CONFERENCE BOARD OF THE MATHEMATICAL SCIENCES

REPORT OF THE SURVEY COMMITTEE

VOLUME IV

UNDERGRADUATE EDUCATION IN THE MATHEMATICAL SCIENCES, 1970-71

JOHN JEWETT
and
C. RUSSELL PHELPS
with the technical assistance of
CLARENCE B. LINDQUIST

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PREFACE

This volume is a repetition, with modifications, of our first survey, reported on in Volume I. That, in turn, was a repetition and amplification of a pioneer study done single-handedly by Clarence B. Lindquist for the U.S. Office of Education five years before. Thus, the three studies give three points on a curve for four-year colleges, and two points for two-year colleges.

There are, of course, many possible types of surveys. It is perhaps of value, at this point in our series, to attempt to define the characteristics of ours. First of all, our surveys are produced by a committee of mathematical scientists, working on a voluntary basis, and with a minimum of full-time or part-time staff. They are under the sponsorship of an "umbrella" organization, the Conference Board of the Mathematical Sciences, a private organization which itself is primarily composed of specialist organizations in the mathematical sciences. In our surveys we have attempted to furnish comprehensive studies of high validity, in which we try to give a rich background of information. We have avoided spending our limited resources--one might even say our non-existent resources--on quick ad hoc surveys on matters of current interest. Rather, we have aimed at presenting data which might obviate the need for such surveys, or which provide means of validating or interpreting their results. We have tried to keep value judgments or subjective interpretations out of our reports. That has been a principle made easy to adhere to, by the nature of our sponsorship. And, last, we have tried to be periodic. This volume is the only example to date. But in principle, we would like to establish a historical record from which we can obtain an understanding of the dynamics of our situation, and which will increase the reliability of predictions.

Let me comment on the virtues and drawbacks of our pattern, as I now see the work of the committee. What has the Conference Board sponsorship meant? In the first place, it has assured us a committee and panels broader in range and more highly competent than any one of the CBMS organizations or any non-mathematical agency, public or private, could have sponsored. One of the advantages of that I would like to call "minor", since other advantages overshadow it in my mind. That one is that we have gotten, for no cost, planning, advice, work, criticism that would have cost thousands of dollars on another basis. Without that, we could not have stretched the grants to do as much as we have done, and certainly not as well.

More important than the economy is that our sponsorship, and the type of committee member it has led to, has ensured that the right questions got asked. I may be permitted, perhaps, in this last volume of my chairmanship, to say that I was extraordinarily lucky to have had this particular committee to work with. Composed of individuals of great experience and knowledge in their various fields, it has been a harmonious, hard-working group that brought all this experience to bear on each question we considered, and on the interpretation of each answer. A group less broad and less experienced might, in all ignorant goodwill, have missed the right information to gather about some part of the work of the mathematical sciences. From examination of the results of ours and of other studies, I have become convinced that <u>in survey studies of a scientific discipline, the basic authority must be in the hands of scientists actively involved in that discipline.</u>

The Conference Board sponsorship has also made it easy to maintain the objectivity of our studies. Indeed, our charge from the Board directed us to refrain from drawing conclusions from the data, an instruction we have faithfully followed. The one drawback of CBMS sponsorship is the dependence on outside financing. The resources of CBMS are so small that the most limited general survey activity is beyond them. That reflects the general poverty of the mathematical organizations, of course, and I will not here discuss the reasons for that. But it is a fact. I cannot imagine that work of the scope and quality of the Survey Committee can be done for less money by any group. Given the social need, society has been getting a bargain. But such activities should not be so dependent on accidental fads of funding.

This shortage of funds has prevented us from properly studying two extremely important areas, industrial mathematics and mathematical education in the schools. In both of these, the most elementary questions cannot be answered. I hope to say elsewhere what this means, in more detail than would be appropriate here. It has also prevented us from repeating the study of graduate work reported on in Volume II. We have been unable, up to now, to obtain funding. Admittedly, the view of a mathematician on the importance to the national future of proper development of the mathematical sciences is apt to be biased. Yet the history of science suggests that progress in the other disciplines often waits on progress in mathematics. Since World War II, we have been the world leader in the mathematical sciences, but our supremacy is now threatened by unfavorable developments at all levels--cutbacks in academic positions and in graduate programs, deterioration in school mathematics development, a weaker research funding position. To devise remedies, or even to understand the problems, requires at least that we understand the facts. Without studies of the type this Committee has carried out, we cannot solve our problems, and the country will be the poorer for it.

It remains for me to acknowledge the indebtedness of the Committee for assistance in preparing this volume. Special thanks are, of course, due to the two authors who took on the heavy task of analyzing the data and organizing it in such a satisfactory form. It would be hard to overvalue the expert technical assistance of Clarence B. Lindquist of the U.S. Office of Education, and who has a claim to being the father of all these studies. His patient and effective editing of the questionnaires put the present survey upon a much firmer foundation than would otherwise have been the case. His advice and counsel on the technical aspects of the Survey proved invaluable, especially in its formative stages. As a department chairman myself, I know how much trouble and work such a questionnaire caused the department chairmen who received ours. The whole mathematical science community should be grateful to them for their assistance. Truman Botts, the Executive Director of CBMS, was so closely involved with the Survey that it is hard to realize that our project was only a small part of his work. The study would have been impossible without a grant from the National Science Foundation, awarded at a time of stringency. We are most grateful for it.

Finally, in leaving the chairmanship of the Committee, I would like to tell its members that they formed the best and most enjoyalbe committee I have ever served on. I am grateful for their dedication and their patience with me.

September 1972 Gail S. Young

CONTENTS

CHAPTER

LIST OF TABLES

Chapter I

SCOPE AND METHODOLOGY

This volume reports on a survey of undergraduate training in the mathematical sciences, the data for which were collected during the academic year 1970-71 by means of questionnaires sent to chairmen of mathematical science departments in both two- and four-year institutions. The present survey was conducted under the supervision of the Survey Committee of the Conference Board of the Mathematical Sciences and is the fourth volume to appear as a part of the report of that Committee.

The present survey is a direct successor to two earlier studies conducted at five-year intervals in 1960-61 and 1965-66. The first of these, done by Clarence B. Lindquist for the U.S. Office of Education, was a study of graduate and undergraduate programs in four-year institutions. The detailed findings of the 1960-61 survey are reported in the U.S. Office of Education publication, Mathematics in Colleges and Universities (OE-56018). In 1965-66 the Survey Committee repeated this survey while expanding its coverage to include basic facts about faculty in the mathematical sciences. The 1965-66 survey was published as Volume I of the Report of the Survey Committee, [E]*. Also described in that report are the results of a separate but related survey of two-year colleges conducted by the Survey Committee one year later, in 1966-67.

Much of the usefulness of the present study lies in its combination with the two earlier studies to give a comprehensive long-term picture of certain aspects of the mathematical sciences. Nevertheless, there have been certain changes in emphasis in successive surveys. The 1970-71 survey views two-year colleges more as an integral part of the total educational system than did the 1965-66 survey; it places less stress on curricular patterns and places greater emphasis on manpower considerations and on the

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* For bibliographical references in brackets, see pages 111-112.

special characteristics of computing and statistics. In order to maximize the continuity of information from one survey to the next, questions asked for more than one survey were asked with identical wording and format. The questionnaires for both four-year and two-year institutions are reprinted in Appendices A and C.

Sampling and Response

The sample of four-year institutions was prepared from a primary population consisting of a USOE computer-prepared listing of degree-granting institutions, separated into public universities, private universities, public four-year colleges, and private four-year colleges, with each sublist arranged in decreasing order of total opening fall enrollment for 1969-70. (The data bank which produced this list was later used to produce the text for the USOE Education Directory 1970-71 (OE-50000-71)and the institutions and their enrollments are listed therein.) To conform with the classifications used in our earlier surveys, we deleted from this primary population 176 institutions consisting of independent medical and law schools, bible colleges and seminaries, art and music schools, and other purely graduate or professional schools having no undergraduate offerings in the mathematical sciences. At the same time we added eight technology institutes and six other institutions, all of which offer Ph.D.'s in the mathematical sciences but are not listed by USOE as universities because they do not have three or more professional schools. For multi-campus institutions, which typically have a single USOE listing based on the highest degree awarded, we separated out new listings for those university branches and four-year branches which are at a different geographical location, and transferred the two-year off-campus branches to the two-year college population described in Chapter V. Each newly-listed branch was entered at the proper place according to its own enrollment.

The final four-year population consisted of 1,369 degree-granting colleges and universities, stratified by control (public or private) and by level (university or college), as shown in Table 1.1.* Within each stratum the large institutions were

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* We are indebted to Mr. Abraham Frankel of the National Center for Educational Statistics, USOE, for the technical design of the stratified sampling procedures.

Table 1.1

SAMPLING AND RESPONSE IN MATHEMATICS DEPARTMENTS
UNIVERSITIES AND FOUR-YEAR COLLEGES

Group	Enrollment Range	Number In Universe	Sampling Ratio	Number In Sample	Responses Received	Percent Response
1. Large Public Universities	25,000+	25	1:1	25	22	88%
2. Smaller Public Universities	under 25,000	87	1:2.8	31	30	97%
3. Large Private Universities	13,000+	17	1:1	17	11	65%
4. Smaller Private Universities	under 13,000	59	1:2.68	22	19	86%
5. Larger Public Colleges	14,000+	21	1:1	21	17	81%
6. Smaller Public Colleges	under 14,000	335	1:7	48	32	67%
7. Larger Private Colleges	6,000+	10	1:1	10	6	60%
8. Small Private Colleges	under 6,000	815	1:11.2	73	51	70%
		1,369		247	188	76%

sampled with probability 1, and the remainder with probabilities shown in the table, which also shows the response rates for each of the eight resulting groups. The effect of this method of stratified sampling was to obtain estimates of the entire faculty and enrollment on the basis of responses which involve 14 percent of the institutions but cover 34 percent of faculty and enrollment.

The population which was sampled was categorized in a different way than in our previous survey because of changes in the USOE classification system. Formerly the USOE classified four-year institutions as universities, public and private liberal arts colleges, (public) teachers colleges, and technological schools, and the results of the 1965-66 CBMS Survey [E] were presented in terms of universities, public colleges, private colleges, and technological schools. Prior to the preparation of the sample for the present survey the categories of teachers colleges and technological schools were abandoned by USOE and these institutions were classified merely as colleges or universities, most of them going into the college category. In 1965-66 technological schools taught only five percent of all mathematical science students and had seven percent of all faculty. Nevertheless, the reclassification of this group together with the gradual reclassification of individual institutions as circumstances have changed limits the comparability of, say, public colleges in 1970-71 with public colleges in 1965-66. The specialized "teachers colleges" have now essentially all been transformed into "state colleges" or, in some cases universities, but this trend was anticipated in our earlier report. In the exposition which follows we have tried to restrict explicit comparisons to cases where in our opinion the essential validity of the message is clearly not affected by inexact comparability.

Although the sample was chosen by institutions the questionnaires were sent to department chairmen and the reporting unit was the department. Every institution in the sample had a mathematics department so that the sample of mathematics departments had the same structure as the sample of institutions. An extensive list of other mathematical science departments in these sample institutions--computer science, statistics, operations research, applied mathematics, mathematics education, biomathematics, and various combinations--was available from the Survey Committee's previous report [J], and this information was brought up to date from other sources; questionnaires were then sent to the chairmen of all such departments in the institutions of the sample.

We received responses from 27 university departments of computer science and/or information science, reasonably distributed over public and private, large and small universities, so that we were able to establish a valid classification of "university computer science departments" in our various tabular studies. Similary, 24 responses from university statistics and biostatistics departments led to a separate classification of "university statistics departments", although we had to combine the subgroups of large private universities and small private universities to get a subgroup adequate for extrapolation purposes. The details of these considerations, including response rates for the various subgroups of universities, are shown in Tables 1.2 and 1.3, and the departments covered are included in Appendix B.

Responses from two departments of operations research and three departments of mathematics education in universities, and from five departments of computer science in public and private colleges were deemed too minimal in number to use as a base for extrapolation, even though the full number of such departments in the total population is also relatively small. Consequently, in each of these cases the information submitted was amalgamated with the data presented for the mathematics department, making the resultant composite "departments" comparable to comprehensive "mathematics" departments in many other institutions. In the sequel, then, the data have been collected, projected, and presented in terms of five categories of departments: university mathematics, university computer science, university statistics, mathematics in public colleges, and mathematics in private colleges, with the understanding that mathematics includes the other branches of the mathematical sciences except for those universities which have separate departments of computer science or statistics.

Estimation Procedures and Reporting Results

The data presented in this report are our estimates of national totals for degree-granting institutions rather than sample data. Results are frequently reported separately for each of the above types of departments whenever such a subdivision is illuminating. However, care must be used to interpret the results of such a subdivision as departmental characteristics rather than as characteristics of the fields involved since much of the teaching of computer science and statistics is done

Table 1.2

SAMPLING AND RESPONSE IN UNIVERSITY STATISTICS DEPARTMENTS

Group	Number of Departments In Universe	Number In Sample	Number Of Responses	Percent Response
Large Public Universities	13	13	11	85%
Smaller Public Universities	21	9	8	89%
Private Universities	17	8	5	63%
	51	30	24	80%

Table 1.3

SAMPLING AND RESPONSE IN UNIVERSITY COMPUTER SCIENCE DEPARTMENTS

Group	Number of Departments In Universe	Number In Sample	Number Of Responses	Percent Response
Large Public Universities	17	17	14	82%
Smaller Public Universities	36	15	8	53%
Large Private Universities	6	4	2	50%
Small Private Universities	14	6	3	50%
	63	42	27	64%

in departments of mathematics or in non-mathematical science departments (cf. Table 2.10). Correspondingly, about three-fourths of the 188 university mathematics departments in our universe teach computer science and/or statistics too, although the latter subjects account for only 5 percent of their total enrollments.

Only in isolated instances did our data from public universities differ in any interesting way from data from private universities. Therefore, for the sake of simplicity of exposition, and comparison with earlier surveys, we have almost always presented data from universities as a unit.

The distinction between universities and colleges in the USOE classification is based on overall institutional characteristics and thus reflects the environment in which mathematical science departments find themselves rather than internal characteristics of the departments themselves. Almost one-third of the institutions classified as universities do not have Ph.D. programs in the mathematical sciences. The reader will probably gain a better understanding of this classification by inspecting the list in Appendix B of departments in our sample which responded to our questionnaire.

In order to arrive at estimated national totals we have multiplied sample respondent data by appropriate weighting factors to allow for sampling and for non-response. Since sampling ratios and response rates were different for each of fifteen groups of mathematical science departments listed in Tables 1.1 through 1.3, the weighting factors were determined separately for each of these fifteen groups and for each question on the questionnaire.

Suppose, for example, it is desired to estimate the total national enrollment in differential equations. From Table 1.1 we observe there existed 87 smaller public universities (Group 2) of which 31 were sampled, 30 returned questionnaires, and 28 of these answered the question. Then the total of the enrollments in differential equations from the 28 respondents in Group 2 should be multiplied by the fraction 87/28 in order to obtain an estimate for the total national enrollment in differential equation within Group 2 departments. In a few cases in which the respondents were not very uniformly distributed throughout the (population-ordered) sample, the calculations were made using appropriate subsamples. Treating each of the fifteen groups similarly, and adding, we get the estimated total enrollment in differential equations for all four-year institutions.

In some tables the information presented tells what percentage of departments of a given type have a given characteristic. For example, we assert that 32 percent of university mathematics departments have official teaching loads of 7 or 8 hours. To arrive at this figure we first treat each of the four groups of university mathematics departments separately to obtain the estimate number of departments in each group having teaching loads in this range. We then divide the sum of these four numbers by the total number of university mathematics departments. Thus in computing such percentages we allow for differences in sampling ratios and response rates.

Due to the size of the sample used in this survey it was anticipated that the chances would be 68 out of 100 that estimates for sample items would differ from complete census values by less than a relative error of eight percent. It appears that this precision requirement has been met. As an empirical test we used the methods described above to estimate the total number of bachelor's degrees conferred in mathematics during 1969-70; the result agreed with that tabulated by USOE in Earned Degrees Conferred to within five percent. Other empirical comparisons with data external to the survey exhibited a similar or better agreement. It should be noted that various external sources of data may involve slightly differing definitions of the universe of discussion; we have attempted in the foregoing to define our universes so that reasonable comparisons can be made or estimated.

CHAPTER II

ENROLLMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCE COURSES

Summary of Conclusions

In the five year period from Fall 1965 to Fall 1970 enrollments in undergraduate mathematical science courses in four-year institutions increased from 1,068,000 to 1,386,000 or 30 percent, the same percentage increase as the number of students in college. This repeats the experience of the preceding five years so that over a ten year period mathematical science enrollments have remained a relatively constant fraction of all course enrollments.

Not all segments of the mathematical sciences have grown equally. Mathematics courses at the level of calculus or below have increased by only 19 percent although still comprising 81 percent of all course enrollments in mathematics. Upperclass mathematics courses have increased more rapidly but even so the total enrollment in all mathematics courses, excluding statistics and computer science, has increased only 20 percent.

Our data show, however, an explosive increase in statistics and computer science. The enrollment in statistics has more than doubled in five years from 43,000 in 1965-66 to 92,000 in 1970-71 while computing enrollments more than tripled from 25,000 to 90,000 in the same period. Thus enrollment increases in statistics and computing accounted for 36 percent of all enrollment increases in the mathematical sciences even though these areas accounted for only 13 percent of actual enrollments in 1970-71.

The gain in mathematical science enrollments from 1965-66 to 1970-71 was 318,000, almost identical to the gain of 324,000 for the previous five years. If mathematical science enrollments continue to grow proportionally to the general enrollment the increases over the next five years could be expected to be smaller both in absolute size and as a percentage of present enrollment.

The Background of the Data

The reader should keep certain things in mind in interpreting the data on course enrollments. The questionnaire reproduced in the appendix was sent to all chairmen of mathematical science departments at a stratified random sample of institutions chosen in the manner described in Chapter I. The present survey is a repetition of earlier surveys done in 1960 and 1965 using quite similar methodology. The enrollment figures reported are our estimates of national totals estimated from sample data by methods described in Chapter I. The unit of reporting is a course enrollment so that no distinction is made between quarter courses, semester courses, and year courses, nor between courses carrying different amounts of credit. The course enrollments are for the first term only. All enrollment totals in this chapter are for universities and four year colleges; two-year college data will be summarized separately in Chapter V. Finally it should be noted that we have collected data on enrollments in undergraduate courses only, although some of the enrollments in these courses are enrollments by graduate students.

Data for Comparison with Mathematical Science Enrollments

The full implications of the information to be presented in this chapter can be understood only if viewed against a background of trends in general enrollments.

It is not entirely clear which enrollment figures are most suitable for purposes of comparison with mathematical science enrollments. Table 2.1 gives several types of undergraduate enrollments as reported and projected by the U.S. Office of Education in [A]. The projections are not predictions but are formal extrapolations based only on percentage trends over the immediately preceding ten year period as applied to population age-groups. Full-time equivalent enrollments are full-time enrollments plus one-third of all part-time enrollments. First-time enrollments are essentially entering freshmen (never before enrolled in higher education).

Between 1960 and 1965 full-time equivalent enrollment increased by 50 percent. and first-time enrollment increased by 47 percent. Between 1965 and 1970, however, full-time equivalent enrollment increased by only 30 percent while the increase in first-time enrollment was only 13 percent. It is important to

Table 2.1

UNDERGRADUATE DEGREE-CREDIT ENROLLMENTS IN FOUR-YEAR COLLEGES AND UNIVERSITIES

(Enrollments in Thousands)

Year (Fall)	Full Time	Percent Increase	Full Time Equivalent	Percent Increase	First Time	Percent Increase
1960	2,077		2,310		709	
		52%		50%		47%
1965	3,159		3,461		1,041	
		32%		30%		13%
1970*	4,169		4,505		1,177	
		22%		22%		18%
1975*	5,082		5,496		1,383	

Source: Projections of Educational Statistics to 1979-80, National Center for Educational Statistics (USOE), Tables 15 and 19.

