. Biomathematics								
9. Mathematics of Finance, etc.								
10. Other: specify								

VI. Does your institution require an admissions examination for freshmen which includes mathematics as a part of it? ____ Yes ____ No

If applicable, check type of test(s) required, or optionally required:
(1) ____ College Entrance Examination Board Aptitude Examination
(2) ____ College Entrance Examination Board Achievement Examination
(3) ____ American College Testing examination
(4) ____ State examination (e.g., New York State Regents examination)
(5) ____ Your own institutional examination
(6) ____ Other: specify

VII. Does your department or college use or administer a placement examination in mathematics? ____ Yes ____ No

If Yes, check appropriate items:

A. Placement examination is taken by;
1. ____ All entering freshmen
2. ____ Students taking mathematics in college for the first time
3. ____ Students in special curricula only (e.g., engineering, etc.)
4. ____ Students desiring advanced placement (See question VIII also)
5. ____ Other: specify:

B. This placement examination tests for a knowledge of:
1. _____ Algebra
2. _____ Geometry
3. _____ Trigonometry
4. _____ Analytic geometry & Calculus
5. _____ Other: specify:

C. The objectives or purposes of this placement examination are:
1. _____ To determine which students have the necessary mathematical knowledge to undertake regular college courses
2. _____ To determine the mathematical aptitude of the student
3. _____ To section students by ability level
4. _____ To determine which course the student may enroll in
5. _____ Other: specify:

D. Are standardized or nationally distributed exams used? _____ Yes _____ No

III. Does your institution have a program of advanced standing (advanced placement) in mathematics, in which an entering student, on the basis of high school record or examination, may enroll in a course more advanced than usual for an entering freshman? _____ Yes _____ No

If so, for which courses may college credit be entered on the student's record?
1. _____ College Algebra and/or Trigonometry
2. _____ Analytic Geometry (as a separate course)
3. _____ Calculus (possibly including Analytic Geometry)
4. _____ Courses more advanced than Calculus
5. _____ Other: specify:

IX. Computers and Pocket Calculators

A. Does your department have access to a computer or to computer terminal facilities? _____ Yes _____ No

If so,
1. In departmental space _______
2. In your building _______
3. Free of charge _______
4. From departmental budget _______
5. Project-by-project _______
6. Other _______

B. What percentage of your departmental full-time faculty make substantial use of computer facilities?
1. In research? _____%
2. In teaching? _____%

C. Are there courses taught by your department, other than those in computer science, in which the use of a computer is specified? _____ Yes _____ No

If so, list here the relevant courses, using the course numbers from Question IV: ____________________

D. Are there courses taught by your department in which the use of a pocket calculator is recommended for
1. Homework? _____ Yes _____ No
2. Taking exams? _____ Yes _____ No

E. If your answer to either part of D is Yes, list the relevant courses by their course numbers from Question IV: ____________________

X. Check any techniques of instruction, other than the standard or traditional lecture-recitation system, used to a substantial degree by your department:
1. _____ Large lecture classes with small quiz sections
2. _____ Large lecture classes with help sessions
3. _____ Organized program of independent study
4. _____ Television (closed-circuit or broadcast)
5. _____ Audio-tutorial
6. _____ Programmed instruction
7. _____ Computer-assisted instruction (CAI)
8. _____ Computer-managed instruction (SMI)
9. _____ Self-paced instruction
10. _____ Other: specify:

XI. Check in the appropriate column any innovations in undergraduate programs and requirements in the mathematical sciences introduced since 1965:

	A Introduced 1966-1970	B Introduced 1971-1975
1. Have introduced new degree programs	______	______
2. Have provided new courses appropriate for the biological and medical sciences	______	______
3. Have provided new courses appropriate for the social and management sciences	______	______
4. Have provided new courses appropriate for the physical sciences and engineering	______	______
5. Have provided new courses appropriate for computing and data processing	______	______
6. Have provided new courses or tutorial work to meet broadened admissions policies	______	______
7. Have significantly altered the program for freshman year	______	______
8. Have introduced or substantially altered a program for the undergraduate preparation of secondary school teachers of mathematics	______	______
9. Have introduced or substantially altered a program for the methematics preparation of elementary school teachers	______	______
10. Have introduced other innovations	______	______

If parts 6, 7, 8, 9, or 10 are checked, please indicate briefly, in the space below or at the top of the next page, what these changes were.