* Projected.

notice not only that the increase in full-time equivalent enrollment has slowed, but also that the increase of first-time enrollment has slowed even more.

The explanation is to be found in trends in first-time enrollment in two-year colleges. Between 1960 and 1965 first-time enrollment in two-year colleges increased from 214,000 to 401,000. This five year increase of 187,000 was considerably smaller than the increase of 332,000 in four-year institutions. But between 1965 and 1970 the increment in first-time enrollment was 253,000 for two-year colleges compared with only 136,000 for four-year institutions. Moreover, the fact that full-time equivalent enrollment in four-year institutions increased by over a million in this five year period makes it clear that the greater part of enrollment increases in such institutions has come from increases in the number of juniors and seniors.

As a confirmation of this trend and as an indication that the shift of freshman enrollments to junior colleges may in the future be more pronounced than is indicated by the USOE projections, we observe that Garland Parker has reported in the February 1972, issue of School and Society that freshman enrollments in four-year institutions actually declined by 0.7 percent from Fall 1970 to Fall 1971. At the same time preliminary indications (quoted by Parker) are that overall enrollments in two-year colleges increased by somewhat more than 13 percent from 1970 to 1971.

Enrollments in mathematical science courses are affected not only by the number of students in college but also by the fields in which these students specialize. Table 2.2 gives the number of bachelor's degrees awarded in several broad areas in 1961, 1966, and 1971. Our interest is in the trends in such degrees. The number of degrees in mathematics and statistics increased by 49 percent over the most recent five year period. In other fields, degrees in engineering and physical sciences increased least and at less than half the rate of degrees in the broad field of social sciences, humanities, and related profesions.

Table 2.2

NUMBERS OF BACHELOR'S DEGREES IN SELECTED FIELDS

(Numbers in Thousands)

	Bachelor's Degrees In 1960-61	Bachelor's Degrees In 1965-66	Bachelor's Degrees In 1970-71	Increase over Last Five Years
Social Sciences, Humanities, and Related Professions	281.5	412.5	674.1	63%
Natural Sciences and Related Professions	113.7	138.5	188.9	36%
Engineering	35.7	35.6	44.7	26%
Biological Sciences	16.1	26.9	38.5	38%
Physical Sciences	15.5	17.1	21.8	27%
Mathematics and Statistics	13.1	20.1	29.9	49%

Source: Projections of Educational Statistics to 1979-80 (USOE), Table 23, with 1970-71 figures from USOE unpublished data.

Moreover, the U.S. Office of Education projections (in [A], table 22) call for degrees in engineering to decrease from 5.2 percent of all bachelor's degrees to 4.4 percent from 1970 to 1980 and for physical science degrees to decrease from 2.7 percent of all bachelor's degrees to 1.6 percent. The article by Parker cited above states that from 1970 to 1971 there was a 17 percent decline in the number of freshman engineering students, a large decline of 14 percent in the number of freshmen in education, and a small drop in the number of freshmen business students.

In summary, these data say that from the time of our 1965-66 survey to the present survey the number of students in four-year institutions has increased 30 percent but that the increase in entering freshmen has been only 13 percent. The number of majors in fields which are heavy users of mathematical science courses has increased much more slowly than the number of majors in other less mathematically oriented fields. The U.S. Office of Education projections as well as the most recent figures given by Parker indicate that these trends will continue, and perhaps intensify, during the next five to ten years.

Although the U.S. Office of Education projections call for a continued increase in the number of bachelor's degrees in the mathematical sciences, recent information on the plans of entering freshmen make it doubtful that these increases will in fact take place. The American Council on Education has conducted a large scale continuing study [B] based on questionnaires administered initially to a sample of entering freshmen. The data displayed in Table 2.3 show that the percentage of freshmen intending to major in mathematics or statistics has declined steadily since 1966. Because of the increased number of entering freshmen, the number of freshmen planning to major in some field of the mathematical sciences has not shown any really significant change. The data do seem to contradict any expectation of a continuing increase in the number of bachelor's degrees in the mathematical sciences.

Enrollments in Mathematical Science Courses

The number of enrollments in undergraduate courses taught by mathematical science departments in four-year institutions was 1,386,000 for the fall term of the academic year 1970-71.

Table 2.3

PROBABLE MAJORS IN MATHEMATICS AND STATISTICS AS DECLARED BY FRESHMEN ENTERING UNIVERSITIES AND FOUR-YEAR COLLEGES

Entering Year (Fall)	Percent of Freshmen Declaring Probable Major in Mathematics or Statistics			Estimated Total Number of Freshmen Majors in Math and Stat in Universities and Four-Year Colleges
	All Four-Year Institutions	Four-Year Colleges	Universities	
1966	5.4	6.0	4.5	48,000
1967	5.3	6.0	4.3	48,000
1968	5.0	5.5	4.2	48,000
1969	4.6	4.9	4.3	47,000
1970	4.1	4.3	3.9	44,000
1971	3.7	3.6	3.8	41,000

Source: American Council on Education, National Norms for Entering College Freshmen (annually); estimated totals calculated from first-time, full-time enrollment, USOE Opening Fall Enrollment in Higher Education (annually).

These enrollments are reported in Tables 2.4 through 2.8. Although the reported data exclude courses regarded by the respondents as graduate courses they include a number of enrollments by graduate students. Courses taught outside mathematical science departments are excluded from these tables; to the extent permitted by the respondents' knowledge these are reported separately in Table 2.9. It is interesting to note the considerable extent to which the enrollment trends in mathematical science courses as reported in Tables 2.4 through 2.8 can be viewed as consequences of the more general trends presented above.

Table 2.4 gives a broad picture of the situation. By consolidating enrollments in individual courses we find that mathematical science departments taught 92,000 students in courses in probability and statistics and 90,000 students in courses in numerical analysis and computing. These courses were taught not only by departments of statistics and computing but also, especially in smaller institutions, by departments of mathematics. At the risk of seeming somewhat arbitrary, we classify all

Table 2.4

TOTAL ENROLLMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCE COURSES IN FOUR-YEAR INSTITUTIONS

(Enrollments in Thousands)

	Fall 1960-61	Fall 1965-66	Percent Increase 1960-61 to 1965-66	Fall 1970-71	Percent Increase 1965-66 to 1970-71
Total Mathematical Science Enrollments	744	1,068	44%	1,386	30%
Exclusive of Numerical Analysis, Computing, and Statistics	714	1,000	40%	1,204	20%
Numerical Analysis and Computing	7	25	257%	90	260%
Statistics	23	43	87%	92	114%

mathematical science courses other than probability and statistics or numerical analysis and computing as "mathematics". Thus defined, mathematics accounts for almost 87 percent of all enrollments with the remainder being divided approximately equally between computer science and statistics. The table shows vividly the extremely rapid growth of enrollment in computer science and statistics.

Table 2.5 gives more details about how enrollments were distributed among various mathematical science subjects. This table also shows trends in enrollments over the ten year period from 1960-61 to 1970-71. The individual entries and the totals in this and succeeding tables were calculated separately from unrounded data and hence details in these tables may not add to totals.

Over the last five years, only a few subjects matched the growth shown by statistics and computing. Among these were finite mathematics, linear and matrix algebra, real variables, and the area of history, logic and foundations. Mathematics courses typically taken mainly by engineering and physical science students showed little or no growth. For example, differential equations, advanced calculus, and advanced mathematics for engineers and physicists had no increases at all. At a lower level the enrollment in elementary algebra increased from 12,000 to 25,000 and mathematics for elementary school teachers increased from 61,000 to 89,000. It should perhaps be remarked that

Table 2.5

TOTAL ENROLLMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCE COURSES
(Enrollments in Thousands)

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

except for increases in finite mathematics and mathematics for elementary school teachers, the data show very little evidence of significant extension of the services of mathematicians to groups of students who formerly took little mathematics.

It is interesting to examine the distribution of mathematics enrollments by level as recorded in Table 2.6. First, we should observe that in 1970-71 only 19 percent of all undergraduate course enrollments in mathematics were in upperclass courses and that 52 percent were in pre-calculus courses. The five year enrollment increase in pre-calculus courses in four-year institutions was only 20 percent, a reflection of the fact that an increasing proportion of freshmen and sophomores have been attending junior colleges. The even lower percentage increase in calculus enrollments is probably attributable both to this and to relative stability in the number of students majoring in engineering and the physical sciences. The relatively greater increase of 29 percent in junior and senior courses seems to be explainable, in spite of constant enrollments in physical science related courses, by a large increase in the number of courses taken by undergraduate mathematics majors. (As shown in Table 2.2, bachelor's degrees in mathematical science increased by 49 percent between 1965-66 and 1970-71.)

Table 2.6

TOTAL ENROLLMENTS IN UNDERGRADUATE MATHEMATICS COURSES IN FOUR-YEAR INSTITUTIONS BY LEVEL

(Enrollments in Thousands)

Level	Fall 1960-61	Fall 1965-66	Increase 1960-61 to 1965-66	Fall 1970-71	Increase 1965-66 to 1970-71
Below Calculus (Subjects 1-10 of 2.5)	408	527	29%	630	20%
Calculus (Subject 11 of 2.5)	184	295	60%	345	17%
Upperclass Mathematics (Subjects 15-29 of 2.5)	122	178	46%	229	29%

We are now in a position to make an instructive observation about one of the sources of demand for mathematical scientists. It can be argued that mathematics courses at the level of calculus or below are plausible assignments for any faculty member or in some cases for graduate assistants, but that junior and senior courses in mathematics and courses in statistics and computer science may well require special training or special interest. Between 1960-61 and 1965-66 enrollments in upper division mathematics courses increased by 56,000 students while the increases in statistics and computer science courses, at 18,000 and 20,000, respectively, were much smaller. Between 1965-66 and 1970-71, however, the increase in upper division mathematics enrollments was 51,000 compared with 49,000 for statistics and 65,000 for computer science (Table 2.4). Since demand for mathematical scientists is generated more by increased enrollment than by a need for replacements, this observation may help to explain the preferences of chairmen for hiring specialists in statistics amd computer science to be described in the next chapter.

Table 2.7 gives enrollments for fall 1970-71 in the 76 individual mathematical science courses actually listed in the questionnaire. The list of courses used in the most recent survey was sufficiently different from that of previous surveys that meaningful comparisons with prior years are not possible at this level of detail. The label GCMC attached to certain courses refers to courses suggested by the Committee on the Undergraduate Program in Mathematics in its report, <u>A General Curriculum in Mathematics for Colleges</u>, (1965), and the label ACM refers to courses suggested by the Association for Computing Machinery, as listed in <u>Communications of the ACM</u>, March 1968, pp. 151-197. The symbol L in the body of the table indicates an estimated enrollment of less than 500. The reader will remember that the respondents were instructed to report only those courses which they regarded as undergraduate courses. Thus many of the courses which are shown in Table 2.7 as having few students may actually have had significant enrollments which were unreported because some respondents considered these courses to be graduate courses.

The fact that over half of undergraduate mathematics enrollments were in pre-calculus courses has analogues for statistics and computer science. If courses 48 through 51 are viewed as introductory courses in probability and/or statistics, then approximately 91 percent of the total enrollment in undergraduate course in this area was in introductory courses. Similarly, if courses

Table 2.7

DETAILED ENROLLMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCE COURSES BY TYPE OF INSTITUTION

(Enrollments in Thousands)

	Course	Total	Universities	Public Colleges	Private Colleges
	TOTAL	1,386	629	496	261
1.	Arithmetic for College Students	4	1	2	1
2.	High School Geometry	3	L	1	2
3.	Elementary Algebra (H.S.)	25	4	19	2
4.	Intermediate Algebra (H.S.)	50	11	33	6
5.	College Algebra	92	40	45	7
6.	Trigonometry	31	14	16	1
7.	College Algebra and Trigonometry, combined	113	44	52	17
8.	Elem. Math Analysis (algebra,et.) GCMC:0	38	15	13	10
9.	Basic Concepts (structure, logic, sets)	74	21	26	27
10.	General Math (basic skills, operations)	19	3	13	3
11.	Finite Mathematics	47	26	11	10
12.	Math of Finance	4	2	1	1
13.	Business Mathematics	14	3	11	L
14.	Math for Elementary School Teachers	89	28	45	16
15.	Other pre-calculus	27	12	5	10
16.	Analytic Geometry	10	4	5	1
17.	Analytic Geometry & Calculus	224	121	72	31
18.	Calculus GCMC:1,2,4	111	60	22	29
19.	Advanced Calculus GCMC:5	20	11	5	4
20.	Differential Equations	31	16	9	6
21.	Partial Differential Equations	2	1	1	L
22.	Real Analysis GCMC:11,12	11	6	3	2

	Course	Total	Universities	Public Colleges	Private Colleges
23.	Complex Variables GCMC:13	7	4	2	1
24.	Vector Analysis	4	2	2	L
25.	Advanced Math for Engineers and Physicists	12	8	2	2
26.	Fourier Series and Boundary Value Problems	1	1	L	L
27.	Geometry GCMC:9	10	3	4	3
28.	Projective Geometry	2	1	L	1
29.	Differential Geometry GCMC:9alt.	1	1	L	L
30.	Topology	5	2	2	1
31.	Graph Theory	L	L	L	L
32.	Linear Algebra GCMC:3	41	18	8	15
33.	Modern Algebra GCMC:6	23	9	8	6
34.	Matrix Theory	6	3	3	L
35.	Theory of Equations	1	1	L	L
36.	Combinatorial Algebra	L	L	L	L
37.	Foundations of Math	8	2	6	L
38.	Theory of Numbers	4	2	1	1
39.	Set Theory	4	2	1	1
40.	Operational Math.	L	L	L	L
41.	History of Math.	4	1	2	1
42.	Math Logic	2	1	1	L
43.	Math for Sec. School Teachers (methods, etc.)	7	4	2	1
44.	Calculus of Finite Differences	L	L	L	L
45.	Applied Math. (models) GCMC:10	1	1	L	L
46.	Theoretical Mechanics	L	L	L	L
47.	Ecological Mathematics	L	L	L	L
48.	Elementary Statistics (no calculus prereq.)	36	17	7	12
49.	Probability & Stat. (no calculus prereq.)	21	14	4	3

	Course	Total	Universities	Public Colleges	Private Colleges
50.	Math. Statistics (Calculus) GCMC:7S	16	5	8	3
51.	Probability (Calculus) GCMC:2P/7P	11	7	2	2
52.	Applied Statistical Analysis	7	5	1	1
53.	Design & Analysis of Experiments	1	1	L	L
54.	Sampling Methods	L	L	L	L
55.	Analysis of Variance	L	L	L	L
56.	Stochastic Processes	L	L	L	L
57.	Time Series Analysis	L	L	L	L
58.	Multivariate Analysis	L	L	L	L
59.	Nonparametric Statistics	L	L	L	L
60.	Operations Research (Queuing/Optimization)	L	L	L	L
61.	Senior Seminar	3	2	L	1
62.	Independent Study or Honors Course	3	2	L	1
63.	Senior or Honors Thesis	L	L	L	L
64.	Introduction to Computing ACM:B-1	38	23	7	8
65.	Computers and Programming ACM:B-2	26	14	7	5
66.	Introduction to Discrete Structures ACM:B-3	1	1	L	L
67.	Numerical Calculus ACM:B-4	3	2	L	1
68.	Data Structures ACM:I-1	2	2	L	L
69.	Programming Languages ACM:I-2	5	4	L	1
70.	Computer Organization ACM:I-3	3	3	L	L
71.	Systems Programming ACM:I-4	2	1	1	L
72.	Compiler Construction ACM:I-5	1	1	L	L
73.	Switching Theory ACM:I-6	1	1	L	L
74.	Sequential Machines ACM:I-7	L	L	L	L
75.	Numerical Analysis ACM:I-8&9	8	5	2	1
76.	Other: specify	16	10	3	3

L = less than 500

64, 65, 67 and 75 are considered to be introductory to numerical analysis and computing, then 83 percent of all enrollment in undergraduate courses in this area was in introductory courses. There is considerable anecdotal evidence indicating that a student's first courses in statistics and computing tend to be taken much later than his first college course in mathematics, perhaps most commonly when he is an upper division or graduate student. To the extent that this is true shifts in enrollments to two-year colleges would have a smaller effect on statistics and computer science than on mathematics.

Table 2.8 presents enrollments by type of institutions. A feeling for the distinctions among universities, public colleges, and private colleges can quickly be obtained by examining the list of respondents in the appendix. Universities taught 45 percent of all mathematical science courses while 36 percent were taught in public colleges and only 19 percent in private colleges. Enrollments in mathematics courses were less highly concentrated in universities than were enrollments in statistics and computer science; universities had 43 percent of all enrollments in mathematics while the corresponding figures for statistics and computer science were 53 percent and

Table 2.8

ENROLLMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCE COURSES
BY TYPE OF INSTITUTION, FALL 1970-71
(In Thousands)

	All Institutions	Universities	Public Colleges	Private Colleges
All Subjects	1,386	629	496	261
Mathematics	1,204	523	457	224
Remedial	101	19	68	14
Below Calculus	529	205	225	99
Calculus and Analytics	345	185	99	61
Upper Class Subjects	229	114	65	50
Numerical Analysis and Computing	90	57	17	16
Statistics	92	49	22	21

63 percent respectively. Public colleges differed significantly from other institutions in that almost two thirds of all enrollments in mathematics were in pre-calculus courses.

Mathematical Science Courses Taught Outside

Mathematical Science Department

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

The Survey Committee has been interested in courses taught outside mathematical science departments from the very beginning of its work. In the 1965-66 survey sufficient information [E] was collected to demonstrate the widespread existence of this phenomenon, at least in universities. Volume III of the Report of the Survey Committee [J] devotes a chapter to a thorough discussion of this problem, based largely on case studies of the situation at seven major universities.

In the present survey we have tried for the first time to get some quantitative information on the enrollments in such courses. In an effort to gather as much information as possible on this elusive question we went against our usual custom and asked for data for the entire academic year instead of merely the first term. We specifically asked for undergraduate courses only. The discussion in Volume III of the Report of the Survey Committee was not so restricted. That discussion, therefore, reflects concerns at the graduate level which are outside the scope of our present data.

There are difficulties in acquiring data of the same degree of accuracy as our other enrollment data. Since the respondents to the questionnaire (chairmen of mathematical science departments) were reporting on courses outside their own departments, the question asked only for their "estimates" of enrollments. Mathematical science courses taught outside mathematical science departments are not always clearly advertised as such. In fact, chairmen of mathematical science departments are frequently surprised to discover almost by accident of the existence of mathematical science courses taught by other departments. Thus, the data presented in Table 2.9 should be interpreted as lower bound estimates; the exact enrollments, if known, would probably be larger, possibly by a considerable amount.

Table 2.9

ESTIMATED ENROLLMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCE COURSES TAUGHT OUTSIDE MATHEMATICAL SCIENCE DEPARTMENTS, ALL TERMS OF ACADEMIC YEAR 1970-71

(Enrollments in Thousands)

	Enrollment in Courses Given by Divisions Specializing in:							
	Biol. Science	Physical Sciences	Engi-neering	Educa-tion	Business Admin.	Social Sciences	Other	Total
Probability			4	L	3	L	1	8
Statistics	2	L	5	14	38	58	6	123
Calculus or Diff. Equations	L	1	1		1	L	L	3
Advanced Math for Engineers/Physics		2	5					7
Computer Science & Programming	L	3	40	L	22	1	7	73
Numerical Analysis			2				L	2
Optimization & Linear Programming			3		2	L	1	6
Biomathematics	L		L				1	1
Mathematics of Finance, etc.					7			7
Other	—	—	1	2	1	L	4	8
TOTAL	2	6	61	16	74	59	20	238

L = some, but less than 500.