XII. Questions on Mathematics Faculty (Graduate and Undergraduate)

A. Full-time faculty: indicate the number of full-time mathematical science faculty members in your department in the table below, according to their highest degrees and subject fields in which these were earned:

Highest degree	In Math.	In Stat.	In Computer Science	In Math. Ed.	In Another field (specify)
Doctor's degree					
Master's degree					
Bachelor's degree					

B. Part-time faculty, other than graduate students: indicate the numbers of part-time mathematical sciences faculty members in your department in the table below, by highest degrees and subject fields:

Highest degree	In Math.	In Stat.	In Computer Science	In Math. Ed.	In another field (specify)
Doctor's degree					
Master's degree					
Bachelor's degree					

C. Teaching assistants employed in instruction (by highest degree):

	1974	1975
No. of teaching assistants with master's degree:	___	___
No. of teaching assistants with bachelor's degree"	___	___
No. of undergraduates employed as teaching assistants:	___	___

D. Teaching assignments: indicate in the following table your estimate of the percentage of the total freshman-sophomore teaching load in your department, distributed by type of teaching personnel:

Teaching Group	Percent of total freshman-sophomore teaching load
Full-time faculty	
Part-time faculty	
Teaching assistants	

XIII. Age, Sex and Ethnic Group of Full-time Faculty

A. Record the number of full-time faculty members in each category:

Age	Under 30	30-34	35-39	40-44	45-49	50-54	55-59	60 & Over
Tenured, PhD								
Tenured, non-PhD								
Non-tenured, PhD								
Non-tenured, non-PhD								
Men								
Women								
Caucasian								
Oriental								
Hispanic								
Black								
Amerindian								

B. List the ages of all your faculty members who were granted tenure during year 1974-75: ______________________

XIV.

A. What is the expected (or typical) teaching load in credit hours for your full-time faculty (excluding thesis supervision):

	Full semester or quarter	Spring semester or quarter
(a) Professors		
(b) Associate Professors		
(c) Assistant Professors		
(d) Instructors with PhD		
(e) Instructors without PhD		
(f) Teaching Assistants		

B. If there are significant departures from these expected teaching loads for certain classes of individuals, please specify:

C. For regular faculty members above the rank of instructor, with teaching loads as indicated above, which of the following best describes your department's normal expectation (explicit or implicit) with respect to an individual's research activity?

(a) Publication of scientific papers or articles, on a reasonably regular basis, averaging perhaps ________ publications in a five-year period.

(b) Maintaining research activity, but with no expected rate of publication ________.

(c) No particular expectation of research and/or publication ________.

(d) Other: specify: ______________________________

XV. Does your department have a sabbatical-leave plan under which a faculty member may have leave (one semester at full pay or a year at half pay, every seven years or so, or roughly equivalent)? _____ Yes _____ No

If so, is this leave granted:

(a) automatically (without restriction) _______
(b) only with well-defined research plans _______
(c) other; specify: ____________________________

If there is no regular sabbatical plan as described above, but other provision is made for paid leaves of absence, please comment:

VI. Employment and Mobility of Faculty (Graduate and Undergraduate)

A. Of the new full-time faculty in your department this year, how many were during the previous year 1974-1975 --

	Ph.D.'s	Non-Ph.D.
(1) enrolled in graduate school	_______	_______
(2) teaching in a four-year institution	_______	_______
(3) teaching in a two-year institution	_______	_______
(4) holding postdoctoral study/research appointments	_______	_______
(5) employed in non-academic positions	_______	_______
(6) otherwise occupied; specify:	_______	_______

B. Of the full-time faculty last year, who are no longer part of your full-time faculty, how many --

	Ph.D.'s	Non-Ph.D.
(1) died, or retired	_______	_______
(2) are teaching in a four-year institution	_______	_______
(3) are teaching in a two-year institution	_______	_______
(4) left for a non-academic position	_______	_______
(5) returned to graduate school	_______	_______
(6) are otherwise occupied; specify:	_______	_______

C. Give your best estimate of total faculty size in your department for 1976-77 and 1977-1978:

	1976-77	1977-78
Full-time	_______	_______
Part-time	_______	_______

D. In seeking new faculty members for 1976-77, approximately how many do you seek in each of the following subfields?

(a) Algebra & Number Theory	_______	(f) Applied Mathematics	_______
(b) Analysis	_______	(g) Biomathematics	_______
(c) Topology & Geometry	_______	(h) Operations Research	_______
(d) Probability & Statistics	_______	(i) Math. Education	_______
(e) Computer Science	_______	(j) Math--general	_______

E. Of your present full-time Ph.D. faculty members who were also part of your full-time staff in previous years, how many have completed the requirements for their Ph.D. while in your employ --

(1) between July 1973 and June 1974? _______
(2) between July 1974 and June 1975? _______
(3) since July 1975? _______

XVII. How many bachelor's degrees with major in mathematical sciences were awarded by your department between July 1974 and June 1975? Indicate the number of these with each specialty:

Mathematics, general	_______	Applied Mathematics	_______
Statistics	_______	Secondary School Teaching	_______
Actuarial Science	_______	Other; specify	_______
Computer Science	_______		

If you have found some question(s) difficult to interpret or to secure data for, please supply elucidating comments or suggestions which would be helpful to the Committee in future surveys:

Information supplied by: ______________________________

Title and Department: ______________________________

Institution and Campus ______________________________

Date: ______________________________

APPENDIX B

LIST OF RESPONDENTS TO FOUR-YEAR INSTITUTION SURVEY

A: Public Universities

Arizona State University	Mathematics
Auburn University	Mathematics
Bowling Green State University	Mathematics, Computer Science Quantitative Analysis and Control
University of California, Berkeley	Mathematics, Computer Science
University of California, Irvine	Mathematics
University of California, Los Angeles	Mathematics
University of California, San Diego	Mathematics
University of Cincinnati	Mathematical Sciences
Clemson University	Mathematical Sciences
University of Connecticut	Statistics
University of Florida	Mathematics, Statistics
University of Georgia	Mathematics
University of Hawaii	Mathematics, Computer Science
University of Houston	Mathematics
University of Illinois	Mathematics, Computer Science
Iowa State University	Mathematics, Statistics
University of Kansas	Mathematics
Kansas State University	Mathematics, Computer Science, Statistics
University of Maine	Mathematics
University of Maryland	Mathematics, Computer Science
University of Michigan	Mathematics, Biostatistics
Michigan State University	Computer Science
University of Minnesota	Statistics
University of Missouri, Columbia	Mathematics
University of Montana	Mathematics, Computer Science
University of Nebraska, Lincoln	Mathematics & Statistics, Computer Science
University of New Mexico	Mathematics & Statistics, Computing & Information Science
University of North Carolina, Chapel Hill	Mathematics
North Texas State University	Mathematics, Computer Science
Ohio State University	Mathematics, Statistics
Oregon State University	Statistics
Pennsylvania State University	Mathematics, Computer Science, Statistics
University of Pittsburgh	Mathematics & Statistics
Purdue University	Mathematics, Computer Science, Statistics
University of South Carolina	Mathematics & Computer Science
Southern Illinois University	Mathematics
SUNY, Stony Brook	Mathematics, Computer Science, Applied Mathematics & Statistics
Temple University	Statistics

A: Public Universities (continued)

University of Tennessee	Mathematics, Computer Science
University of Texas	Mathematics
Texas Tech University	Mathematics
University of Washington	Computer Science
Wayne State University	Mathematics
University of Wisconsin, Madison	Mathematics, Computer Science, Stati
University of Wisconsin, Milwaukee	Mathematics

B: Private Universities

Brown University	Applied Mathematics
Case Western Reserve University	Operations Research
Columbia University	Electrical Engineering & Computer Sc
Drexel University	Mathematics
Fordham University	Mathematics
George Washington University	Mathematics, Statistics, Operations Research
Johns Hopkins University	Mathematics, Mathematical Sciences
New York University	Mathematics
University of Pennsylvania	Mathematics, Statistics
University of Rochester	Statistics
St. Louis University	Mathematics
Stevens Institute of Technology	Mathematics
University of Southern California	Mathematics
Tulane University	Mathematics

C: Public Four-Year Colleges

Alabama State University	Mathematics & Basic Engineering
Appalachian State University	Mathematical Sciences
Baruch College of CUNY	Mathematics
Bemidji State University	Mathematics & Computer Science
Boise State University	Mathematics
Brooklyn College of CUNY	Mathematics
California State University, Fullerton	Quantitative Methods
California State University, Long Beach	Mathematics
California State University, Northridge	Mathematics
California State University, Sacramento	Mathematics & Statistics
Cameron University	Mathematics
Central Michigan University	Mathematics
Cleveland State University	Mathematics

C: Public Four-Year Colleges (continued)

Edinboro State College	Mathematics
Georgia State University	Computer Science, Statistics
Hunter College of CUNY	Mathematics
University of Illinois, Chicago Circle	Mathematics
Indiana University of Pennsylvania	Mathematics, Computer Science
Jacksonville State University, Alabama	Mathematics
Mary Washington College	Mathematics, Computer Science, Statisti
University of Michigan, Dearborn	Mathematics & Statistics
Middle Tennessee University	Mathematics
Montclair State College	Mathematics
Morehead State University	Mathematical Sciences
University of North Carolina, Greensboro	Mathematics
University of North Colorado	Research & Statistical Methodology
University of North Florida	Mathematical Sciences
University of Northern Iowa	Mathematics
Northern Kentucky State College	Mathematical Sciences
Northwestern State University, Louisana	Mathematics
Portland State University	Mathematics
Purdue University, Calumet Campus	Mathematical Sciences
Queens College of CUNY	Mathematics
Salisbury State College	Mathematical Sciences
San Diego State University	Mathematics
San Jose State University University	Mathematics
Slippery Rock State College	Mathematics
University of South Florida	Mathematics
University of Southern Louisiana	Mathematics & Statistics, Computer Scie
Stephen F. Austin State University	Mathematics & Statistics
University of Tennessee, Nashville	Mathematics
Western Carolina University	Mathematics & Computer Science
Western Michigan University	Mathematics
Western Washington State College	Mathematics & Computer Science
William Paterson College	Mathematics
University of Wisconsin, La Crosse	Mathematics
Wright State University	Mathematics, Computer Science