The estimated number of enrollments in undergraduate mathematical science courses outside mathematical science departments was 238,000 during the entire academic year 1970-71. Dividing this figure by two to get some degree of comparability with data for the fall term only there were in the fall term 119,000 enrollments in mathematical science courses outside mathematical science departments compared with 1,386,000 enrollments within mathematical science departments. Surprisingly, over 40 percent of the total enrollments recorded in Table 2.9 were in colleges rather than in universities.

The divisions teaching the majority of mathematical science courses were engineering (61,000 enrollments), business administration (74,000) and social science departments (59,000). There was comparatively little evidence of the teaching of mathematical science courses by departments in the biological and physical sciences. The bulk (over 86 percent) of the enrollment was in courses in numerical analysis and computer science and in probability and statistics, with very little evidence of teaching of courses such as calculus, linear algebra, or differential equations.

The overall situation in computer science and statistics, including courses given in both mathematical science and other departments, is displayed in Table 2.10. Within the mathematical science departments, about a third of the courses in statistics are taught in statistics departments and half the courses

Table 2.10

ESTIMATED ENROLLMENT IN UNDERGRADUATE COURSES IN STATISTICS AND COMPUTER SCIENCE, BY TYPE OF DEPARTMENT, FALL 1970-71

(Enrollments in Thousands)

	University Departments			Colleges Math.	Non-Math.Sci.Depts.		Total All
	Stat.	Comp.Sci.	Math.	Depts.	Univs.	Colleges	Depts.
Probability and Statistics	32	-	17	43	32	34	158
Numerical Analysis and Computing	-	46	11	33	27	11	128

in computing in computer science departments, this mostly in institutions which offer graduate specialization in these areas. Again using one-half the academic year data, approximately 66,000 out of 158,000 students in probability and statistics and 38,000 out of 128,000 students in numerical analysis and computer science courses during the fall term were taught outside mathematical science departments. This table is presented here for comparison with faculty data in the next chapter.

CHAPTER III

MATHEMATICAL SCIENCE FACULTY

Summary

This chapter reports the results of the CMBS Survey of 1970-71 concerning the numbers and qualifications of mathematical science faculty in four-year institutions and discusses historical trends. Also reported are the results of a detailed study of faculty mobility in 1970 and certain information about utilization of mathematical science faculty. Finally, we discuss relationships between faculty and undergraduate mathematical science enrollments.

The 17,043 full-time mathematical science faculty in 1970-71 represented a surprising increase from the 7,640 reported eight years earlier in [C]. Moreover, the percentage of doctorates had risen sharply from 48 percent in 1962-63 to 64 percent in 1970-71. The 3,658 doctorates on the faculty in 1962-63 were joined by 7,260 net additional doctorates over the next eight years. Between 1965-66 and 1970-71 the total faculty increased at a slightly smaller annual rate (9.7 percent) than over the preceding three years. For the last of these years the increase was only 5.4 percent.

In fact, it seems to be true that hirings for the academic year 1970-71 (which we studied in some detail) represent a transition to a quite different supply and demand situation than that prevailing in earlier years. The number of faculty with master's degrees actually decreased and the total mathematical science faculty in four-year institutions increased by only 873 compared with an eight year average increase of 1,175 per year.

We observe that the use of large lecture sections, which increased greatly between 1960-61 and 1965-66, exhibited little growth in universities during the last five years, and declined in other types of institutions. We recorded few increases and

some actual decreases in use of other "innovative" methods of instruction such as independent study, television, or programmed learning.

In 1965-66 the ratio of enrollments in undergraduate mathematical science courses to mathematical science faculty was almost exactly 100 to 1. By 1970-71 this ratio had declined to 81 to 1, presumably representing both increased faculty concentration on graduate work and increased adequacy of the size of the mathematical science faculty.

Some Cautionary Remarks

Before considering the more detailed analyses which follow, the reader should perhaps be reminded explicitly of certain facts which might influence his interpretation of the data.

All the information in this Chapter concerns _four-year institutions only_; the faculty of two-year colleges will be discussed in Chapter VI. Our division of four-year institutions into universities, public colleges, and private colleges is derived (as indicated in Chapter I) from the U.S. Office of Education classification of institutions, which is based on institutional characteristics in all fields. Thus, the "universities" group includes a number of institutions--about 30% in our sample--which did not award a mathematical science Ph.D. in 1970. We also note again that we have classified branch campuses according to their local degree-granting character, differing from USOE in this regard.

The faculty reported on in this Chapter includes faculty in all mathematical science departments including departments of statistics and computer science and includes all faculty for graduate _and_ undergraduate instruction employed by such mathematical science departments. The numbers reported are our estimates of national totals as derived from sample data by methods described fully in Chapter I.

It may seem to the reader that in this chapter we show an excessive preoccupation with the degrees held by mathematical science faculty. Unfortunately, this measure of faculty quality is the only one which is a matter of record. We would prefer a more perspicacious measure of qualification if it were available.

Mathematical Science Faculty in 1970-71

In the academic year 1970-71, the full-time mathematical science faculty in all four-year institutions numbered approximately 17,043, of whom 9,812 had mathematical science doctorates and 1,106 had doctorates in other fields. Thus, 64 percent of the full-time faculty had doctorates in some field. Of the total full-time faculty, 45 percent taught in universities, 35 percent in public colleges and 20 percent in private colleges. However, universities employed almost two-thirds of all mathematical science doctorates.

Of the 1,106 non-mathematical-science doctorates 818 were in mathematics education. Imperfect information from the questionnaires indicated that well over half of the remaining 288 were Ph.D.'s in engineering or physics. Within universities a majority of non-mathematical science Ph.D.'s were teaching in departments of computer science or statistics.

Table 3.1

NUMBER OF FULL-TIME FACULTY IN THE MATHEMATICAL SCIENCES

1970-71

	Total	Math Sci. Doctorates	Other Doctorates	Non Doctorates	Percent Doctorates
Total Faculty	17,043	9,812	1,106	6,125	64%
Universities	7,623	6,304	348	971	87%
Public Colleges	6,068	2,298	568	3,202	47%
Private Colleges	3,352	1,210	190	1,952	42%

The figure of 64 percent doctorates is an average of quite different situations in different types of institutions. Although 87 percent of the university mathematical science faculty held doctorates, the percentage of doctorates on the faculties of other types of institutions was only about half as high, being 47 percent for public colleges and 42 percent for private colleges. Only one out of six of the faculty without doctorates was employed by a university.

Table 3.2 is restricted to university faculties and compares mathematics departments with departments of statistics and computer science. Computer science departments and statistics departments each employed nine percent of university mathematical science faculty in 1970-71. A large (but undetermined) number of computer scientists and statisticians teach in departments classified as mathematics. Speculation on the size of this number might well be guided by the data on distribution of computer science and statistics enrollments by type of department as given in Table 2.10.

Table 3.2

FULL-TIME MATHEMATICAL SCIENCE FACULTY IN UNIVERSITIES, BY TYPE OF DEPARTMENT, 1970-71

	Total	Doctorates	Non-Doctorates	Percent Doctorates
Total	7,623	6,652	971	87%
Mathematics Departments	6,235	5,478	757	88%
Computer Science Departments	688	527	161	77%
Statistics Departments	700	647	53	92%

Table 3.3

EDUCATIONAL QUALIFICATIONS OF FULL-TIME MATHEMATICAL SCIENCE FACULTY, BY TYPE OF INSTITUTION, 1970-71

	Doctorates In			Master's In			Bachelor's In		
	Math Sci.	Math Ed.	Other	Math Sci.	Math Ed.	Other	Math Sci.	Math Ed.	Other
Total	9,812	818	288	5,156	603	146	200	8	12
Universities	6,304	171	177	834	50	17	50	8	12
Public Colleges	2,298	492	76	2,817	268	29	88	0	0
Private Colleges	1,210	155	35	1,505	285	100	62	0	0

Table 3.4

PERCENTAGE DISTRIBUTION OF FULL-TIME MATHEMATICAL SCIENCE FACULTY AT GIVEN TYPES OF INSTITUTIONS, BY LEVEL OF QUALIFICATION, 1970-71

(Add rows to get 100%)

	Doctorates In			Master's In			Bachelor's In		
	Math Sci.	Math Ed.	Other	Math Sci.	Math Ed.	Other	Math Sci.	Math Ed.	Other
All Institutions	57%	5%	2%	30%	4%	1%	1%	L	L
Universities	83%	2%	2%	11%	1%	L	1%	L	L
Public Colleges	38%	8%	1%	47%	4%	L	2%	0	0
Private Colleges	36%	5%	1%	45%	8%	3%	2%	0	0

L = less than 0.5%

Table 3.3 repeats most of the above information in greater detail. Tables 3.4 and 3.5 are percentage versions of 3.3 from two different points of view. For example, Table 3.4 says that 8 percent of all professors in public colleges have doctorates in mathematics education, while Table 3.5 asserts that 60 percent of all professors having doctorates in mathematics education teach in public colleges. The similarity of faculty training for public and private colleges may be noted in Table 3.4.

Table 3.5

PERCENTAGE DISTRIBUTION OF FULL-TIME MATHEMATICAL SCIENCE FACULTY WITH GIVEN QUALIFICATIONS, BY TYPE OF INSTITUTION, 1970-71

(Add columns to get 100%)

	Doctorates In			Master's In			Bachelor's In		
	Math Sci.	Math Ed.	Other	Math Sci.	Math Ed.	Other	Math Sci.	Math Ed.	Other
Universities	64%	21%	62%	16%	8%	12%	25%	*	*
Public Colleges	24%	60%	26%	55%	45%	20%	44%	*	*
Private Colleges	12%	19%	12%	29%	47%	68%	31%	*	*

*Too few cases to calculate meaningful percentages.

We note that teachers having only a bachelor's degree constitute about one percent of the faculty and probably result mainly from emergency appointments. The professors shown as having master's degrees represent a very wide range of qualifications ranging from holders of specialized (but socially useful) degrees for high school teachers to persons who are putting the finishing touches on Ph.D. theses.

There is reason to believe that some (unknown) number of those listed as having mathematical science doctorates actually obtained their degrees in other subjects. This has been verified in particular instances by contact with a small number of respondents. The error in reporting typically arises because, after a period of years during which a professor functions as if he had a mathematical science degree, the fact that his initial training was in another subject has no practical consequences and hence is forgotten. Indeed, such reporting errors, to the extent which they occur, may not mislead us about qualifications as much as about the sources of supply of mathematical science faculty.

It is necessary to give some consideration to the question of part-time faculty. Such faculty members are clearly a heterogeneous group. Some of those reported may hold joint appointments with other departments; some of the part-time faculty, especially in evening classes, may be another institution's full time faculty members; some may be graduate students appointed as part-time instructors instead of as teaching assistants. Fortunately

Table 3.6

NUMBER OF PART-TIME FACULTY IN THE MATHEMATICAL SCIENCES, 1970-71

	Total	Math Sci. Doctorates	Other Doctorates	Non Doctorates	Percent Doctorates
Total	2,830	568	335	1,927	32%
Universities	1,009	421	131	457	55%
Public Colleges	876	57	33	786	10%
Private Colleges	945	90	171	684	28%

for our degree of understanding of faculty structure this heterogeneous group numbers only 2,830 and hence, even if their teaching loads are as much as half-time on the average, the group as a whole bears less than ten percent of the total load.

As might be expected the part-time faculty has much lower formal qualifications (Table 3.6) than does the full-time faculty; only 32 percent have doctorates. Moreover, over one-third of these hold doctorates in fields other than the mathematical sciences. Part-time faculty were more prevalent in computer science than in other university departments; in computer science departments there were 300 part-time faculty of whom 130 had mathematical science doctorates and 82 had doctorates in other fields.

Of far greater significance quantitatively is the teaching done by graduate teaching assistants. By our estimates there were slightly over 9,000 teaching assistants in 1970-71, of whom 78 percent were in universities. In universities teaching assistants were almost as numerous as full-time faculty, and in some institutions had almost as high a teaching load. The total at first may seem surprisingly high. However, the most commonly reported data, deriving from departmental applications for NSF traineeships and including only teaching assistants in over 90 percent of the Ph.D.-granting departments [N], show 5,373 teaching assistants and 6,035 full-time faculty for the fall of 1970, with about the same ratio of assistants to faculty as in our larger group of universities.

Table 3.7

NUMBER OF GRADUATE TEACHING ASSISTANTS, BY TYPE OF DEPARTMENT, 1970-71

	Total	Mathematics Departments	Computer Science Departments	Statistics Departments
Total	9,005	7,949	309	747
Universities	7,055	5,999	309	747
Public Colleges	1,804	1,804	-	-
Private Colleges	146	146	-	-

Although we estimate 1,804 teaching assistants in public colleges the majority of public colleges reported no graduate teaching assistants at all. Teaching assistants in public colleges were highly concentrated in those institutions having enrollments over 14,000, many of which offer master's degrees and some of which are on the verge of attaining university status.

Full-time faculty, part-time faculty, and graduate teaching assistants form three distinct components of the teaching staff. In order to compare the relative magnitudes of these three components it is necessary to reduce them to the common denominator of full time equivalents (FTE's). The U.S. Office of Education on the basis of empirical studies has long considered three part-time faculty members to be the equivalent of one full-time faculty member. Graduate teaching assistants are most commonly given half-time appointments (0.5 FTE) or less but the teaching loads for teaching assistants shown in Table 3.16 (especially in mathematics departments) do not support an assignment on the average of less than one-half FTE for teaching assistants. Accordingly we will assume in what follows that a part-time faculty member represents one-third FTE and that a teaching assistant represents one-half FTE.

Table 3.8, then, presents the teaching staff in terms of full-time equivalents. In all four-year institutions the total full time equivalent teaching staff number 22,490. Of these FTE's 76 percent are attributable to full-time faculty, 4 percent to part-time faculty and 20 percent to teaching assistants. If only universities are considered the percentage of FTE's attributable to teaching assistants rises to 31 percent.

It has been stated above that 64 percent of full-time mathematical science faculty have doctorates. A better expression of the probability that a typical mathematical science student is being taught by a teacher with a doctorate might well be the percentage of FTE doctorates among the FTE teaching staff. From some elementary calculations with the data from Tables 3.1, 3.6, and 3.8, it turns out that only 50 percent of the total number of FTE's represent teachers holding doctorates. In universities, where 87 percent of full-time faculty hold doctorates, the percentage of FTE teaching staff holding doctorates is only 60 percent. For public and private colleges the percentage of doctorates among FTE teaching staff is 40 percent, which is close to the percentages of doctorates among the full-time faculty.

Table 3.8

NUMBER OF FULL-TIME EQUIVALENT TEACHING STAFF IN THE MATHEMATICAL SCIENCES, 1970-71

	Total FTE Faculty	Number Of Full-Time Faculty	FTE Equivalent Of Part-Time Faculty	FTE Equivalent Of Graduate Teaching Asst.
Total	22,490	17,043	943	4,504
Universities	11,488	7,623	336	3,529
Mathematics Dept.	9,440	6,235	205	3,000
Computer Science Dept.	943	688	100	155
Statistics Dept.	1,105	700	31	374
Public Colleges	7,262	6,068	292	902
Private Colleges	3,740	3,352	315	73

While a doctorate percentage of around 40 percent may well be respectable for institutions such as public and private colleges whose main efforts are directed toward undergraduate instruction, it is clear from a study of individual responses to the present survey that mathematical science doctorates are still not plentiful in small colleges. Only half of all private colleges had any mathematical science doctorates on the faculty in 1970-71, just as five years earlier, and another one-fourth of private colleges had only one. The situation is much the same for those public colleges which are comparable in size to the private colleges. Table 3.9 includes comparable data for both years for private colleges, showing that while 21 percent had at least two doctorates on the faculty five years earlier, 26 percent had at least two in 1970-71, and most of these had four or more. However, the presence of at least two doctorates still obtains at only one-quarter of the private colleges.

In terms of numbers of institutions, we estimate there to be 416 private colleges and 70 public colleges having no mathematical science doctorates and another 200 private colleges and 14 public colleges having only one. Thus each college could be assured of having at least two mathematical science doctorates by the addition of 1,186 individuals holding Ph.D.'s (suitably

Table 3.9

MATHEMATICAL SCIENCE DOCTORATES IN PRIVATE COLLEGES

Number of Mathematical Science Doctorates on Faculty	Percent of Private Colleges having this number, 1965-66	Percent of Private Colleges having this number, 1970-71
0	49%	50%
1	31%	24%
2	15%	4%
3	5%	2%
4	1%	11%
more than 4	0%	9%

deployed). It is worth noting that five years earlier in 1965-66 the number required for this purpose would have been 1,120.

Trends in Mathematical Science Faculty

The first comprehensive data concerning mathematical science faculty in four-year institutions became available as a part of the COLFACS study [C], done by the U.S. Office of Education in 1962-63. A study by Rogers [D], also for the U.S. Office of Education, was from a somewhat different point of view but produced comparable data for the academic year 1963-64. These two studies are discussed in greater detail in the report of our 1965-66 survey [E]. Our surveys provide comparable data for mathematical science faculty for the academic years 1965-66 and 1970-71. The information available from other sources for years other than these four is for various technical reasons not strictly comparable. The data summarized in Table 3.10 give a coherent picture of faculty growth and changes in faculty qualifications over the eight year period from 1962-63 to 1970-71.

First let us examine the first column of Table 3.10 describing the growth in total numbers of full-time mathematical science faculty. Over the eight year period the faculty

Table 3.10

TRENDS IN NUMBER AND QUALIFICATIONS OF FULL-TIME MATHEMATICAL SCIENCE FACULTY

Year	Total Faculty	Doctorates	Non Doctorates	Percent Doctorates
1962-63 (COLFACS)	7,640	3,658	3,982	48%
1963-64 (Rogers)	8,818	4,079	4,739	46%
1965-66 (CBMS)	10,753	5,712	5,041	53%
1970-71 (CBMS)	17,043	10,918	6,125	64%

increased from 7,640 to 17,043, an average increase of 1,175 per year. The four entries for total faculty size can be thought of as empirically-determined estimates for four values of some underlying function. In this case the data are consistent with a linear function; the line determined using least squares agrees with the values given for total faculty in Table 3.10 to within three percent for each year, a margin smaller than could reasonable be claimed for the accuracy of the data.

It has become more customary in recent years in such studies to assume (sometimes tacitly) that the underlying function is exponential in nature and to calculate annual growth rates over all or part of the time period under consideration (see, for example, [G] and [H]). This does not do too badly here. An exponential function passed through the first and last points is only four percent lower than the observed values at the two intermediate points. It is, therefore, not stretching matters too far to think of the underlying function as exponential and to calculate an annual (compound) growth rate of 10.6 percent for total faculty over the eight year period. One can proceed further and formally calculate separate annual growth rates for shorter time periods and for the doctorate and non-doctorate segments of the faculty:

	Total	Doctorates	Non-doctorates
1962-63 to 1965-66	12.1%	16.1%	8.2%
1965-66 to 1970-71	9.7%	13.8%	4.0%

From this it is clear that all segments of the faculty increased at a slower rate from 1965-66 to 1970-71 than during the earlier periods, and that the rate of growth of the non-doctorate portion of the faculty was much less than the growth rate in faculty with doctorates. In fact, as we shall see shortly, the number of non-doctorates actually decreased by approximately 200 from 1969-70 to 1970-71 and there are indications from the annual salary survey of the American Mathematical Society [K], that such non-doctorate faculty decreased further by roughly 500 in the following year.

As a result of the higher growth rates for doctorate as opposed to non-doctorate faculty, the percentage of doctorates among full-time mathematical science faculty increased rapidly from 48 percent in 1962-63 to 53 percent in 1965-66 and to 64 percent in 1970-71. It is interesting to note that over the eight year period the faculty increased by 7,260 doctorates while only 2,170 non-doctorates were added. Thus on balance 77 percent of the net faculty additions held doctorates.

Table 3.11 gives the numerical changes in numbers of faculty members in the five years between the two CBMS surveys. Because of changes in the U.S. Office of Education classification of institutions as described in Chapter I, it is difficult to compare 1965-66 data with 1970-71 data for more specific groups of institutions, but these are divided into "universities" and "colleges" in Table 3.11. (The sub-category of "technological schools" used in 1965-66 has been grouped with colleges for that year, but several of these as well as a few former "colleges" have been included in the university group in 1970-71.)

Table 3.11

NUMERICAL CHANGE IN FULL-TIME MATHEMATICAL SCIENCE FACULTY, FROM 1965-66 TO 1970-71

	Total	Math Science Doctorates	Other Doctorates	Non Doctorates
Total	+ 6,290	+ 4,807	+ 399	+ 1,084
Universities	+ 2,893	+ 2,867	+ 201	- 175
Colleges	+ 3,397	+ 1,940	+ 198	+ 1,259

The mathematical science faculty in all four-year institutions increased by 6,290, of whom 5,206 held doctorates and 4,807 held mathematical science doctorates, so over this period 83 percent of net faculty additions held doctorates. In universities the number of non-doctorate faculty actually declined slightly.

These impressive increases in the mathematical science faculty occurred over a five-year period in which much smaller percentage increases were the case for undergraduate mathematical science course enrollments, for the full-time-equivalent enrollment in four-year colleges and universities (Table 2.1), and for full time equivalent faculty in all fields [A, Tables 34 and 35]. However, there seems to be little doubt that the figure of 17,043 full-time mathematical science faculty is essentially correct. The total is closely corroborated by extrapolation from the data of the AMS Salary Survey of 1970-71 [K]. The AMS Salary Surveys for the years between 1965-66 and 1970-71 show yearly growth rates for individual departments of 9.7%, 9.6%, 12.0%, 6.7%, and 3.1%, which when compounded give a total increase for the five-year period of 48 percent in the size of individual departments. On top of this there has been a proliferation of additional departments, principally in statistics and computer science; over 50 such departments were established.

Finally, the NSF study [G], although its data are not strictly comparable to ours, does support the thesis that the mathematical science faculty grew at least as rapidly as our data indicate. They report that in 1965 there were 13,700 mathematicians (mathematical scientists) employed full or part-time in universities and colleges, while 23,500 such persons were so employed in 1970, the latter figure being a linear interpolation between values reported by NSF for 1969 and 1971. Their figures exclude graduate assistants. Since our estimates for full- and part-time faculty (a more restricted category of individuals) are 12,504 and 19,873 for the same two years, the NSF data indicate an even greater growth (71%) than do ours (59%).

It is interesting (and somewhat puzzling) to note that the net increase of 4,807 in the number of faculty reported as holding mathematical science doctorates compares with a total of 5,165 Ph.D.'s in the mathematical sciences granted in academic years 1965-66 through 1969-70 (see [A]). If some allowance (at least 1% per year) is made for deaths and retirements among the 5,005 mathematical science doctorates in the faculty in 1965-66, these data seem to imply that virtually every recent mathematical science Ph.D. has been going into college teaching. However, data from Volume III of the CBMS Survey [J] and from the NAS-NRC Doctorate Recipients [L] indicate that three-fourths of recent mathematical science Ph.D.'s have been employed in college teaching in the United States immediately upon receipt of their degrees, and about 5% more take postdoctoral appointments and (presumably) join faculties thereafter. We thus have over 1,000 individuals reported as having doctorates in the mathematical sciences who have been added to the doctorate faculty since 1965 and whose origins cannot easily be identified. A similar situation held with respect to the 1965-66 survey [E, pg. 38]. The following are possible sources for these faculty members: (1) individuals reported as having mathematical science Ph.D.'s whose doctorates were not so identified at the time they were conferred, (2) immigrants with foreign (including Canadian) doctorates*, and (3) U.S. mathematical science doctorates entering teaching after initial employment in industry or abroad. A more refined analysis of these matters would be possible only after several yearly repetitions of the mobility studies discussed below.

Faculty Mobility

In the questionnaire for the present survey we sought information on the movements of full-time mathematical science faculty of universities and four-year colleges from the academic year 1969-70 to the academic year 1970-71. The respondents were first asked about the sources of faculty members employed full-time for the first time in 1970-71. They were then asked what happened to those who were members of the full-time faculty in 1969-70 but were not members of the full-time faculty in 1970-71. The respondents were asked to report separately on doctorate holding and non-doctorate holding faculty.

A certain part of the resulting data deals with movement from one faculty position to another faculty position. Setting this aside for the time being and considering only entrances into or exits from the total mathematical science faculty of four-year institutions, the results are presented both in the form of

* This number appears to be relatively small: see CBMS Newsletter, March 1972, page 15.

Table 3.12

CHANGES IN NUMBERS OF FULL-TIME MATHEMATICAL SCIENCE FACULTY
ACADEMIC YEAR 1969-70 TO ACADEMIC YEAR 1970-71

Additions To Faculty	Total	Doctorates	Non-Doctorates
From Graduate School	1,355	843	512
From Post-Doctorals	87	87	
From Non-Academic Positions	96	52	44
From Other Sources	25	11	14
Total Additions	+ 1,563	+ 993	+ 570
Subtractions From Faculty			
Deaths and Retirements	192	103	89
To Non-Academic Positions	137	55	82
Returned To Graduate School	279	49	230
Other	82	54	28
Total Subtractions	- 690	- 261	- 429
Obtained Ph.D. While Engaged In Full-Time Teaching (Net Change)	0	+ 373	- 373
Net Change In Faculty Size	+ 873	+ 1,105	- 232

a balance sheet, as in Table 3.12, and also in the form of a flow chart (page 43).

For 1970-71 there were 1,563 new entrants into the mathematical science faculty counterbalanced in part by 690 professors who left teaching. There was therefore a net gain of 873 in the size of the mathematical science faculty, compared with an average increase of 1,175 per year over the eight year period ending in 1970-71.

The net increase of 873 in total faculty was made up of an increase of 1,105 in the number of doctorates and a net decrease of 232 in the number of non-doctorates. From this and the count of faculty numbers in 1970-71 it follows that the faculty in the preceding year numbered 16,170 of whom 9,813 held doctorates and 6,357 did not.

It is interesting to note that 373 of the net increase in doctorates were attributable to individuals who completed requirements for their degrees while employed in some institution as full-time faculty members. In our balance sheet this also appears as a loss of 373 non-doctorate faculty. Only 30 percent of these 373 were employed by universities. As a curiosity we observe that our data reveal 49 persons who held doctorates but yet returned to graduate school, presumably to study some subject differing from the original doctorate. The 230 non-doctorates who returned to graduate school accounted for over half of all non-doctorates leaving college teaching. These two groups of 1969-70 faculty who were involved in graduate study during 1970-71 together constituted almost 10 percent of the non-doctorate faculty.

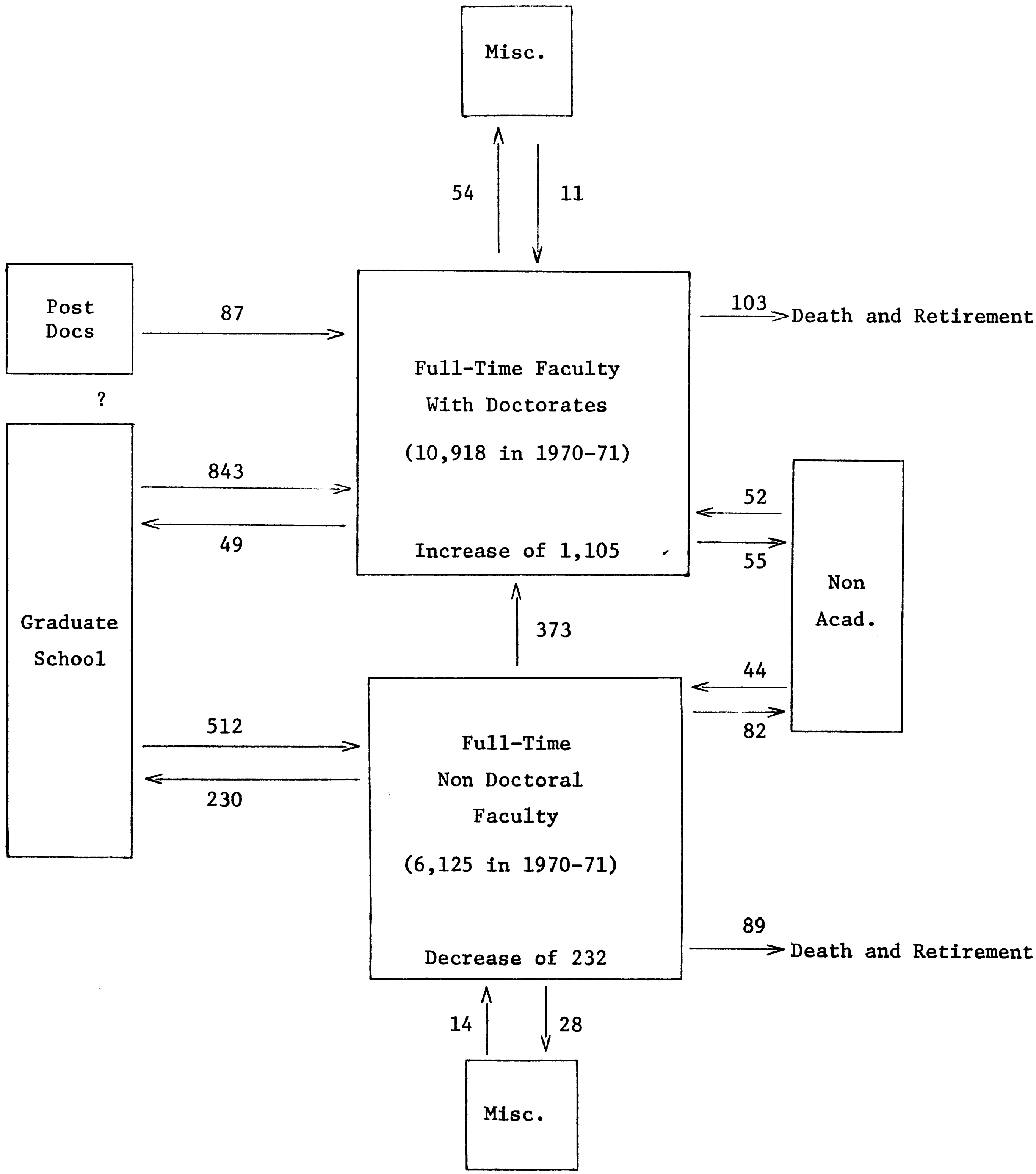
The rate of deaths and retirements has a strong cumulative effect on future demand for mathematical science professors. A conventional assumption for college faculty as a whole is a rate of two percent. The mathematical science faculty has been growing extremely rapidly. Since new entrants are typically quite young, one would expect the rate of deaths and retirements to be lower. The 192 deaths and retirements reported were 1.2 percent of the 1969-70 mathematical science faculty. The deaths and retirement rate was 1.0 percent for doctorates compared with 1.4 percent for non-doctorates. The higher retirement rate for non-doctorates is plausibly explained by slower growth of the non-doctorate segment of the faculty, since most entrants to the teaching profession are relatively young. If the mathematical science faculty were to grow at a slower rate than in the past the rate of deaths and retirements could be expected to rise as the age distribution of the faculty shifted upwards.

We were surprised at the extremely small amount of interchange between academic positions and non-academic ones. Only 137 people left college teaching for non-academic positions and only 96 moved in the opposite direction.

The questionnaire sent to four-year institutions was not as specific about movements between academic positions as about the to-and-from movement, and no distinction was made between academic positions in two-year colleges and positions in four-year colleges. However, returns from our questionnaire to two-year institutions (see Chapter V) indicate that approximately 20 Ph.D.'s and slightly over 100 non-doctorate faculty migrated from four-year institutions in 1969-60 to two-year institutions in 1970-71; the flow in the opposite direction is not known. For clarity of argument we make the plausible assumption that the <u>net</u> flow of faculty between two-

FLOW CHART FOR FACULTY MOBILITY

ACADEMIC YEAR 1969-70 TO ACADEMIC YEAR 1970-71



and four-year institutions was essentially zero. Both the estimates of net change in faculty size given above and the discussion which follows would be affected in obvious ways if this assumption were significantly in error.

An estimated 611 doctorate-holding faculty members were reported as transferring from one academic position to another. This is an internal mobility rate of six percent, which is equivalent to approximately two job changes during a typical career. The non-doctorate-holding faculty was less mobile. A total of 174 were hired from other academic positions, an internal mobility rate of not quite three percent (perhaps less if there was a net transfer to junior colleges). A total of 307 doctorates and 106 non-doctorates were on leaves not involving a return to graduate school.

Restricting our attention to the universities we note that 83 more professors left universities for other academic positions than went in the other direction. The excess leaving departments of mathematics was 175, the difference representing a net importation by university departments of statistics and computer science of professors from other types of institutions. Taking into account all the kinds of changes mentioned above we estimate (rather roughly) that the university mathematical science faculty had a net increase of 463 of whom 236 were in mathematics departments, 52 in statistics departments, and 175 in computer science departments. This indicates a higher growth rate in statistics departments than in mathematics departments and a much higher growth rate for departments of computer science. It should also be remembered that statisticians and computer scientists are, or were, employed by many mathematics departments and by departments outside the mathematical sciences, and that some may have changed their departmental affiliations within the mathematical sciences.

In addition to the facts discussed above concerning faculty hired for 1970-71 the respondents were asked how many additional faculty members they planned to seek for 1971-72 (exclusive of replacements) and for 1972-73. The replies, many of which were prepared in December and January and were thus undoubtedly premature with respect to administrative approvals, indicated that about 900 additional faculty--750 doctorates and 150 non-doctorates--were desired, exclusive of replacements. This would have been about the same net addition as for the previous year (Table 3.12). In reality, the chairmen were clearly unable actually to obtain these new positions in the difficult financial period which followed; the data from the AMS Salary Survey [K] in the summer of 1971 indicate that the number of new positions actually added to the total faculty was probably not much over 200. The chairmen's aspirations for 1972-73 were even larger, and thus not at all meaningful in the light of 1971-72 actualities.

However, it is instructive to compare the percentage distribution by field of the Ph.D.'s granted in 1971, as reported in [L], with the desires of department chairmen for 1971-72 and 1972-73:

	Ph.D's Granted 1970-71	Ph.D.'s Wanted 1971-1973
Mathematics	65%	40%
Applied Mathematics	9%	12%
Computer Science	10%	32%
Probability and Statistics	16%	16%

In the cases of applied mathematics and probability and statistics, the nice matching in percentages does not imply a balance between supply and demand in these fields, since academic demand overall seems likely to fall far short of supply; Ph.D's in these fields would merely not have as difficult a time as those in core mathematics. With respect to computer science, the healthy demand for Ph.D.'s has been recognized by universities for some time. To meet this demand, many new graduate departments have been formed and the number of Ph.D.'s granted has risen [L], from 18 in 1966 to 51 in 1968 and to 118 in 1970. Should the number of computer science doctorates continue to double every two years, the supply and demand ratio for faculty in the field would probably tend to converge toward that of the other mathematical sciences, even though over half the Ph.D.'s in this area are employed (as of 1970) in non-academic activities [O].

Faculty Utilization

In this section we report on data concerning teaching loads, expectations of research, and trends in methods of instruction.

The information presented all bears on manpower questions.

Table 3.13 gives a tabulation of the answers to the question, "What percent of the total freshman-sophomore teaching load is borne by graduate assistants?" This question must be difficult to answer if graduate assistants are used primarily as graders or are in charge of quiz sections or laboratories. There are difficulties with the data from statistics and computer science departments, and except for universities the responses were scattered. However, in university mathematics departments the data were excellent and are reported in Table 3.13 in terms of the

Table 3.13

LOWER DIVISION TEACHING DONE BY GRADUATE ASSISTANTS IN UNIVERSITY MATHEMATICS DEPARTMENTS IN 1965-66 AND 1970-71

Percent of Freshman-Sophomore Teaching Done by Graduate Assistants	Percent of University Mathematics Departments In This Range 1965-66	Percent of University Mathematics Departments In This Range 1970-71
0% to 19%	22%	21%
20% to 39%	24%	28%
40% to 59%	30%	37%
60% to 79%	14%	7%
80% to 100%	10%	7%

percentage of university mathematics departments whose responses fell in a given range. The same information is also presented from the 1965-66 survey. In both years the median university had 40 percent of its freshman-sophomore mathematics taught by graduate assistants, but apparently there has been some movement from extreme situations toward the median. Here we have one of the few differences between public and private institutions. Of private universities over one-third have less than 20 percent of all lower division mathematics taught by graduate assistants while only ten percent of public universities report such a small utilization.

We also asked about upper division classes and about other segments of the teaching staff. As might be expected from data previously presented on the full time equivalent of part-time faculty (Table 3.8) a very small percentage of the total load is borne by this group. Upperclass courses were rarely taught by any except full-time faculty members, and almost never by teaching assistants.

Information on teaching loads is presented in Table 3.14 and 3.15. Information was sought separately for each faculty rank and for each term of the year and the respondents were asked to comment on exceptions to the general policies. Differences by rank or by loads in different semesters were only infrequently reported. The only standard exceptions to the stated policies were reductions in load for various types of administrative duties. A number of departments just beginning to become established as research centers have formal policies assigning higher teaching loads to those faculty members not involved in research.

Table 3.14

PERCENTAGES OF MATHEMATICS DEPARTMENTS HAVING GIVEN TEACHING LOADS FOR FACULTY, 1970-71

Teaching Load	Percentage of Departments Having This Load		
	Mathematics in Universities	Public Colleges	Private Colleges
Less Than 6 Hours	8%	-	-
6 Hours	40%	3%	-
7 or 8 Hours	32%	5%	-
9 Hours	8%	14%	7%
10 or 11 Hours	5%	25%	17%
12 Hours	7%	35%	60%
Over 12 Hours	-	18%	16%

The median university mathematics department had a teaching load of seven hours although the most common teaching load was six hours. Teaching loads of less than six hours were only infrequently reported and were usually unbalanced, being less than six hours in only one term (e.g., six hours the first semester and three the second). A total of 72 percent of all university mathematics departments reported teaching loads in the range from six to eight hours. Since a teaching load of seven or eight hours virtually always involves only two courses, we can conclude that a two course teaching load or less is standard in 80 percent of university mathematics departments. With a single exception all reports of teaching loads of nine hours or more were from departments without a Ph.D. program in mathematics. However within the university category a majority even of non-Ph.D.-granting departments had teaching loads of less than nine hours.

The teaching loads in public and private colleges were significantly higher. A total of 74 percent of public colleges and

Table 3.15

PERCENTAGES OF STATISTICS AND COMPUTER SCIENCE DEPARTMENTS HAVING GIVEN TEACHING LOADS FOR FACULTY, 1970-71

Teaching Load	Percentage of Departments Having This Load in Universities	
	Computer Science	Statistics
Less Than 6 Hours	17%	44%
6 Hours	46%	28%
7 or 8 Hours	27%	12%
9 Hours	-	8%
10 or 11 Hours	7%	8%
12 Hours	3%	-
Over 12 Hours	-	-

84 percent of private colleges had teaching loads between nine and twelve hours. The median teaching load was twelve hours both in public and in private colleges. Reports of teaching loads higher than twelve hours came mostly from small colleges. Only one private college and no public colleges reported a standard load as high as fifteen hours.