D: Private Four-Year Colleges

Albion College	Mathematics
Alderson-Broaddus College	Mathematics
Alfred University	Mathematics
Antioch College	Mathematics
Ashland College	Mathematics
Azusa Pacific College	Mathematics

D: <u>Private Four-Year Colleges</u> (continued)

Baldwin-Wallace College	Mathematics & Astronomy
Baylor University	Mathematics
Belmont Abbey College	Mathematics
Bethel College, Kansas	Mathematical Sciences
Brigham Young University	Computer Science, Statistics
Bryan College	Mathematics
Butler University	Mathematics
Calvin College	Mathematics
Central Methodist College	Mathematics
Chapman College	Mathematics
Cumberland College	Mathematics
Davidson College	Mathematics
Florida Institute of Technology	Mathematical Sciences
Golden Gate University	Mathematics
Goucher College	Mathematics
Grove City College	Mathematics
University of Hartford	Mathematics & Physics
Heidelberg College	Mathematics
Hendrix College	Mathematics
High Point College	Mathematics
Hofstra University	Mathematics
Illinois College	Mathematics
King's College	Mathematics
Lafayette College	Mathematics & Astronomy
Lewis & Clark College	Mathematics
Loyola University	Mathematical Sciences
Lycoming College	Mathematics
Malone College	Mathematics & Science
Marquette University	Mathematics & Statistics
Mary Crest College	Mathematics & Science
University of Miami, Florida	Mathematics
Morningside College	Mathematics
Muskingum College	Mathematics & Computer Scienc
Northland College	Mathematics
Ohio Wesleyan University	Mathematics
Pacific College	Mathematics
Park College	Mathematics
Pepperdine University	General Studies
Polytechnic Institute of New York	Mathematics
University of Puget Sound	Mathematics
University of Richmond	Mathematics
Roosevelt University	Mathematical Sciences
Russell Sage College	Mathematics/Physical Science
St. Joseph College	Mathematics
St. Mary's College	Mathematics
St. Peter's College	Mathematics
St. Xavier College, Chicago	Mathematics

D: Private Four-Year Colleges (continued)

University of Santa Clara	Mathematics
Southeastern University	Mathematics
Stetson University	Mathematics
Suffolk University	Mathematics
Teachers College, Columbia University	Mathematical Educa
Tougaloo College	Mathematics
Trinity University	Mathematics
Warren Wilson College	Mathematics
Washington College	Mathematics & Comp
Washington & Lee University	Mathematics
Westminster College, Pennsylvania	Mathematics
Westminster College, Utah	Mathematics
Whitman College	Mathematics
Widener College	Mathematics
Wilkes College	Mathematics
Wittenberg University	Mathematics

APPENDIX C
QUESTIONNAIRE FOR TWO-YEAR INSTITUTIONS

SURVEY OF PROGRAMS IN MATHEMATICS
IN
TWO-YEAR COLLEGES

1975-76

General Instructions

This questionnaire should be completed by the person who is directly in charge of the mathematics program at your institution.

You are asked to report on all the mathematics courses and faculty in your institution. For some colleges this may involve courses in statistics, applied mathematics, and computers that, althought mathematical in nature, are taught outside a mathematics department. Please include data on part-time and evening students and faculty as well as data on occupational and terminal programs. Include non-credit and remedial courses. Do not, however, include data concerning campuses jurisdictionally separate from yours, if such exist.

Please return completed questionnaire by 1 March 1976 to:

Conference Board of the Mathematical Sciences
2100 Pennsylvania Avenue, N.W., Suite 832
Washington, D. C. 20037

* * * * * * * *

I. A. Name of institution ____________________

If this two-year institution is part of a larger organization, identify this relationship: ____________________

B. Year institution was established ________

C. Plan under which your institution operates:

1. ______ semester
2. ______ quarter
3. ______ trimester
4. ______ four-one-four
5. ______ other (specify): ____________________

D. How is the mathematics program administered at your institution?

______ Mathematics department
______ Mathematics and science department or division
______ No departmental structure
______ Other (specify_: ____________________

II. Institutional enrollment (approximate):

	College-Transfer Program		Occupational/Training	
	Full-time Students	Part-time Students	Full-time Students	Part-time Students
Freshmen				
Sophomores				
Unclassified or other				
Total				

III. Student training and ability

A. We are trying to find out changes in mathematical ability of undergraduates in various categories of institutions. Do you feel that such changes have occurred in your students? _____ Yes _____ No

B. If "Yes", has the change been upwards or downwards?

	training	ability
up		
down		

IV. Courses in the Mathematical Sciences:

Instructions for preparing table on pages 3-4:

a. The courses in column (1) in the following table are listed with typical course titles (which may not necessarily coincide with the titles you use). They are listed in approximate "catalogue order", beginning with remedial and freshman courses. Additional blank spaces are provided to permit you to write in names of courses which do not fit reasonably under some listed title.