In computer science and statistics departments teaching loads were lighter than in university mathematics departments. The median load in each was six hours; 63 percent of computer science departments and 72 percent of statistics departments had teaching loads of six hours or less.

The same type of data for teaching assistants is summarized in Table 3.16. First we observe that in departments of computer science and statistics almost two thirds of all respondents reported teaching loads of three hours or less for graduate assistants. This probably reflects a different balance of teaching and non-teaching assignments for assistants in these fields.

In university mathematics departments the situation is quite different, especially if a comparison is made between the

Table 3.16

PERCENTAGE OF MATHEMATICAL SCIENCE DEPARTMENTS HAVING GIVEN TEACHING LOADS FOR GRADUATE ASSISTANTS, 1970-71

Teaching Load for Graduate Assistants	Percentage of Departments Having This Load in Universities		
	Mathematics	Computer Science	Statistics
Less Than 4 Hours	23%	65%	62%
4 or 5 Hours	35%	4%	8%
6 Hours	35%	31%	30%
Over 6 Hours	7%	-	-

load of a teaching assistant and that of a full-time faculty member in the same department. In only 36 percent of the responding university mathematics departments does the teaching load for a professor exceed that for a teaching assistant by more than two hours. In 44 percent the loads for professors were higher but by less than two hours, and in 20 percent the loads were the same or (in two instances) the graduate assistants had higher loads.

Table 3.17 gives some information concerning expectations of research and publication. It is no surprise that all Ph.D.-granting departments have some such expectation. About half of the university respondents balked at stating these expectations in terms of numbers of publications over a five year period, including the majority of respondents from prestigious departments where research accomplishment is most highly valued. A reading of the raw data indicates that outside universities publication at some stated rate probably does represent a genuinely stronger emphasis on research. It comes as somewhat of a surprise to the authors that 38 percent of public colleges and 28 percent of private colleges stated some expectation of faculty research and publication. (Information on actual publication rates of Ph.D.'s was reported in our earlier graduate survey, [F], pp. 108-110.)

Table 3.17

PERCENTAGE OF MATHEMATICAL SCIENCE DEPARTMENTS HAVING GIVEN EXPECTATIONS OF RESEARCH AND PUBLICATION

Expectation	Universities (Mathematics Depts.)	Public Colleges	Private Colleges
(a) Publication at a Stated Rate	41%	13%	4%
(b) Maintaining Research Activity but With no Expected Rate of Publication	53%	25%	24%
(c) No Expectation of Research or Publication	6%	62%	72%
Average Rate of Publication in Papers Per Year (Where Stated)	1.0	0.4	0.6

In this connection it may be interesting to note that 80 percent of universities, 66 percent of public colleges and 79 percent of private colleges have a sabbatical leave plan. Many institutions not having a formal plan indicated that ad hoc arrangements can frequently be made to achieve the same ends. A sabbatical leave is rarely granted automatically as a matter of right but usually requires an application expressing well-formulated plans for research or for some other activity. As we stated earlier only 307 or three percent of the doctorate faculty were on leave in 1970-71; even if all of these were on sabbatical leave, which is quite unlikely, the average frequency of leave of absence is clearly not literally "sabbatical".

Table 3.18

PREVALENCE OF METHODS OF INSTRUCTION OTHER THAN SMALL SECTIONS, MATHEMATICAL SCIENCE DEPARTMENTS, 1970-71

Method of Instruction	Percent of Departments Using This Method				
	Universities (Mathematics)	Computer Science	Statistics	Public Colleges	Private Colleges
Large Lecture Classes With Small Quiz Sections	43%	51%	15%	11%	3%
Large Lecture Classes With Help Sessions	42%	47%	29%	8%	10%
Organized Program of Independent Study	24%	51%	18%	22%	51%
Courses by Television	6%	2%	9%	10%	4%
Courses by Film	3%	0%	0%	0%	0%
Courses by Programmed Instruction	9%	3%	2%	7%	10%
Courses by Computer-Assisted Instruction	5%	11%	2%	2%	2%
Other	6%	11%	5%	0%	17%
None of the Above	27%	21%	49%	53%	37%

We turn now to the information we have acquired about methods of instruction in the mathematical sciences. The questionnaire asked the respondents to give yes or no answers as to whether in their department at least some use was made of specified methods of instruction. The percentages of departments giving positive answers are summarized in Table 3.18. The most commonly used methods were independent study and some form of large lectures. The "other" methods listed in the next to the last line in the table were mainly slight variations of the methods previously listed. It is interesting to note that some form of large lecture classes was used in 56 percent of university mathematics departments, 77 percent of computer science departments, 40 percent of statistics departments, 17 percent of public colleges and 12 percent of private colleges. The last line lists the percentages of departments who used only traditional small class methods.

Apart from the intrinsic interest of the subject it would be useful with respect to considerations of manpower to have some idea of the proportion of students taught by each of these methods. It is easy to see from the data of Table 3.18 that courses conducted using television, films, and computer assisted instruction are not at present encountered by very many mathematical science students, but it is not possible from data of the type we have to make satisfactory estimates of the proportions of mathematical science students taught in large sections or involved in independent study. However, from the point of view of manpower and especially for purposes of making projections it is more important to have some knowledge of general trends than to have detailed and precise knowledge of a static situation. Information on trends in those methods which are most prevalent is provided in Table 3.19.

We observe that from 1960-61 to 1965-66 various forms of large scale teaching came into much more widespread use in all kinds of institutions, perhaps doubling in frequency. In the next five years, however, there seems to be on the whole no significant spread of large class instruction. There may possibly have been some modest increase in universities as opposed to a significant falling off in public and private colleges. A similar pattern seems to hold with respect to independent study--a significant increase followed by slight declines thereafter. Programmed instruction continued to increase modestly in universities but declined somewhat in public and private colleges. On the whole we see little evidence of any greatly increased use of new formats for mathematical science instruction from 1965-66 to 1970-71.

Table 3.19

TRENDS IN METHODS OF INSTRUCTION, 1960-61 TO 1970-71
MATHEMATICS DEPARTMENTS

Method of Instruction	Percent of Departments Using This Method								
	Universities			Public Colleges			Private Colleges		
	60-61	65-66	70-71	60-61	65-66	70-71	60-61	65-66	70-71
Large Lecture Classes With Small Quiz Sections	21%	42%	43%	2%	13%	11%	4%	10%	3%
Large Lecture Classes With Help Sessions	27%	34%	42%	11%	28%	8%	8%	15%	10%
Organized Programs of Independent Study	15%	24%	24%	7%	27%	22%	16%	25%	22%
Courses by Programmed Instruction	0%	6%	9%	0%	11%	7%	1%	11%	10%

Course Enrollments and Mathematical Science Faculty

We turn now to a consideration of the relationships between undergraduate course enrollments and numbers of faculty as observed in our 1965-66 survey [E] and in the present survey. The supply and demand studies of Allan M. Cartter and others have been based on the assumption that the number of new faculty members required for expansion will bear a fixed ratio to the number of additional students. Historical data [A] support this assumption as applied to faculty in all disciplines and the total number of students in college. The validity of this assumption as applied to individual disciplines cannot generally be tested because the appropriate data are lacking. Cartter states in [M]:

> It is not too difficult to assess the aggregate flows of new teachers, as well as replacement and expansion needs, for errors tend to cancel out. For each 100,000 new students in higher education, about 5,000 new college teachers will commonly be required. But whether those new teachers will be scientists or humanists, specialists or generalists depends on a host of factors that are not revealed by the aggregates...

The next three tables consider this situation for the mathematical sciences. Table 3.20 brings together data for 1965-66, taken from [E], about course enrollments and faculty in that year.

A ratio which we have found to be a useful indicator is the ratio of enrollments in undergraduate mathematical science courses to full-time mathematical science faculty. Let r denote this ratio. It should be noted that r compares undergraduate enrollment with the number of full-time faculty available for all purposes, including graduate teaching and research. A purer ratio, comparing the magnitude of the undergraduate teaching effort with the manpower available for that effort only, would be preferable were it possible to obtain the necessary information.

From Table 3.20 we observe that r was 99.3 for all four-year institutions in 1965-66 and within ten percent of that figure for each category of institution except for the (relatively small) category of technological schools.

Table 3.21 summarizes the same facts for 1970-71. Observe that r, far from remaining constant, has declined from 99.3 to 81.3 and is even more nearly uniform among different classes of institutions. Table 3.22 breaks up the university component by type of department.

Table 3.20

UNDERGRADUATE COURSE ENROLLMENTS AND MATHEMATICAL SCIENCE FACULTY, 1965-66

	Total	Universities	Public Colleges	Private Colleges	Technological Schools
Course Enrollments (In Thousands)	1,068	493	310	201	64
Full-Time Faculty	10,753	4,730	3,056	2,228	739
Part-Time Faculty	1,751	698	293	625	135
Enrollments per Full-Time Faculty Member	99.3	104.2	101.4	90.2	86.6

Table 3.21

UNDERGRADUATE COURSE ENROLLMENTS AND MATHEMATICAL SCIENCE FACULTY, 1970-71

	Total	Universities	Public Colleges	Private Colleges
Course Enrollments (In Thousands)	1,386	629	496	261
Full-Time Faculty	17,043	7,623	6,068	3,352
Part-Time Faculty	2,830	1,009	876	945
Graduate Assistants	9,005	7,055	1,804	146
FTE Faculty	22,490	11,488	7,262	3,740
Enrollments per Full-Time Faculty Member	81.3	82.5	81.7	77.9
Enrollments per FTE Faculty	61.6	54.8	68.3	69.8

Table 3.22

UNDERGRADUATE COURSE ENROLLMENTS AND MATHEMATICAL SCIENCE FACULTY IN UNIVERSITIES, BY TYPE OF DEPARTMENT, 1970-71

	University Mathematics Departments	Computer Science Departments	Statistics Departments
Course Enrollments (In Thousands)	551	46	32
Full-Time Faculty	6,235	688	700
Part-Time Faculty	615	300	93
Graduate Assistants	5,999	309	747
FTE Faculty	9,440	943	1,105
Enrollments per Full-Time Faculty Member	88.4	66.9	45.7
Enrollments per FTE Faculty	58.4	48.8	29.0

There are three conceivable causes for a decline in r: (1) An increase in the proportion of full-time faculty among the full-time-equivalent teaching staff. This would happen, for example, if full-time faculty were hired to replace a considerable number of teaching assistants. (2) Decreased teaching loads or decreased average class size in undergraduate instruction so that a typical faculty member would handle fewer students. (3) Additional faculty members hired for purposes other than undergraduate teaching. That the first alternative did not occur between 1965-66 and 1970-71 is shown by the fact that full-time faculty constituted 77 percent of the entire full-time-equivalent teaching staff in 1965-66 compared to 76 percent in 1970-71.

Alternative (2) must be virtually the complete explanation for the decline in r for the category of private colleges since these institutions conduct only a negligible amount of graduate work and paid research. The value of r for these institutions in 1970-71 was 77.9, which was 90 percent of its 1965-66 value. If a closely comparable decrease in r were observed in universities one might feel justified in assuming that decreases in teaching loads or class size provided an explanation for observed decrease in r in universities. However, the value of r in universities for 1970-71 was 82.5, which was only 79 percent of the 1965-66 value so that it is extremely plausible that alternative (3) has also had a considerable effect in universities.

It is instructive to compare what Table 3.21 says about universities, (which have extensive graduate programs) with private colleges (which have essentially none). The category of public colleges is, in a sense, intermediate in this respect. The universities have substantially the same value of r as do private colleges. In universities in 1970-71 there were 7,623 full-time faculty members and 7,055 teaching assistants. At the cost of some oversimplification this can be thought of as stating that one professor plus one graduate assistant in a university teach the same number of undergraduates as does one professor in a private college. Thus in a beautifully symbiotic relationship the teaching assistant frees precisely as much of the professor's energy as is utilized in providing the program of graduate instruction and research which is the real payment for the teaching assistant's services.

Chapter IV

OTHER ASPECTS OF UNDERGRADUATE PROGRAMS

In this chapter we discuss several matters which have a certain intrinsic interest but are not related directly to the main themes of the preceding chapters. Among these are computer use by faculty, mathematical requirements for graduation, admissions and placement testing, and various types of curricular innovations, all in degree-granting institutions.

The part of our questionnaire upon which this chapter is based was composed mainly of questions requiring a yes or no answer as a description of some characteristic of a responding department. We are aware that in many instances this forces an oversimplification of the actual situation so that the data collected are perhaps somewhat less objective and more dependent on the judgment of individual respondents than the data of the preceding chapters.

In tables reporting the percentages of departments having given characteristics, the percentages have been calculated by methods described more fully in Chapter I which take into account differences in sampling ratios and response rates. The reader should keep in mind that the data of this chapter are not weighted with respect to numbers of students affected.

Computer Access and Utilization

Table 4.1 shows the percentages of mathematics departments which had access to a computer or to computer terminal facilities. All computer science and statistics departments had such access. The most important fact here is that the percentage of departments in private colleges having access to a computer or to terminals increased from 39 percent in 1965-66 to 75 percent in 1970-71. The colleges reporting no access tended to be the very smallest institutions. To the extent that access to computers for a

Table 4.1

PERCENTAGES OF MATHEMATICS DEPARTMENTS HAVING ACCESS TO A COMPUTER OR TO COMPUTER TERMINAL FACILITIES, 1965-66 and 1970-71

	Percent Having Access 1965-66	Percent Having Access 1970-71
Universities	98%	98%
Public Colleges	62%	87%
Private Colleges	39%	75%

department constitutes access for an undergraduate student, it can be said that in 1970-71 virtually all undergraduates in universities and over 90 percent of undergraduates in four-year colleges had access to computers or to computer terminals.

The respondents were asked if there were courses taught by their departments, other than courses in computer science, in which the use of a computer is specified. An affirmative answer was given by 61 percent of university mathematics departments, by 29 percent of public colleges, and by 40 percent of private colleges. The courses most mentioned as those in which a computer was specified were calculus, numerical analysis, linear algebra, and finite mathematics.

It is difficult to formulate questions which will get usable responses indicating quantitatively the amount of involvement of faculty members and students in computing. As one measure we asked chairmen what percentage of faculty in their departments used computers (a) in research and (b) in teaching. In order to present the results of this question, we have defined (after reviewing the data and for the purposes of this question only) "minimal use" to be use by less than 10 percent of departmental faculty, "moderate use" to be use by between 10 and 25 percent of departmental faculty, and "high use" to be use by at least 25 percent of departmental faculty. Table 4.2 gives the results for research and Table 4.3 gives the results for teaching.

Table 4.2 says, for example, that 84 percent of university mathematics chairmen reported that not more than ten percent of

Table 4.2

PERCENTAGES OF MATHEMATICAL SCIENCE DEPARTMENTS
REPORTING MINIMAL, MODERATE AND HIGH USE OF
COMPUTERS IN RESEARCH, 1970-71

	Minimal Use: Not More Than 10% of Faculty	Moderate Use: Between 10% and 25% of Faculty	High Use: At Least 25% of Faculty
Universities			
Mathematics	84%	0%	16%
Statistics	4%	45%	51%
Public Colleges	71%	17%	12%
Private Colleges	74%	5%	21%

their departmental faculty made use of a computer in research and Table 4.3 says that 71 percent of university mathematics chairmen reported that not more than ten percent of their

Table 4.3

PERCENTAGES OF MATHEMATICAL SCIENCE DEPARTMENTS
REPORTING MINIMAL, MODERATE AND HIGH USE OF
COMPUTERS IN TEACHING, 1970-71

	Minimal Use: Not More Than 10% of Faculty	Moderate Use: Between 10% and 25% of Faculty	High Use: At Least 25% of Faculty
Universities			
Mathematics	71%	19%	10%
Statistics	37%	15%	48%
Public Colleges	42%	44%	16%
Private Colleges	63%	7%	30%

faculty used a computer in teaching. It is interesting to note that high faculty use of computers was reported by only 51 percent of statistics departments for research and only by 48 percent for teaching. For colleges, reported research utilization must have been held down by the proportion of faculty members involved in research. With respect to teaching, it is noteworthy that 30 percent of private colleges reported high faculty use compared to only 10 percent in university mathematics departments; however, over half the private colleges had no more than four members of the mathematical faculty, so that "high use" may only mean that at least one member uses the computer.

Mathematical Science Courses as Graduation Requirements

The respondents were asked whether their institutions had some mathematical science course as an institution-wide requirement for graduation. The situation compared with former years is presented in Table 4.4. There does not appear to have been any significant change since 1965-66.

An institution-wide mathematical science requirement was favored by the mathematics chairmen in only 10 percent of universities, 15 percent of public colleges and 4 percent of private colleges.

Table 4.4

PERCENTAGES OF INSTITUTIONS HAVING SOME MATHEMATICAL SCIENCE COURSE AS AN INSTITUTION-WIDE GRADUATION REQUIREMENT

	1960-61	1965-66	1970-71
Universities	21%	20%	20%
Public Colleges	33%	45%	49%
Private Colleges	25%	28%	28%

Of the universities not having a specific mathematical science requirement 49 percent had an institution-wide requirement of an alternative choice of either mathematics or some other subject. The corresponding percentages were 72 percent for public colleges and 48 percent for private colleges. Consequently, a student in 52 percent of universities, 86 percent of public colleges and 62 percent of private colleges could use some mathematical science course to satisfy some institution-wide graduation requirement.

Entrance and Placement Examinations

An admissions examination including questions on mathematics was required in 1970-71 at 63 percent of universities, 35 percent of public colleges, and 91 percent of private colleges. These percentages were lower in all categories than those reported five years earlier, but are quite similar to the requirements of 1960-61, as shown in Table 4.5. The rapid rise and fall of admission examinations over the decade in public colleges and universities is probably correlated with the expanded admission pressures in the middle of the period, followed by the introduction of "open admissions" more recently. Leading examinations were the College Entrance Examination Board Aptitude Examination and the American College Testing examination. Other examinations, including state examinations, institutional examinations, and the CEEB Achievement Examinations were far behind.

Table 4.5

PERCENTAGES OF INSTITUTIONS REQUIRING
ADMISSIONS EXAMINATIONS THAT INCLUDE MATHEMATICS

	1960-61	1965-66	1970-71
Universities	68%	90%	63%
Public Colleges	55%	80%	35%
Private Colleges	91%	96%	91%

In addition there are placement examinations in mathematics. The ten year trend in the percentages of institutions giving such examinations is exhibited in Table 4.6.

Table 4.6

PERCENTAGES OF INSTITUTIONS USING PLACEMENT EXAMINATIONS IN MATHEMATICS

	1960-61	1965-66	1970-71
Universities	68%	50%	57%
Public Colleges	59%	50%	68%
Private Colleges	48%	39%	37%

These examinations tend to test the student's knowledge of algebra and trigonometry more than of more advanced material. Their goal is principally to place students in appropriate courses with some special emphasis on finding out which students have the necessary mathematical knowledge to undertake regular college courses. Among those institutions giving placement tests, standardized or nationally distributed examinations were used by 46 percent of universities, 45 percent of public colleges and 48 percent of private colleges.

There are striking counter-trends observable in Table 4.5 and 4.6. From 1960-61 to 1965-66, the admissions to public institutions were increasingly controlled through admission examination requirements and other selective procedures because of the unusually rapid increases in college-age population. In the latter half of the decade these admissions restrictions seems to have been moderated, perhaps because of the diversion of many potential candidates to junior colleges and because more adequate physical plant had been built in the meantime. But while the admission requirements were being increased in the early nineteen-sixties, the necessity for placement testing after admission decreased. More recently, as admissions examinations have been eased (and in some instances essentially abolished under "open admissions" policies), the necessity for testing for purposes of placement again increased. It is noteworthy that neither of these apparently-related trends occurred to any great extent in private colleges, perhaps because they have always been committed to selective admissions in some form.