For the purpose of this survey, consider as a single course, instruction in a particular area of mathematics which you offer as a sequence of two or more parts (e.g., calculus).

b. For each course in column (1) that is offered, write in column (2) the title(s) of the text(s) used and the name(s) of its author(s). In column (3) write the total number of students who enrolled in (any part of) the course in the fall term of 1975. For a course not offered in Fall 1975 but offered sometime, write "0".

c. In column (4) give the total number of sections in the course.

IV. Courses in Mathematics

Name of Course (or equivalent) (1)	Title and Author(s) of Text (2)	Total No. of Students Enrolled Fall 1975 (3)	Total No. of Sections (4)
1. Arithmetic			
2. High School Geometry			
3. Elementary Algebra (H.S.)			
4. Intermediate Algebra (H.S.)			
5. College Algebra			
6. Trigonometry			
7. College Algebra and Trigonometry, combined			
8. Elem. Functions			
9. Math. for Liberal Arts			
10. General Mathematics (basic skills, operations)			
11. Finite Mathematics			
12. Mathematics of Finance			
13. Business Mathematics			
14. Math. for Elementary School Teachers			
15. Technical Mathematics			
16. Technical Mathematics (calculus level)			

-3-

IV. Courses in Mathematics

Name of Course (or equivalent) (1)	Title and Author(s) of Text (2)	Total No. of Students Enrolled Fall 1975 (3)	Total No. of Sections (4)
17. Analytic Geometry			
18. Analytic Geometry and Calculus			
19. Calculus (math.,phys. & eng. sciences)			
20. Calculus (bio., soc. & mgt. sciences)			
21. Differential Equations			
22. Linear Algebra			
23. Diff. Equations & Linear Algebra			
24. Elementary Statistics			
25. Probability (and statistics)			
26. Programming of Digital Computers			
27. Other Computer Science Course			
28. Use of Hand Calculators			
29. Slide Rule			
30.			
31.			
32.			

-4-

V. To what extent are courses in mathematics taught in division or departments of your institution other than that division or department having primary responsibility for mathematics? If your institution does not have a departmental or divisional structure, consider the group of all mathematics professors to be the "mathematics department" for the purpose of this question. Enter in the relevant boxes an estimate of the total course enrollments for the year.

Courses	Enrollment in courses given by division specializing in: Natural Sciences	Occupational Programs	Business	Social Sciences	Other (specify)
1. Arithmetic					
2. Business Mathematics					
3. Statistics					
4. Probability					
5. Pre-calculus College Math.					
6. Calculus or Diff. Equations					
7. Computer Science & Programming					
8. Other: specify					

VI. Do you offer specific certificate programs or associate degrees in mathematical subjects:

	Certificate Program	Associate Degree Program	Number of Awards 1975
1. Computer programming	______	______	______
2. Data Processing	______	______	______
3. Statistical assistant	______	______	______
4. Other mathematical specialty: specify: ______	______	______	______

VII. Does your institution require an admission examination _____ Yes _____ No

If applicable, check type of test(s) required, or optionally required:

(1) _____ College Entrance Examination Board Aptitude Examination
(2) _____ College Entrance Examination Board Achievement Examination
(3) _____ American College Testing examination
(4) _____ State examination (e.g., New York State Regents examination)
(5) _____ Other: specify

VIII. Does your department or college use or administer a placement examination in mathematics? _____ Yes _____ No

If Yes, check appropriate items:

A. Placement examination is taken by:
1. _____ All entering freshmen
2. _____ Students taking mathematics in college for the first time
3. _____ Students in special curricula only (e.g., engineering, etc.)
4. _____ Other; specify:

B. This placement examination tests for a knowledge of:
1. _____ Arithmetic
2. _____ Algebra
3. _____ Geometry
4. _____ Trigonometry
5. _____ Other; specify:

C. The objectives or purposes of this placement examination are:
1. _____ To determine which students have the necessary mathematical knowledge to undertake regular college courses
2. _____ To determine the mathematical aptitude of the student
3. _____ To section students by ability level
4. _____ To determine which course the student may enroll in
5. _____ Other; specify:

D. Are standardized or nationally distributed exams used? _____Yes _____No

IX. Use of Computers and Pocket Calculators

A. Does your department have access to a computer or to computer terminal facilities? _____Yes _____No

B. What percentage of your departmental full-time faculty makes substantial use of computer facilities --
1. in research ______%
2. in teaching ______%

C. Are there courses taught by your department, other than those in computer science, in which the use of a computer is specified? _____Yes _____No.