Related to this subject are programs of advanced standing (advanced placement) in mathematics, in which an entering student, on the basis of high school record or examination, may enroll in courses more advanced than usual for an entering freshman and/or receive college credits for advanced work in high school. Options of this type open to the student over a ten year period are presented in Table 4.7. The variety of existing arrangements of this general nature must be quite large and some exercise of judgment must have been necessary on the part of many of our respondents to determine whether the arrangements constituted an advanced standing program as defined above. The reported data indicate that such programs existed by 1970-71 in almost all universities and private colleges and in about three-fourths of public colleges. The big increase in advanced standing programs occurred between 1960-61 and 1965-66 in public and private colleges and, apparently, even earlier in universities. The most interesting message of Table 4.7 seems to be a great increase between 1965-66 and 1970-71 in the percentage of institutions willing to recognize advanced standing by the award of college credit. Among universities having advanced standing programs, the percentage willing to give credit for advanced standing in calculus increased from 44 percent to 95 percent over this five year period. Similar increases were reported for college algebra-trigonometry in public and private colleges. (The blanks in this table, and the next, indicate that the corresponding question was not asked before 1970-71.)

Curricular Innovations in Undergraduate Programs

Table 4.8 gives the incidence of specified types of curricular innovations between 1960 and 1965 and between 1965 and 1970. The relatively high figures in this table seem to show that courses and programs evolved continously from 1960 to 1970. By comparing percentages for different types of institutions one can observe that strong interest in courses for biological and social sciences began in the first half of the decade in universities but really got going only in the second half of the decade in colleges. It also seems to be true that the intensity of interest in curricular

Table 4.7

ADVANCED STANDING PROGRAMS

	Universities			Public Colleges			Private Colleges		
	1960-61	1965-66	1970-71	1960-61	1965-66	1970-71	1960-61	1965-66	1970-71
Percentages of Institutions Having Programs of Advanced Standing (Advanced Placement)	95%	95%	95%	53%	82%	73%	63%	92%	96%
Percentages of Institutions Having Such Programs In Which Credit Can be Entered on Student's Record for									
(a) College Algebra and/or Trigonometry	40%	30%	34%	34%	31%	99%	29%	20%	95%
(b) Analytic Geometry	35%	34%	29%	28%	19%	22%	27%	20%	4%
(c) Calculus	46%	44%	95%	12%	19%	62%	20%	25%	68%
(d) Courses above Calculus	—	—	53%	—	—	16%	—	—	7%

Table 4.8

PERCENTAGES OF MATHEMATICS DEPARTMENTS REPORTING GIVEN TYPES OF INNOVATIONS IN UNDERGRADUATE PROGRAMS IN TWO FIVE-YEAR PERIODS

	Universities		Public Colleges		Private Colleges	
	1960-65	1965-70	1960-65	1965-70	1960-65	1965-70
1. Have introduced new degree programs	31%	42%	32%	41%	20%	30%
2. Have provided new courses appropriate for the biological and medical sciences	27%	28%	18%	42%	12%	34%
3. Have provided new courses appropriate for the social and management sciences	59%	53%	28%	54%	27%	51%
4. Have provided new courses appropriate for the physical sciences and engineering	68%	32%	33%	38%	30%	30%
5. Have provided new courses appropriate for computing and data processing	64%	54%	50%	59%	27%	36%
6. Have provided new courses or tutorial work to meet broadened admissions policies	—	28%	—	36%	—	36%
7. Have significantly altered the program for freshman year	56%	41%	59%	49%	58%	55%
8. Have introduced or substantially altered a program for the undergraduate preparation of secondary school teachers of mathematics	46%	35%	56%	48%	38%	36%
9. Have introduced or substantially altered a program for the mathematics preparation of elementary school teachers	41%	21%	62%	53%	39%	42%
10. Have introduced other innovations	20%	30%	31%	12%	22%	19%

work in courses for physical scientists and for teachers has declined somewhat in the last five years in universities, while continuing unabated in colleges.

The respondents were asked to give a description of those innovations classified as falling under items 6 through 10. One gets a strong picture of prudent tinkering and adjustment rather than revolutionary change. A substantial number of the respondents indicated they had adopted recommendations of the Committee on the Undergraduate Program in Mathematics [R], or gave a description of some change that was specifically recommended by CUPM. This was especially true with respect to teacher training. The "other" innovations described in item 10 were not startling, being for the most part almost classifiable under one of the earlier headings. Many of the changes reflected a desire to achieve greater variety or flexibility in course offerings. Among the innovations mentioned most frequently were combination of algebra and trigonometry into an elementary functions course, introduction of linear algebra into the standard calculus sequence, offering alternative (and shorter) calculus courses for special groups of students, partial adoption of CUPM courses for elementary school teachers, and the offering or more widespread use of courses in finite mathematics.

Chapter V

TWO-YEAR COLLEGES

This chapter reports on a survey made of two-year colleges, relating to course enrollments, placement, and other curricular matters, and parallel to the survey of degree-granting institutions reported on in the preceding chapters. This survey of two-year institutions was conducted by CBMS in the late fall of 1970, at the same time as the four-year college survey, using a questionnaire (Appendix C) which was similar but modified to fit two-year college characteristics.

This survey is a direct successor to the first such study, conducted in the fall of 1966-67 and reported on in Volume I of the Report of the Survey Committee [E].

Significant evidence comes from this study that the number of course enrollments in the mathematical sciences in junior colleges has kept pace with the phenomenal growth in total student enrollment at these institutions, with each increasing by 68 percent over the four-year interval. This rapid growth reflects a widespread acceptance of two-year institutions as a basic component of the public education system and is in contrast to a 30 percent growth, over five years, in both total and mathematical enrollment in degree-granting institutions. These parallel changes indicate that the overall position of the mathematical sciences within the academic world has remained essentially fixed in spite of a major shift in institutional patterns.

Within mathematical science, however, there have been some shifts in emphasis. There has been an increase in the proportion of junior-college courses devoted to subjects normally considered to be pre-collegiate level, especially arithmetic. At the same time, there have been relatively greater increases in the teaching of computer programming, statistics, and finite mathematics in the two-year institutions, while calculus and other "sophomore" courses have not increased as rapidly as the student population has.

During this period the mathematical sciences faculty in two-year institutions has increased by 80 percent, with a slight trend toward a greater full-time component. This improvement in the quantity of the staff, relative to enrollment increases, has been accompanied by a measurable increase in its educational qualifications. An analysis of the faculty situation in junior colleges is given in Chapter VI.

Sample and Response

The methodology for determining a population of two-year institutions and for selecting a sample thereof was identical to that for degeee-granting institutions, and is described in detail in Chapter I. The U.S. Office of Education listing of 683 public (independent) two-year colleges and 267 private two-year institutions was supplemented by the addition of 94 public and 2 private two-year off-campus branches of four-year institutions. Also we deleted from the population, for sampling purposes, eight private institutions which specialize in art, bible, or dental technology and 33 private institutions with enrollment under 100, primarily under religious auspices; all of these institutions appear not to teach mathematical science. After deleting two other institutions which had been changed to degree-granting status, we ended with a population of 1,003 two-year institutions. These were sampled on the same weighted basis which is described in Chapter I. The sample ratios and response rates are shown in Table 5.1 and a list of responding institutions is given in Appendix D. These responding institutions, constituting 15 percent of all two-year colleges, actually cover 30 percent of two-year students and faculty under the weighted sampling procedure used.

Because two-year colleges have varying organizational structures, our questionnaires were addressed to the dean with the request that he forward it to the person directly in charge of the mathematics programs. From the 151 responses we determined that 70 institutions had a mathematics department, 55 included mathematics in a division of science and mathematics, 11 small institutions had no departmental structure, and 15 others provided for mathematics within such departments as engineering or general education. In every case, the responses indicated that there were no separate departments whose primary mission was instruction in computer science or statistics, although these subjects were occasionally assigned to other departments to teach.

Table 5.1

SAMPLING AND RESPONSE FOR MATHEMATICAL SCIENCE PROGRAMS
IN TWO-YEAR COLLEGES

Group	Enrollment Range*	Number in Universe	Sampling Ratio	Number in Sample	Responses Received	Percent Response
A. Large Public Colleges	9,600-28,000	41	1:1	41	33	81
B. Medium Public Colleges	1,500-8,800	330	1:7.5	44	35	80
C. Small Public Colleges	under 1,500	405	1:7.5	54	36	67
D. Large Private Colleges	1,000-5,000	24	1:1	24	17	71
E. Small Private Colleges	under 1,000	203	1:4	51	30	59
Totals		1,003		214	151	71

* Enrollment includes both full-time and part-time students, fall 1970 (USOE data).

Table 5.2

ENROLLMENTS IN TWO-YEAR INSTITUTIONS, FALL 1970

(In thousands)

	Full Time	Part Time	Public Colleges	Private Colleges	Total
Total enrollment	1,165	1,058	2,102	121	2,223
Degree-credit	876	754	1,520	110	1,630
Nondegree-credit	289	304	582	11	593
First-time freshmen (Deg.Cr.)	414	240	601	53	654
First-time freshmen (Total)	562	355	857	60	917

Source: USOE, Projections of Educational Statistics to 1980-81. Includes 50 states and D. C. Does not include off-campus branches of degree-granting institutions, or Puerto Rico.

General Information on Two-year Colleges

As a point of reference we present in Table 5.2 the Fall 1970 enrollment for two-year institutions as they are categorized by USOE. For the CBMS adjusted population of 1,003 institutions listed in Table 1.1, a close estimate can be obtained by adding 90,000 to the public component in Table 5.2 to represent the added off-campus branches, the other adjustments being essentially self-balancing. On the basis of USOE data for individual colleges [Q], the distribution of the added 90,000 students is estimated to be two-thirds full-time, nine-tenths degree-credit, and two-fifths first-time freshmen. The USOE data in Table 5.2 are, however, reasonably suitable for time-series and other comparisons.

Table 5.2 shows that almost half--47 percent--of the two-year college students attend on a part-time basis; an examination of colleges by group indicates that part-time attendance is a common characteristic, but that it varies roughly according to institutional size, from 14 percent in small private colleges to 58 percent in the large public colleges (as shown in Table 5.7). The table above shows that about a quarter of all two-year college students are enrolled in "nondegree-credit" programs, principally in public colleges. A question in the survey as to total student enrollments in college-transfer (degree-credit) programs and in occupational/terminal (nondegree-credit) programs revealed that most public institutions had substantial fractions taking each kind of program. Furthermore, with respect to the enrollment of these students in mathematical science courses, those respondents who did distinguish the types of students in their classes reported both types mixed together in most of their courses except for a few occupationally-oriented courses in technical or business mathematics. Even the latter courses seemed to carry credits for the enrollees, and apparently the fact that a student is officially enrolled in an occupational or terminal program does not preclude his obtaining credits in mathematical courses which may be transferable at the option of the receiving institution. Consequently, although we have noted in Table 5.2 the subcategorization of students as to credit basis, this division has little apparent relationship to the character of the institution or to coursework in mathematics.

Although 22 percent of the two-year institutions tabulated in Table 5.1 are under private control, the overwhelming fact is that most of these private institutions are relatively small; only five had a 1970 enrollment of over 2,000, and as a group the private colleges enrolled less than 6 percent of the two-year students. (This represents a distinct change over the last ten years; in 1960, 40 percent of junior colleges were private and they enrolled 14 percent of the students.) This preponderance of public junior college students within the total number obviously results in obscuring the private colleges' differences where they exist; thus we will take special notice of the private college situation where it is noticeably different from the public one.

Two-year college students are also unevenly distributed nationally. Over 31 percent of them attend junior colleges in California, and the seven states of California, New York, Illinois, Michigan, Texas, Florida, and Washington account for two-thirds of all the junior college students in the country, although the higher education enrollments in these states constitute only 44 percent of the U.S. total. The position of the public junior college in California is unique--junior college students constitute 55 percent of the higher education enrollment, and 80 percent of the first-time freshman total for the institutions in the state. About half of the 690,000 junior college students in California attend the 25 public colleges with enrollment over 10,000. The educational impact of the junior college movement in California is perhaps unique, also--the widespread availability of junior college educational opportunities is evidently related to the fact that California enrolls 15 percent of the higher education students in the U.S., even though the state's population is only nine percent of the national total. Because the California junior colleges loom so prominently in the national picture, and so dominantly in the group of large public junior colleges, their characteristics with respect to mathematics enrollment and curriculum will be the subject of a special discussion later on.

As a matter of terminology, we shall refer to two-year colleges or junior colleges as generic terms, without any intended distinction between them, and include in this categorization all educational institutions which offer typically two years of post-secondary school instruction but which do not offer baccalaureate degrees. Some of these institutions offer an associate in arts degree, and most offer college-level credits for at least some of their courses, such credits being transferable to degree-granting institutions and often applicable there toward a baccalaureate degree. The general category of two-year college, as we use the term, includes many institutions called community colleges and some technical institutes, business colleges, art and music schools, and agricultural schools; quite a few use the name "college" without further qualification. The students at most of the public institutions and many of the private ones commute for the most part, and many attend in the evening and/or part-time. All of these factors should be considered when attempting to compare the mathematics programs in junior colleges with those in senior colleges.

The rapid growth of enrollments in two-year colleges over the last four years is shown in Table 5.3. The growth of 68 percent in total enrollment is approximated in each of the component enrollments shown in the table, and this 68 percent growth, which is equivalent to an annual (compound) rate of 14 percent, contrasts sharply with the 30 percent growth in total enrollment in degree-granting institutions over five years, equivalent to slightly over 5 percent annually. It is noteworthy, too, that the annual growth rate of 15 percent in degree-credit enrollment is more than double the rate of 7 percent which was predicted four years earlier (cf. [E], page 54). The USOE <u>Projections</u> [A] for 1980-81 indicate a continued growth for two-year institutions at a compound annual rate of more than 6 percent over the next ten years, in spite of

Table 5.3

ENROLLMENT GROWTH IN TWO-YEAR INSTITUTIONS, 1966 TO 1970
(In thousands)

	Total	Degree Credit	Nondegree Credit	Full Time	Part Time	First-Time Freshmen
Fall 1966 Enrollment	1,380	990	390	773	607	571
Fall 1970 Enrollment	2,313	1,706	607	1,225	1,088	957
Percent Increase 1966-1970	68%	72%	58%	59%	80%	68%
Annual Growth Rate	14%	15%	12%	12%	16%	14%

Source: USOE data as in Table 5.2, with adjustment to include Puerto Rico and off-campus two-year branches of degree-granting institutions.

a leveling-off of the birth rate. This projection may well prove to be quite conservative, for the growth in new freshmen at the junior colleges from Fall 1970 to Fall 1971 was estimated at over 13 percent by Parker (see page 12).

Course Enrollments in Two-year Colleges

In the fall term of 1970-71 there were 584,000 course enrollments in mathematical science courses in junior colleges, according to our survey. This represented a 68 percent gain over the number estimated from our previous junior college survey four years earlier, and this percentage gain is essentially identical to the gain in total enrollment of students. The gain in full-time equivalent student enrollment was, however, only 63 percent, because the growth in part-time students was greater than in full-time. Thus the mathematical science course enrollment averaged 0.37 course per FTE student for the fall term, a slight improvement over four years earlier. According to department chairmen's estimates the total mathematical course enrollment for the second semester or quarter of 1970-71 was expected to be 520,000 (89 percent of the fall enrollment), and the group of institutions which schedule a third quarter expected about 108,000 more enrollments then. All in all, therefore, the mathematical science course enrollment for the academic year was some 1,212,000, in courses lasting for one semester or quarter. The

Table 5.4

MATHEMATICAL SCIENCE COURSE ENROLLMENT IN TWO-YEAR COLLEGES
1966 AND 1970

	Fall 1966	Fall 1970	Increase 1966-1970
Course Enrollments in mathematical science	348,000	584,000	68%
Total student enrollment, full & part time	1,380,000	2,313,000	68%
Full-time equivalent student enrollment	975,000	1,588,000	63%
Mathematical science courses per FTE student	0.36	0.37	3%

Full-time equivalent (FTE) = full-time plus one-third of part-time.

total exposure of the average student to mathematical science is thus equivalent to 0.77 semesters annually, or between two and three credits.

Enrollments in individual courses are shown in Table 5.5 for both 1966 and 1970. What perhaps is most striking is that there is little radical change: the increases in individual courses tend to follow the student enrollment growth in general. Subjects with especially rapid growth include college arithmetic, elementary algebra, basic concepts, finite mathematics, statistics and probability, and computer programming. The subjects of analytic geometry and calculus have increased in proportion to the student body, but there has been a definite shift from a combined course to separate courses (which is contrary to the trend in senior colleges). There has been, relatively, a decline in the total enrollment in college algebra and trigonometry, but with a shift of emphasis from separate courses toward a combined one. Advanced courses such as differential equations, linear algebra, and other post-calculus mathematical subjects constitute a minimal portion of the mathematical offerings for both years. The rapid increases in statistics and in computing, as taught in the mathematics program, are less than we might really have expected. Together they constituted about 3 percent of the total enrollments in 1966, but in 1970 they accounted for 5 percent of the total and over 7 percent of the non-remedial subjects. (This does not take into account the enrollments in courses taught outside of the

Table 5.5

DETAILED ENROLLMENTS IN MATHEMATICAL SCIENCE COURSES
IN TWO-YEAR COLLEGES

(In thousands)

	Course	Fall 1966 Enrollment	Fall 1970 Enrollment	Typical Credits*
1.	Arithmetic	15	36	2-3
2.	High School Geometry	5	9	3-4
3.	Elementary Algebra (H.S.)	35	65	3-4
4.	Intermediate Algebra (H.S.)	37	60	3-4
5.	College Algebra	52	52	3
6.	Trigonometry	18	25	3
7.	College Algebra & Trigonometry	15	36	3-5
8.	Elementary Math. Analysis(algebra, etc.)	7	11	4
9.	Basic Concepts (structure, logic)	21	48	3-5
10.	General Math. (basic skills, operations)	17	21	3-5
11.	Finite Mathematics	3	12	3
12.	Mathematics of Finance	4	5	3
13.	Business Mathematics	17	28	3
14.	Math. for Elementary School Teachers	16	25	3-6
15.	Technical Mathematics (pre-calculus)	19	26	3-9
16.	Analytic Geometry	4	10	3-4
17.	Analytic Geometry & Calculus	32	41	5-13
18.	Calculus	8	17	4-9
19.	Technical Mathematics (calculus level)	1	3	3-4
20.	Differential Equations	2	1	3-4
21.	Elementary Statistics	4	11	3
22.	Probability (& Statistics)	1	5	3
23.	Programming of Digital Computers	3	10	3
24.	Other Computer-oriented Mathematics	2	3	3
25.	Linear Algebra	1	1	3
26.	Modern Algebra	L	L	3
27.	Slide Rule	3	9	1
28.	Mathematics for Liberal Arts	1	9	-
29.	Other pre-calculus mathematics	5	4	-
30.	Other advanced mathematics	L	1	-
	TOTALS	348	584	

* Credits may include several semesters for continuing courses under same title. Credits are in semester hours, estimated at the quartiles (unweighted).