D. Are there courses taught in your department in which the use of a pocket calculator is recommended for:
1. homework? _____Yes _____No
2. taking exams? _____yes _____No

E. If the answer to either part of D is yes, list the relevant courses, using the numbers from Question IV:

X. Check any techniques of instruction, other than the standard or traditional lecture-recitation system, used by your department:

1. _____ Large lecture classes with smallquiz sections
2. _____ Large lecture classes with help sessions
3. _____ Organized program of independent study
4. _____ Courses by television (closed-circuit or broadcast)
5. _____ Courses by film
6. _____ Courses by programmed instruction
7. _____ Courses by computer-assisted instruction (CAI)
8. _____ Modules
9. _____ Audio-tutorial
10. _____ PSI
11. _____ Other; specify

XI. Coordination of transfer programs with four-year institutions:

1. Are your course offerings and/or curricula subject state control or approval? _____ Yes _____ No
2. Is there official state-wide coordination of your mathematical offerings with those of four-year institutions? _____ Yes _____ No
3. Do you, or your mathematics staff, consult regularly with the mathematics department of four-year colleges on course offerings designed for transfer credit? _____ Yes _____ No
4. Are there other coordination activities involving your mathematics staff and mathematics departments of four-year colleges or universities in your area? _____ Yes _____ No
   If so, please describe these:

XII. Questions on Mathematics Faculty

A. Full-time faculty: indicate the numbers of full-time mathematical sciences faculty members in your department in the table below, according to their highest degrees and subject fields in which these were earned:

Highest degree	In math.	In stat.	In computer science	In math. ed.	In another field (specify)
Doctor's degree					
Master's degree in math., plus 1 year					
Master's degree					
Master's degree (spec. program) e.g., MAT, MST					
Bachelor's degree					

B. Part-time faculty: other than graduate students; indicate the numbers of part-time mathematical sciences faculty members in your department in the table below, by highest degrees and subject fields:

Highest degree	In math.	In stat.	In computer science	In math. ed.	In another field (specify)
Doctor's degree					
Master's degree in math., plus 1 year					
Master's degree					
Master's degree (spec. program) e.g., MAT, MST					
Bachelor's degree					

C. What is the approximate percentage of the total teaching activity in mathematics which is borne by the part-time faculty? _____ %

D. What is the expected (or typical) teaching load in credit hours for members of your full-time faculty? _____

E. If there are significant departures from this expected teaching load for certain classes of individuals, please specify:

XIII. Faculty Employment and Mobility

A. For full-time faculty members who were first employed on a full-time basis this year, how many were during the previous year 1974-75?

	Ph.D. (math)	Ph.D. (math. ed.)	Non Ph.D.
1. enrolled in graduate school			
2. teaching in a 4-year college or university			
3. teaching in another 2-year college			
4. teaching in a secondary school			
5. employed by you part-time			
6. employed in non-academic positions			
7. otherwise occupied; specify:			

B. Of the full-time faculty last year, who are no longer part of your full-time faculty, how many --

	Ph.D. (math)	Ph.D. (math. ed.)	Non Ph.D.
1. died, or retired			
2. are teaching in a four-year institution			
3. are teaching in a two-year institution			
4. left for a non-academic position			
5. returned to graduate school			
6. left for secondary school teaching			
7. are otherwise occupied; specify			

C. **How many of your full-time faculty have been employed as secondary-school teachers during the last ten years?** ________

	Ph.D. (math.)	Ph.D. (math. ed.)	Non-Ph.D.
1. How many faculty members did you employ full-time for the first time in 1975-76?			
2. How many additional full-time faculty members do you plan to seek for 1976-77?			
3. If you are successful in 2, how many additional faculty members would you need for 1977-78?			

XIV. Age, Sex and Ethnic Group of Full-time Faculty

A. Record the number of full-time faculty members in each category:

Age	Under 30	30-34	35-39	40-44	45-49	50-54	55-59	60 & Over
Bachelors								
Masters								
Doctors								
Men								
Women								
Caucasian								
Oriental								
Hispanic								
Black								
Amerindian								

XV. Professional Activities

A. Memberships: For each organization listed, indicate the number of full-time members of your department who belong to:

MAA	AMATYC (State Affiliate)	NCTM	AMS	SIAM	City Org.	State Org.	Other

B. Estimate the number of full-time members of your department who

1. ________ attend at least one mathematics conference per year
2. ________ take additional graduate mathematics courses during the year or summer
3. ________ give talks on mathematics at conferences
4. ________ give talks on mathematics education at conferences
5. ________ regularly read journal articles on mathematics
6. ________ regularly read journal articles on mathematics eduction
7. ________ write journal articles on mathematics
8. ________ write journal articles on mathematics education
9. ________ write textbooks

?I. **If you have found some question(s) difficult to interpret or to secure data for, please supply elucidating comments or suggestions which would be helpful to the Committee in future surveys:**

Information supplied by: ________________________

Title: ________________________

Date: ________________________

Telephone: ________________________
Area Number Extension

APPENDIX D

LIST OF RESPONDENTS TO TWO-YEAR INSTITUTION SURVEY

A: Public Two-Year Colleges

Allan Hancock College, Santa Maria, California
Anchorage Community College, Anchorage, Alaska
Anne Arundel Community College, Arnold, Maryland
Barstow College, Barstow, California
Beaufort County Technical Institute, Washington, North Carolina
Bergen Community College, Paramus, New Jersey
Blackhawk College, East Campus, Janesville, Wisconsin
Bronx Community College, Bronx, New York
Cabrillo College, Aptos, California
Central Piedmont Community College, Charlotte, North Carolina
Central Virginia Community College, Lynchburg, Virginia
Cerritos College, Whittier, California
Chemeketa Community College, Salem, Oregon
Citras Community College, Azusa, California
City College of San Francisco, San Francisco, California
Compton Community College, Compton, California
Danville Community College, Danville, Virginia
Diablo Valley College, Pleasant Hill, California
Durham Technical Institute, Durham, North Carolina
East Los Angeles College, Los Angeles, California
El Camino College, Torrance, California
El Paso Community College, El Paso, Texas
Emmanuel College, Franklin Springs, Georgia
Florida Junior College, Jacksonville, Florida
Foothill College, Los Altos Hills, California
Fresno City College, Fresno, California
Fullerton College, Fullerton, California
Gadsden State Junior College, Gadsden, Alabama
Golden West Community College, Huntington, California
Grossmont College, San Diego, California
Leeward Community College, Pearl City, Hawaii
Inver Hills Community College, Inver Grove Heights, Minnesota
Jamestown Community College, Jamestown, New York
Lakewood Community College, White Bear Lake, Minnesota
Laney College, Oakland, California
Lansing Community College, Lansing, Michigan
Long Beach City College, Long Beach, California
Los Angeles City College, Los Angeles, California
Los Angeles Valley College, Van Nuys, California
Lurleen B. Wallace State Junior College, Andalusia, Alabama
Marshalltown Community College, Marshalltown, Iowa
Merced College, Merced, California
Mercer County Community College, Trenton, New Jersey

A: Public Two-Year Colleges (continued)

Miami-Dade Community College, North Campus, Miami, Florida
Miami-Dade Community College, South Campus, Miami, Florida
Milwaukee Area Technical College, Milwaukee, Wisconsin
Monroe Community College, Rochester, New York
Monterey Peninsula College, Monterey, California
Montgomery Community College, Rockville Campus, Rockville, Maryland
Moraine Valley Community College, Palso Hills, Illinois
Mt. San Antonio College, Walnut, California
Northeast Wisconsin Technical Institute, Green Bay, Wisconsin
Northern Virginia Community College, Alexandria, Virginia
Northern Virginia Community College, Annandale, Virginia
Northern Virginia Community College, Manassas, Virginia
Northern Virginia Community College, Sterling, Virginia
Northern Virginia Community College, Woodbridge, Virginia
Charles Stewart Mott Community College, Flint, Michigan
Oakland Community College, Oakland, Michigan
Oakton Community College, Morton Grove, Illinois
Orange Coast College, Costa Mesa, California
Panola Junior College, Carthage, Texas
Pearl River Junior College, Pearl River, Mississippi
Pennsylvania State University, Altoona, Pennsylvania
Phoenix College, Phoenix, Arizona
Pierce College, Los Angeles, California
Pima Community College, Tucson, Arizona
Polk Community College, Winter Haven, Florida
Portland Community College, Portland, Oregon
Quinsigamond Community College, Worcester, Massachusetts
St. Petersburg Junior College, Clearwater, Florida
St. Petersburg Junior College, St. Petersburg, Florida
San Joaquin Delta College, Stockton, California
College of San Mateo, San Mateo, California
Santa Ana College, Santa Ana, California
Santa Monica College, Santa Monica, California
Seattle Central Community College, Seattle, Washington
South Plains College, Levelland, Texas
Southwest Virginia Community College, Richlands, Virginia
Spokane Falls Community College, Spokane, Washington
Springfield Technical Community College, Springfield, Massachusetts
Three River Community College, Poplar Bluff, Missouri
Tidewater Community College, Portsmouth, Virginia
Utah Technical College, Salt Lake City, Utah
Virginia Western Community College, Roanoke, Virginia
Wilkes Community College, Wilkesboro, North Carolina

B: Private Two-Year Colleges

Cullman College, Cullman, Alabama
Dean Junior College, Franklin, Massachusetts
Goldey Beacom College, Wilmington, Delaware
Lackawanna Junior College, Scranton, Pennsylv
Miami-Jacobs Junior College of Business, Dayt
Mallinckrodt College, Wilmette, Illinois
Martin College, Pulaski, Tennessee
Ricks College, Rexburg, Idaho
Suomi College, Hancock, Michigan
Union College, Cranfield, New Jersey
Young Harris College, Young Harris, Georgia