Table 5.6

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

Level	Fall 1966	Fall 1970	Increase 1966-1970
Preparatory (Courses 1-4, 10)	109	191	75%
Precalculus Mathematics (5-9, 11-15, 27-29)	181	290	60%
Calculus & Analytic Geometry (16-19)	45	71	58%
Upperclass Mathematics (20, 25-26, 30)	3	3	0%
Statistics (21-22)	5	16	220%
Computing (23-24)	5	13	160%
Total	348	584	68%

mathematical sciences program--especially computing, which is taught extensively in business and technical divisions or departments, which we will discuss subsequently.) In Table 5.6 the enrollments in the mathematical sciences departments are grouped according to the approximate mathematical levels of the courses; the relative growth rates between 1966 and 1970 are shown. When the individual courses of Table 5.5 are grouped in these more general classifications it can be seen that while the amount of course work in preparatory courses has increased more rapidly than the student population, this additional growth has not been inordinate in itself. However, the additional need for such preparatory work is very likely responsible for the relative reductions in calculus and upperclass mathematics since fewer students are able to complete the prerequisites in time to take these subjects during a two-year curriculum.

A comparison of the same levels of mathematical science offerings in the different types of two-year colleges is shown in Table 5.7. To put the magnitude of the offerings in each type of institution in focus we have estimated the total student enrollment and the percentage in full-time attendance; these

Table 5.7

ENROLLMENTS IN MATHEMATICAL SCIENCE COURSES IN TWO-YEAR COLLEGES
BY LEVEL AND INSTITUTIONAL TYPE, FALL 1970
(In thousands)

	Public Colleges			Private Colleges		Total
	Large	Medium	Small	Large	Small	
Preparatory	43	102	32	7	7	191
Pre-Calculus Mathematics	41	156	64	11	18	290
Calculus & Analytics	14	36	15	4	2	71
Upperclass Mathematics	1	2	*	*	*	3
Statistics	6	9	1	*	*	16
Computing	3	6	3	1	*	13
Total course enrollments in Mathematical Science	108	311	115	23	27	584
Total Student Body**	590	1,252	350	48	73	2,313
Percent Full-time Students**	42%	51%	66%	76%	86%	53%
Full-time Equivalent Students	363	847	271	41	66	1,588
Math Courses/FTE Student	0.30	0.37	0.42	0.56	0.41	0.37

*Less than 500. For institutional size, see Table 5.1. **Estimated

estimates are based on data for sample subsets of institutions. Calculation of the corresponding mathematical course enrollments per FTE student makes it immediately apparent that mathematical subjects attract a smaller fraction of the students in the large public colleges. This difference may be attributable in part to the wider variety of other subjects available at these institutions, but we find that a major part of the difference can be accounted for by dividing this group, with the course/student ratio for 25 California colleges being 0.27 while it is 0.34 for the 16 colleges in other states. (The California situation will be discussed later.) At the other extreme, mathematics seems to be taken by more students in the large private colleges; here the course/student ratio is strongly influenced by two technical institutes in which almost every student is enrolled in at least

Table 5.8

FRESHMAN-SOPHOMORE MATHEMATICAL SCIENCE ENROLLMENTS
IN TWO-YEAR AND FOUR-YEAR PUBLIC COLLEGES

Level	Public 2-yr. Colleges (000)	Percent	Public 4-yr. Colleges (000)	Percent
Preparatory/Remedial	177	33%	68	16%
Pre-Calculus Mathematics	261	49%	225	54%
Calculus & Analytics	65	12%	99	24%
Elementary Computing	16	3%	14	3%
Elementary Statistics	12	2%	11	3%
Total	531		417	

one mathematical science (with ratio 1.18!), and a liberal arts college which requires mathematics of all its freshmen.

An interesting comparison can be made between public junior colleges and public four-year colleges (excluding universities) with respect to the level of courses in which students enroll. The percentages for each level in public junior colleges are contrasted in Table 5.8 with data for public four-year colleges as recorded in Tables 2.7 and 2.8. As might be expected, in the junior colleges a larger percentage--about double--of those who take mathematics are enrolled in preparatory work, and a smaller percentage get as far as the calculus. But these figures are deceptive; a comparison of enrollments in preparatory courses with figures for first-time freshmen [A] provides an interesting index, even though it is somewhat rough because there are other students in these preparatory courses. On this basis, the number of enrollments in preparatory courses is approximately 18 percent of the number of first-time freshmen for each group of institutions! A deductive corollary from these two comparisons is that the liklihood that a student might take some freshman or sophomore mathematics course while in college is roughly twice as large if he begins college in a four-year college, even though the liklihood of his taking remedial mathematics is about the same.

Courses in pre-calculus mathematics which were reported under the "other" category, and which are recorded as a group under item 29 in Table 5.5 include courses entitled mathematics for social science, for physical science, for agriculture, for health science, for law enforcement, for accounting, and for secondary school teaching (several instances); numerical methods, logic, introduction to matrices, modern geometry, and algebra combined with analytics. Advanced courses reported under "other" (item 30) include advanced calculus, vector analysis, history of mathematics, statics, theory of real functions, complex variables, engineering graphics, and several instances of descriptive geometry and of matrix analysis. It seems, though, that at least some of these are actually offered as extension courses rather than as part of a regular two-year curriculum.

Availability of Courses

Turning from the actual enrollments in various courses, we show in Table 5.9 the availability of courses in different types of institutions. As might be expected, almost every course is more widely available in large or medium-sized institutions than in small ones. In examining the ranges of subject matter covered by combinations of these specific courses, we find that 92 percent of all two-year institutions offer some type of course involving college algebra (courses 5, 6, 7, or 9), and 84 percent offer trigonometry (courses 6 or 7). Over 91 percent offer calculus and analytic geometry in some form (courses 16-19)--the only exceptions being some business schools and technical centers and some of the smallest colleges. Statistics is offered by 48 percent of the institutions, and by two-thirds of the larger ones. Preparatory mathematical courses (1, 2, 3, 4, or 10) are offered by over 90 percent of the large or medium institutions, by 80 percent of the small public institutions, and almost half of the small private colleges. The last column presents a percentage of all junior colleges which offer each course; the reader is cautioned that since small colleges outnumber the large ones, these percentages do not reflect the percentages of all students to whom these courses are available. In most cases the latter percentages are close to those for medium-sized public colleges.

Major changes from 1966 to 1970 in the availability of individual courses can be ascertained by comparing Table 5.9 with Table B5 of [E], although precise comparison is not feasible because of differences in categorization of institutions by type.

Table 5.9

AVAILABILITY OF MATHEMATICAL SCIENCE COURSES IN TWO-YEAR COLLEGES

Percent of two-year institutions offering each course sometime in 1970-71

Course	Public Colleges Large	Medium	Small	Private Colleges Large	Small	All Colleges
1. Arithmetic	64%	53%	33%	35%	13%	37%
2. High School Geometry	70	35	19	29	3	24
3. Elementary Algebra	94	76	42	24	7	48
4. Intermediate Algebra	91	71	58	47	20	56
5. College Algebra	58	59	58	53	30	53
6. Trigonometry	85	76	58	53	27	64
7. College Algebra/Trig.	48	38	42	53	43	41
8. Elementary Analysis	27	24	17	24	43	25
9. Basic Concepts	36	32	28	18	27	29
10. General Math.	24	18	22	12	20	20
11. Finite Mathematics	45	24	17	18	10	19
12. Math. of Finance	24	18	11	6	10	13
13. Business Math.	33	44	36	35	33	38
14. Math/Elementary Teachers	73	65	53	29	10	48
15. Technical Math.	52	53	50	12	3	41
16. Analytic Geometry	18	26	17	12	7	18
17. Analytics & Calculus	82	79	58	65	43	63
18. Calculus	39	44	42	65	33	41
19. Technical Culculus	27	26	22	12	0	19
20. Differential Equations	70	62	31	41	13	49
21. Elementary Statistics	61	59	33	35	23	41
22. Probability/Statistics	27	15	17	6	13	16
23. Computer Programming	55	44	19	35	7	27
24. Other Computer Math.	33	29	14	12	0	18
25. Linear Algebra	58	15	25	6	0	17
26. Modern Algebra	12	3	6	0	0	4
27. Slide Rule	48	38	22	24	0	24

One traditional course which has decreased significantly over this period is college algebra, which was formerly offered as a separate course by over three-quarters of all institutions with enrollment over 1,000; in 1970 it was offered at only 58 percent of such institutions, being replaced to at least some extent by a combined course in college algebra and trigonometry.

The other course which showed a major decrease was business mathematics, which was formerly taught in about 60 percent of all two-year colleges with enrollment over 2,000, but in 1970 was offered in only about 40 percent of such institutions.

During the same period there were major increases in the availability of half a dozen courses. Perhaps the most significant increase occured in the offering of mathematics for elementary school teachers, which was available in 1966 at only 30 percent of junior colleges, but is now offered at half of all institutions, and at 60 percent of the public colleges. Finite mathematics has increased in availability at both the largest public colleges and the small private ones. Technical mathematics involving calculus, formerly available at less than 10 percent of two-year colleges, is now offered at 25 percent of the public colleges, and a similar situation holds for a course in slide rule. The offering of elementary statistics has increased somewhat in the smaller colleges. Courses in computing, which in 1966 were taught in over half of the junior colleges with enrollment over 5,000, but seldom taught elsewhere, in 1970 were offered in well over half of the institutions with enrollment over 1,500. It should be noted that an increase in availability of a course is not always correlated with a more-than-normal increase in enrollment; of the above courses, only statistics, computing, slide rule, and finite mathematics grew in total enrollment much more rapidly than the student population, as shown in Table 5.5.

Admissions and Placement

In this era of "open admissions", 82 percent of two-year colleges still require some sort of admissions examination which includes mathematics. However, this is a noticeable reduction from four years earlier, when 93 percent of two-year colleges required an admissions examination. Details of admission requirements are given in Table 5.10. The downward trend in admissions examinations is especially evident in the public institutions with over 10,000 enrollment--only 61 percent of these require an examination. Those institutions which require an admissions examination frequently permit the prospective student a choice of examinations, but over half of the public institutions allow the use of the American College Testing (ACT) examinations, whereas the private institutions tend to follow

Table 5.10

PERCENTAGE OF TWO-YEAR COLLEGES
WHICH REQUIRE AN ADMISSIONS EXAMINATION WHICH INCLUDES MATHEMATICS

Type of Institution	Percent requiring admissions exams	Of those requiring examination, Percent which use various exams*					
		(a)	(b)	(c)	(d)	(e)	(f)
Large public colleges	61	5	0	53	5	37	16
Medium public colleges	80	25	0	61	11	11	18
Small public colleges	83	21	14	55	0	0	28
Large private colleges	73	73	18	18	0	0	9
Small private colleges	87	46	15	42	0	0	8
All institutions, 1970-71	82	28	9	53	4	5	20
All institutions, 1966-67	93	20	2	53	10	10	30
All institutions, weighted by total enrollment (1970)	76	21	3	56	7	15	18

* Type of examination:
(a) College Entrance Examination Board, Aptitude Examinations
(b) College Entrance Examination Board, Achievement Examinations
(c) American College Testing (ACT) examinations
(d) State secondary-school achievement examinations
(e) Educational Testing Services, School and College Ability Test (SCAT)
(f) Other; mostly locally prepared
Percentages add to over 100 because some institutions allow alternative examinations.

the private four-year institutions in relying upon the College Entrance Examination Board (CEEB) Aptitude Examinations. Public institutions in the states of New York and Florida usually permit use of the state-wide high-school examination results. No information is available as to how any of the colleges relate admission to the results of the examinations.

Once students are admitted, about half (45 percent) of the junior colleges administer placement examinations in mathematics, usually to determine the courses in which a student may enroll.

Table 5.11

PLACEMENT EXAMINATIONS IN TWO-YEAR COLLEGES

	1966-67	1970-71	
	All instns.	Large colleges	Small colleges
Percent of institutions which administer placement examinations in mathematics	52	49	42
Of institutions which administer placement examinations--			
A. Percent in which exam is taken by:			
1. All entering freshmen	64	37	64
2. Students taking mathematics in college for the first time	24	25	8
3. Students in special curricula (e.g., engineering, etc.)	16	11	12
4. Other (for admission to specific courses, or if so advised)	14	26	12
B. Percent for which placement examination tests for a knowledge of:			
1. Arithmetic	59	62	72
2. Algebra	83	93	88
3. Geometry	31	44	40
4. Trigonometry	46	65	56
5. Other	13	5	4
C. Percent in which objectives are:			
1. To determine which students have the necessary mathematical knowledge to undertake regular college courses	54	34	37
2. To determine mathematical aptitude	34	30	21
3. To section by ability level	15	25	16
4. To determine which course the student may enroll in	70	66	84
5. Other	4	10	4
D. Percent using standardized or nationally distributed examinations	52	66	52

Some details of the trends in placement examinations are given in Table 5.11. It is noteworthy that of those colleges that do not give placement examinations, almost four-fifths have an admissions-examination requirement in mathematics the results of which may be available for placement advising. Even so, the trend since 1966 has been to remove requirements and barriers for students in the larger institutions: whereas 73 percent of the colleges with enrollment over 2,000 gave placement examinations then, only 49 percent of the large and medium institutions did so in 1970.

The placement examinations which are given apparently cover a wider range of mathematical subjects than formerly. In 1970, 90 percent of the tests included algebra, 68 percent included arithmetic, and 42 percent included geometry questions, whereas these subjects were tested in 1966 to the extent of 83, 59, and 31 percent, respectively. The subject of trigonometry is also included in 60 percent of the 1970 tests, as compared with 46 percent in 1966. There is, apparently, little difference between large and small colleges in the content of there examinations; perhaps this reflects the fact that a majority of departments rely upon standardized or nationally distributed examinations for this testing. Over two-thirds of the colleges which administer placement tests give them to all freshmen or to all freshmen taking mathematics; the remainder require them only in certain curricula or for entrance to college-level courses such as college algebra or calculus.

The purpose of admissions and placement examinations is, of course, to ascertain whether students are ready for college mathematics and which courses they are qualified to enter. The actual enrollment of freshmen in the various courses reflects, in some sense, the results of this testing as well as of the faculty advising which (sometimes) follows. We show in Table 5.12 the mathematics enrollments of students who were classified as freshmen in the fall of 1970, as best they could be estimated from the partial responses to this question--apparently a number of chairmen did not have records as to which of their students were classified as freshmen. In this table we have grouped together as "college algebra and equivalent" the courses numbered 5-9, 11-15, and 27-29 of Table 5.5, and courses in statistics and computing have not been included in any of the categories.

In an effort to see whether the initial preparation of junior college students has changed between 1966 and 1970 we have compared in Table 5.13 the fall enrollments for those years. As it happens, the data for the two years are not precisely

Table 5.12

PERCENTAGE DISTRIBUTION OF FRESHMAN ENROLLMENTS IN MATHEMATICS IN TWO-YEAR COLLEGES, FALL 1970

Course Level	Public Colleges			Private Colleges		All
	Large	Medium	Small	Large	Small	Insts.
Arithmetic & General Math	10%	11%	13%	8%	19%	12%
High School Algebra & Geometry	40%	27%	18%	28%	9%	26%
College Algebra & equivalent	41%	55%	61%	52%	67%	54%
Analytics & Calculus	9%	7%	8%	12%	5%	8%

comparable; in 1966 we obtained data for entering freshman, whereas the 1970 data is for all students classified as freshmen. The latter group might be expected to be somewhat more advanced in course assignments; while the table shows a larger percentage of freshmen in 1970 who are taking what is usually considered college-level mathematics, the percentage who have progressed as far as analytical geometry and calculus has diminished in spite of this expectation that the 1970 group would be more advanced at the time of recording the data.

Table 5.13

DISTRIBUTION OF FRESHMAN ENROLLMENTS IN MATHEMATICS IN TWO-YEAR COLLEGES, 1966 AND 1970

	Entering Freshmen Fall 1966		All Freshmen Fall 1970	
	(000)	Percent	(000)	Percent
Arithmetic & General Mathematics	35	12%	51	12%
High School Algebra & Geometry	84	30%	112	26%
College Algebra & equivalent level	124	44%	234	54%
Analytics & Calculus	39	14%	34	8%

Remedial and Prerequisite Courses

The survey respondents were asked whether "prerequisite" instruction in mathematics is offered, with or without credit, to correct the deficiencies of students who are beginning to take college mathematics for the first time. Every institution with enrollment over 1,500 answered affirmatively! Among the smaller junior colleges (all with enrollments under 800), 80 percent of the public institutions and 40 percent of the private ones also answered affirmatively, and several of those who responded negatively to this question listed course offerings (with credit) in arithmetic and high school algebra. Two others reported that they had given up prerequisite offerings during the last five years, one because such courses were given at a neighboring institution, the other because corresponding programmed materials were now avaliable to students on a voluntary basis. On the other hand, over a quarter of the colleges which offer prerequisite work have introduced some or all of it during the last five years. Most of the respondents in this category indicated that specific courses (especially arithmetic and elementary algebra) had been introduced because of student deficiencies which were apparent from placement or admissions examinations. Several very large institutions located in large cities noted that new courses had been added specifically because of new "open" admissions policies with respect to educationally disadvantaged students.

There is no information from our 1970 survey to indicate what distinction, if any, might be made between "prerequisite" and "remedial" course work. Even though the content may not differ much from courses taken, or not taken, in the elementary and secondary schools, credit of some sort is usually given for such courses as college arithmetic, geometry, and elementary or intermediate algebra. We have classified this type of course as "preparatory" in most of the tables above. These tables, especially 5.9, and 5.12, show the extent to which such courses are offered and taken in junior colleges. It will be observed from Table 5.9 that, the larger the institution, the more likely it is to offer preparatory courses. At the same time, the fraction of freshmen enrolled in mathematics who are taking one (or more) of these preparatory courses is shown in Table 5.12 also to be larger in the larger institutions. If we examine the credit status of these preparatory courses, we find, as shown in Table 5.14, that those smaller institutions which do

Table 5.14

CREDITS OFFERED FOR REMEDIAL COURSES IN TWO-YEAR COLLEGES

Course	Percent Offering Course		If course offered, percent offering: No Credit		Remedial Credit		Regular Credit	
College size:	Large	Small	Large	Small	Large	Small	Large	Small
Arithmetic	53	28	16	0	46	39	38	61
High School Geometry	38	14	11	19	47	19	42	62
Elementary Algebra	74	30	14	0	44	48	42	52
Intermediate Algebra	71	46	16	14	24	19	60	67

offer these courses are more likely to give regular credit for them. Most institutions actually offer either regular credit or credit which is designated as remedial--perhaps implying that it may be used for prerequisite purposes and/or is counted as part of the student's credit load, but is probably not available for later transfer credit. It will be seen from Table 5.13 that the fraction of freshmen mathematics students who take preparatory courses has probably not changed materially between 1966 and 1970.

Mathematical Science Courses Taught Outside of Mathematics Program

The information presented so far in this chapter has been limited to those courses in the mathematical science which are taught in the department or division which has the primary responsibility for mathematical instruction. The respondents to the questionnaire were also asked to estimate the enrollments in mathematical science courses which were given by other divisions or departments. These estimates are probably not as reliable as other data presented because the respondents did not have direct responsibility for these offerings; the errors are likely to come from understatement. The estimates of course enrollments for the entire academic year are given in Table 5.15; these

Table 5.15

ESTIMATED ENROLLMENTS IN MATHEMATICAL SCIENCE COURSES
TAUGHT OUTSIDE OF MATHEMATICS PROGRAM IN
TWO-YEAR COLLEGES, ALL TERMS, ACADEMIC YEAR 1970-71

(Enrollment in thousands)

Courses	Enrollment in courses given by division specializing in:					
	Natural Science	Occupational Programs	Business	Social Science	Other	Total
Arithmetic		8	5	1		14
Business Mathematics		3	33	L		36
Statistics		L	4	1	L	5
Probability			1	L		1
Pre-calculus College Math.	4	1	1	L		6
Calculus or Diff. Equations	L	L	L	L	L	L
Computer Science & Programming	2	10	7		2	21
Other courses	L	6	L	L	3	9
Totals	6	28	51	2	5	92

L = some, but less than 500.

figures should be halved to get information comparable to the regular enrollments reported earlier in Table 5.5. It may be noted that the principal course taught outside the mathematics program was business mathematics, with computer programming and arithmetic both strongly represented; all of these courses were taught primarily in the business or occupational programs. Statistics, which was widely taught in other departments in four-year colleges, was not so treated in two-year colleges except for some course efforts by business departments.