APPENDIX E

COURSE BY COURSE ENROLLMENT DATA FOR UNIVERSITIES AND FOUR-YEAR COLLEGES (In Thousands)

	Course	Universities	Public Colleges	Private Colleges	Total
	TOTAL	631	573	293	1497
1.	Arithmetic for College Students	L	5	1	6
2.	General Math (basic skills, operations)	L	23	3	26
3.	High School Geometry	L	1	1	2
4.	Elementary Algebra (H.S.)	4	22	L	26
5.	Intermediate Algebra (H.S.)	26	46	9	81
6.	College Algebra	44	27	9	80
7.	Trigonometry	13	14	4	31
8.	College Algebra and Trigonometry, combined	35	28	16	79
9.	Elementary Functions	13	8	8	29
10.	Mathematics for Liberal Arts	21	64	18	103
11.	Finite Mathematics	25	27	22	74
12.	Math of Finance	1	3	L	4
13.	Business Math	20	18	5	43
14.	Math for Elementary School Teachers	22	34	12	68
15.	Analytic Geometry	2	2	L	4
16.	Other pre-calculus: specify	19	13	8	40

Course	Universities	Public Colleges	Private Colleges	Total
17. Calculus (math., phys., and eng. sciences)	148	83	73	304
18. Calculus (bio., soc., and mgmt. sciences)	43	29	17	89
19. Numerical Analysis	2	3	L	5
20. Differential Equations	10	8	5	23
21. Linear Algebra	9	8	7	24
22. Differential Equations and Linear Algebra	3	1	1	5
23. Advanced Calculus	5	5	4	14
24. Advanced Differential Equations	1	L	L	1
25. Partial Differential Equations	2	1	L	3
26. Real Analysis	2	2	2	6
27. Complex Variables	1	2	1	4
28. Vector Analysis	1	1	2	4
29. Advanced Math for Engineers & Physicists	5	3	1	9
30. Geometry Survey	1	3	1	5
31. Projective Geometry	L	L	L	L
32. Topology	1	L	L	1
33. Modern Algebra	4	4	5	13
34. Matrix Theory	2	2	L	4
35. Combinatorics	L	L	L	L

Course	Universities	Public Colleges	Private Colleges	Total
36. Foundations of Mathematics	L	1	L	1
37. Theory of Numbers	L	1	L	1
38. Set Theory	1	1	L	2
39. History of Mathematics	L	1	1	2
40. Mathematical Logic	L	L	L	L
41. Math for Sec. School Teachers (methods, etc.)	1	1	1	3
42. Applied Math. (models)	1	L	L	1
43. Biomathematics	1	L	L	1
44. Elementary Statistics (no calculus prereq.)	30	27	17	74
45. Probability (& Stat.) (no calculus prereq.)	12	8	5	25
46. Mathematical Statistics (Calculus)	7	4	3	14
47. Probability (Calculus)	3	2	3	8
48. Applied Statistical Analysis	9	1	L	10
49. Design and Analysis of Experiments	1	1	L	2
50. Statistics, Other (specify)	5	2	1	8
51. Intro. to Computing ACM: B-1	24	10	16	50
52. Intro. to Computing, II	5	7	1	13
53. Computers and Programming ACM: B-2	5	5	3	13

Course	Universities	Public Colleges	Private Colleges	Total
54. Intro. to Discrete Structures ACM: B-3	2	1	L	3
55. Numerical Calculus ACM: B-4	3	L	L	3
56. Intro. to File Processing	3	L	L	3
57. Data Structures ACM: 1-1	2	1	L	3
58. Programming Languages ACM: 1-2	5	2	L	7
59. Computer Organization ACM: 1-3	2	1	L	3
60. Systems Programming ACM: 1-4	1	1	L	2
61. Compiler Construction ACM: 1-5	1	L	L	1
62. Design & Anal. of Computer Algorithms	1	L	L	1
63. Artifical Intell. & Heuristic Programming	1	L	L	1
64. Automata Theory	1	L	L	1
65. Information Storage and Retrieval	1	L	L	1
66. Numerical Analysis (Computer) ACM: 1-8&9	1	L	L	1
67. Combinatorics and Graph Theory	1	L	L	1
68. Senior Seminar (Mathematics)	L	L	1	1
69. Senior Seminar (Statistics)	L	L	L	L

	Course	Universities	Public Colleges	Private Colleges	Total
70.	Senior Seminar (Computer Science)	L	L	L	L
71.	Indep. Study or Honors (Mathematics)	1	L	1	2
72.	Indep. Study or Honors (Statistics)	L	L	L	L
73.	Indep. Study or Honors (Computer Science)	1	L	L	1
74.	Other: Specify	14	5	5	24

L = less than 500

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