Computers and Computing

The availability of computers for educational and research purposes in junior colleges has increased materially over the last four years. While the increased importance of computing may be indirectly evident in some of the data already presented, we will recapitulate such information in this section together with a summary of the responses to special questions on computing. By 1970, approximately 80 percent of the mathematics departments in junior colleges with over 1,500 enrollment had access to a computer or to computer terminal facilities, and 30 percent of the mathematics staffs in the smaller junior colleges had similar access, whereas in 1966, just 63 percent of the larger colleges and 15 percent of the smaller ones had access to computing facilities. We calculate from these figures that in 1970 some three-quarters (74 percent) of junior college students were attending institutions in which computing facilities were available, at least to some extent.

A specific course in "Programming of Digital Computers" (course number 23) was offered by the mathematical sciences faculty in 44 percent of the larger junior colleges, and in 15 percent of the smaller junior colleges, as recorded earlier in Table 5.9. This represents a spectacular increase in four years: in 1966, only 21 percent of the larger institutions, and 5 percent of the smaller one offered such a course. "Other computer-oriented mathematics" courses (number 24) were reported as part of the mathematical sciences offerings by 28 percent of the larger colleges and 10 percent of the smaller ones; taken together with Computer Programming, one or both of these courses were offered by the mathematical sciences departments in 59 percent of the larger colleges and 23 percent of the smaller ones. The total enrollments in these courses are estimated at 10,000 for course 23 and 3,000 for course 24, for the fall semester of 1970.

The area of computing and computer programming is, however, only partly under the aegis of the mathematical sciences faculty. While the latter taught some 13,000 students in the fall of 1970, there were some 21,000 others who studied this subject sometime during the academic year under the auspices of other faculties in 32 percent of the institutions. As shown in Table 5.15, about 10,000 of these students enrolled in computing courses in occupational programs, and another 7,000 in business programs;

the remainder were mainly in courses conducted under auspices of engineering or physical science faculty members. A re-examination of reporting institutions as to whether computing courses are offered, irrespective of which department of division offers them, reveals that some 71 percent of the larger institutions and 39 percent of the smaller ones offer this subject somewhere. (For the smaller institutions, the apparent discrepancy between this report of 39 percent offering computing courses and the earlier report indicating that only 30 percent of the smaller institutions had computing facilities available to the mathematical sciences faculty may in some instances reflect the non-availability to the mathematics faculty of facilities located in the occupational or business areas.)

Specific certificate programs in computer programming are offered by 7 percent of the public junior colleges, and 22 percent of these public institutions offer an associate degree with this major. Those institutions (perhaps about 200) which offer one or both of these programs reported that they awarded an average of 5 such certificates or degrees per program in 1970. Such concentrated programs offering either certificates or degrees appear, however, to be available only in public institutions (perhaps because of the high cost factors); out of the 67 private junior colleges reporting in our survey, only one college (a business college) reported such a program.

Certificate programs in data processing are offered by 13 percent of the public junior colleges, and associate degrees with this subject designation are offered by 29 percent of these colleges. Again, this major is principally available only in the public institutions, although three of the largest private junior colleges do offer an associate degree in data processing. In this field, the 300 or so institutions offering programs averaged 12 awards of either certificates or degrees in 1970.

The data compilations of the U. S. Office of Education in its annual series Associate Degrees and other Formal Awards below the Baccalaureate (OE-54045) cannot be compared readily with the data reported in our survey, but they appear to be reasonably consistent. Associate degrees in arts or science were awarded in 1969-70 to some 206,000 graduates of two-year programs--about 85 percent of these were awarded in two-year institutions--but no subdivision of these by majors is reported. In a classification of "awards in organized occupational curricula" (with some overlap of associate degree awards) USOE for 1969-70 recorded 1,627 awards in scientific data processing by 96 institutions and 4,860 awards in business data processing by 318 institutions, most of which are two-year institutions. The numbers of these awards in scientific and business data processing have trebled and doubled, respectively, over a two-year period--a phenomenal growth. No separate classification of computer programming is provided in these reports to USOE; this field is probably subsumed for the most part in the data processing classifications.

The rapid increase in offerings in data processing, computer programming, and other computing subjects, especially in publicly-supported institutions which charge little or no tuition, may well indicate that these offerings are beginning to meet an educational need which up until very recently was only being accommodated by proprietary schools charging relatively high tuition fees. The availability of these low-cost programs is thus opening up these technical specialties to the economically disadvantaged.

Mathematical sciences departments reported the use of a computer as an adjunct to the teaching of a number of courses other than those in computer science; some 18 percent of the institutions which have access to a computer reported such a usage. About two-fifths of these courses using a computer adjunct were in calculus or differential equations, and about one-fifth were in statistics; the remainder covered a wide range of courses, including arithmetic, algebra, finite mathematics, elementary analysis, technical mathematics, and network analysis.

With respect to use of computers by the faculty, the survey found, as indicated above, that 80 percent of the larger junior colleges and 30 percent of the smaller ones have computing facilities which are available to the faculty. We estimate that 28 percent of the faculty at the institutions which have facilities actually use them in connection with their teaching. In terms of all institutions, this means that about 14 percent of the national junior college faculty make some use of computers in their teaching of mathematics. Table 5.16 shows the percentages of mathematics departments in which the faculty makes minimal, moderate, or high use of computers in teaching, in a classification analagous to that used on page 58 and in Table 4.3 for four-year institutions. A comparison of these two tables reveals that while the teaching use of computers is generally somewhat less in junior

Table 5.16

PERCENTAGES OF MATHEMATICS DEPARTMENTS IN TWO-YEAR COLLEGES REPORTING MINIMAL, MODERATE, AND HIGH USE OF COMPUTERS IN TEACHING

	Minimal Use: Up to 10% of Faculty		Moderate Use: 10% to 25% of Faculty	High Use: At Least 25% of Faculty
	No access:	Access:		
Public Junior Colleges	43%	23%	7%	27%
Private Junior Colleges	80%	9%	3%	8%
Large Junior Colleges	20%	29%	13%	38%
Small Junior Colleges	70%	16%	2%	12%
All Junior Colleges	50%	21%	6%	23%

colleges, the percentage of public junior colleges (and especially the larger ones) which make extensive ("high") use of computers is substantially greater than for public four-year colleges. This may of course indicate that for those junior colleges which emphasize computer usage in their teaching the subjects involved form a larger fraction of a more limited curriculum.

The questionnaire also sought information as to the faculty use of computers for research purposes. This usage turned out to be fairly minimal: while 80 percent of the larger colleges have facilities, only 25 percent of the total group reported any research use at all, and for small institutions, 30 percent of which have facilities, only 8 percent use these facilities for research. For both large and small colleges only about 4 percent of the individual faculty members use the computer for research, as compared with some 11 percent of the faculty at public four-year colleges.

Instruction Techniques

The traditional lecture-recitation system continues as the primary method of instruction in the majority of mathematics classes in junior colleges. In fact, it appears as the only method of instruction used in 50 percent of the smaller institutions and in 24 percent of the larger (and medium-sized)

Table 5.17

TECHNIQUES OF INSTRUCTION IN JUNIOR COLLEGES

Percent of junior colleges in which mathematics faculty make use of non-traditional methods of instruction.

Technique	1966-67 Enrollment over 2000	1966-67 Enrollment under 2000	1970-71 Colleges Large	1970-71 Colleges Small
Large lecture classes with small quiz sections	15%	5%	8%	5%
Large lecture classes with help sessions	10	10	11	16
Organized program of independent study	11	10	29	20
Television courses: broadcast or closed-circuit	9	2	3	2
Film courses	1	0	2	2
Courses by programmed instruction	52	16	49	24
Computer-assisted instruction (CAI)	7	1	10	1
Other special techniques	8	11	15	18

institutions. Other techniques of instruction are being used, at least in some classes, but the pattern of innovative techniques of instruction is pretty much the same in 1970-71 as it was in 1966-67, as shown in Table 5.17. There continues to be a rather widespread reliance upon programmed instruction, with half of the larger institutions making some use of programmed methods, apparently primarily in arithmetic, elementary algebra, and other review or remedial subjects. Organized independent study has significantly increased, with 29 percent of the larger institutions and 20 percent of the smaller ones reporting programs of this type.

The increased amount of instruction in review and remedial mathematics has been accompanied by an increase in various methods of auxiliary assistance to students. In addition to the substantial use of programmed instruction, other kinds of auxiliary efforts are reported by a number of institutions. Among these, computer-assisted instruction, audio-tutorial programs, videotape replay systems, tape cassettes, tutorial sessions, and mathematics or computing laboratories were reported by the larger institutions, while the smaller institutions mentioned individualized attention, peer-group instruction, special help sessions for slow students, and team teaching, as well as learning laboratories. However, the use of filmed courses or broadcast or closed-circuit television for instruction in the mathematical sciences was not reported except at a handful of institutions.

Large lecture classes supplemented by quiz sections are in vogue at only 8 percent of the large institutions as compared with 15 percent four years earlier. On the other hand, in the smaller institutions there has been a trend toward the use of large lecture sections supplemented by help sessions. Approximately one-fifth of the small, public institutions are using this approach to reach the student as an individual.

Coordination of Transfer Programs with Four-year Institutions

The articulation of junior college transfer programs with the curricular offerings and requirements of the four-year institutions to which the junior college students may transfer is of obvious importance in mathematics because of the sequential nature of the subject matter. One method of possible correlation of programs is through state action; our survey results indicate that the course offerings and/or curricula in mathematics were subject to state control or approval for 70 percent of the public institutions but only 32 percent of the private colleges. Of course, it does not necessarily follow from the existence of state accreditation requirements or even state boards of administrative control that there is careful coordination--or some degree of uniformity--in the content and packaging of offerings in a specific subject area. Thus the survey sought information as to the nature of specific articulation of the mathematical sciences offerings in those junior colleges which offer college-transfer programs with the mathematics programs of four-year institutions. As shown in Table 5.18, the most prevalent method of coordination was through direct and regular consultations between the staff members of the junior colleges and those of the senior institutions. Official state-wide coordination, at the level of the mathematics staffs, was in effect for about a quarter of the junior colleges, both public and private, and a number of other means were employed to achieve coordination. Altogether, some form of articulation was in effect for virtually all of the public junior colleges, but only for about three-quarters of the private

Table 5.18

COORDINATION OF TRANSFER PROGRAMS OF JUNIOR COLLEGES WITH THOSE OF FOUR-YEAR INSTITUTIONS

	Public Junior Colleges	Private Junior Colleges
Course offerings or curricula subject to state approval	70%	32%
Coordination of junior college offerings in mathematics with those of four-year institutions, through:		
a. an official state-wide coordination program	28%	23%
b. regular consultations of mathematics staffs	81%	63%
c. other coordination activities (see text)	39%	20%
One or more of the above means of coordination:	98%	72%

Note: Business and technical schools whose programs are principally terminal rather than for transfer credit are excluded from this tabulation.

junior colleges. Perhaps the remainder of the private colleges feel that adequate coordination is achieved unilaterally by their use of traditional courses or standard textbooks.

The most frequently mentioned "other" means of coordination were a number of cooperative projects for regional groupings of two-year colleges in conjunction with a nearby university, conducted under grants from the National Science Foundation in its College Science Improvement Program. Several respondents noted collaborative discussions arising in, or resulting from, regional Section meetings of the Mathematical Association or meetings sponsored by the Association's Committee on the Undergraduate Program in Mathematics. In some cases in which the junior college is part of a state education system, coordination is automatically induced because of uniformities of the system. Other examples cited included coordination which resulted from teacher interchange, from attendance of junior college faculty members at university colloquia and mathematics clubs, and from sharing either facilities or faculty members.

California Junior Colleges

The extensive California junior college system consists of 90 public junior colleges with a total 1970-71 enrollment of some 689,000 full- and part-time students. These colleges are administered not as a state-wide system but on a county or local basis. As we noted on page 71, these colleges enroll some 31 percent of all junior college students in the country. They are typically large, averaging 7,600 students, and the group includes 25 which have over 10,000 students. However, only 42 percent of the students are full-time, as compared with 58 percent full-time in junior colleges in all other states.

We have examined the responses from the California colleges in our sample to see in what respects their mathematics programs deviate from those of junior colleges in other states. One important difference, as we observed earlier, appears in the ratio of mathematics course enrollments to the full-time equivalent student body; this ratio was exceptionally low in the 25 large California junior colleges--only 0.27 as compared with 0.37 for the entire country. To get a better fix on this, we have separated the mathematical courses according to levels (cf. Table 5.7), and calculated the course/student ratio for each level, as shown in Table 5.19. This table shows that slightly more preparatory-remedial work is taken by California students--but this may only reflect the fact that a larger percentage of California high school graduates continue on to higher education, so that the comparatively less able are in junior college in higher proportions. The principal difference, however, is in the pre-calculus category of courses, of which California students take less than other students. Why? Part of the cause may be related to the remedial situation: those who must take remedial mathematics in the fall semester cannot register for regular college courses until the spring. The figures in Table 5.19 do not indicate, however, that this is a major factor. Another possibly related factor lies in the analytic geometry-calculus sequence; although California students take about the same amount of these subjects as students in other states, over 70 percent of the California registration is in a combined course (#17) carrying 12 to 16 credits, whereas about half of the students in other states take separate courses (#16 and #18). The combined course, which is presumably designed to be parallel to that offered in the senior institutions in California, may encompass a number of topics in pre-calculus mathematics, but we do not have evidence of this and

Table 5.19

MATHEMATICS COURSES PER STUDENT IN CALIFORNIA JUNIOR COLLEGES

Course Level	Courses per full-time-equivalent student in: 25 Large Public Colleges in California	65 Other Public Colleges in California	All Colleges not in California
Preparatory/Remedial	0.13	0.14	0.12
Pre-Calculus Mathematics	0.08	0.09	0.22
Analytics & Calculus	0.04	0.05	0.04
Upperclass Mathematics, Statistics, and Computing	0.02	0.02	0.02
Total courses/FTE student	0.27	0.30	0.40

in any case the California registration in the calculus sequence is not inordinately high. One might conclude that either the California students are more apt to enroll in curricula which do not require mathematics beyond the remedial, or that California high schools prepare their better students in such a way that they do not need this traditional freshman mathematics. Unfortunately, we have no evidence to sustain either view.

The situation in large California junior colleges might be compared with that in a group of four large State University of New York junior colleges which are in the same sample group. In these the ratio of course enrollments to FTE students (as compared with the first column of Table 5.19) was: preparatory, 0.09; pre-calculus, 0.16; analytics and calculus, 0.05, and other, 0.11; total, 0.41. The lower figure for preparatory mathematics in the SUNY institutions may reflect the better minimum secondary school preparation under the requirements of the New York State Board of Regents. The surprising figure for "other" includes a large 0.09 course/student for elementary statistics, which could have been counted as part of the precalculus level. The actual number of statistics course registrations in the four SUNY colleges was over three times the total for the 25 large, and comparable, California colleges. (If the 43 two-year colleges in the SUNY system had not, by chance, been underrepresented in our sample, the evident contrasts between this group and the California group could have been better portrayed.)

Although the California junior colleges enrolled relatively few students in regular college courses at the pre-calculus level, they enrolled larger than average numbers in such courses as arithmetic, elementary algebra, trigonometry, and slide rule. Such courses may be quite needed; however, a greater expectation in college-level mathematics, statistics, and computing would appear to be socially useful also.

Technical Institutes

Our respondent group included two very large technical institutions specializing in the occupational trades; these offered very little mathematics. Excluding these, and one agricultural-technical college, there were ten smaller technical institutes and technical education centers, varying in size from 200 to 2,800 FTE students. (The two-year college universe probably contains close to 100 such institutions.) The mathematics course per FTE student ratios, as used in Table 5.19 above, were: preparatory, 0.15; pre-calculus, 0.28; analytics and calculus, 0.18; and other, 0.08, totalling 0.69--almost twice as much in each category as in other two-year institutions. This probably should be interpreted as indicating that a larger proportion of students take mathematics, not that individuals take more courses. The course enrollments were, by and large, concentrated in rather traditional combined courses such as college algebra and trigonometry and analytics and calculus. Very little enrollment was reported except in traditional courses in mathematics, except that one institute offered considerable statistics and two others extensive computing. The preparatory-remedial offerings seemed quite consistent with other two-year institutions.

Chapter VI

THE TWO-YEAR COLLEGE MATHEMATICS FACULTY

In this chapter we will examine the characteristics of the mathematical sciences faculty of two-year colleges. In summary, we are able to report that the number of faculty assigned to mathematics teaching has increased in the last four years somewhat more rapidly than has the student course load assigned to them. At the same time, the qualifications which the faculty bring to the teaching of mathematics have increased quite markedly, as measured by several different yardsticks of qualification.

The study of junior college faculties in the mathematical sciences as of 1966-67 which was reported in 1967 in our Volume I was the first such which provided data related in detail to the subject field. Subsequently, the National Science Foundation has issued (1969) a study [P] of the entire junior college science faculty, also as of 1966-67, which includes considerable data on teachers of mathematical subjects. Although the analysis has quite a different statistical base--using courses taught rather than faculty as individuals, for reasons more pertinent to science fields than to mathematics--the data that are comparable are quite consistent with the CBMS data for the same year. For example, the NSF study showed that 3 percent of the courses in mathematics (counting several sections taught by one individual as a "course") were taught by holders of a doctorate degree; the CBMS report showed that 3.7 percent of the full-time mathematics faculty, and 1.3 percent of the part-time faculty, held a doctorate: these estimates are quite consonant. For those especially interested in faculty characteristics, the NSF study is a useful source.

Our current survey shows that the two-year college faculty in mathematics (i.e., the mathematical sciences) in 1970-71 consisted of 4,879 full-time and 2,213 part-time individuals. Using the conventional estimate of one-third as the equivalent load for part-time faculty, this gives a total of 5,616 for the full-time

Table 6.1

TWO-YEAR COLLEGE MATHEMATICS FACULTY, 1970-71

	Full-Time Faculty	Part-Time Faculty	Average FTE Faculty Per Institution
41 Large Public Colleges	723	457	21.3
330 Medium Public Colleges	2,680	1,056	9.2
405 Small Public Colleges	1,055	495	3.0
24 Large Private Colleges	134	79	6.7
203 Small Private Colleges	287	126	1.6
Total	4,879	2,213	5.6

equivalent (FTE) faculty in the mathematical sciences. The spread of these among the different types of colleges is shown in Table 6.1. The actual range of department size varied from 45 full-time faculty in the largest junior college, and 31 full-time and 69 part-time (54 FTE) in another very large institution, to only one part-time individual, as reported by several very small colleges.

Faculty Qualifications

The formal educational qualifications which these faculty members brought to their tasks are exhibited in Tables 6.2 and 6.3. The details shown in these tables are based, as is the rest of our survey, upon an extrapolation from sample studies, and clearly the accuracy which is implied by the exhibited data is not warranted at this fine structure level except as raw material for the succeeding tables which recapitulate this same data in larger cells which therefore have greater probable accuracy.

How does one measure the quality of a faculty group? There are obviously many aspects of quality which cannot be measured, not the least of which is teaching effectivess. But from information provided by the faculty themselves, the best we can do

Table 6.2

EDUCATIONAL QUALIFICATIONS OF FULL-TIME TWO-YEAR COLLEGE MATHEMATICS FACULTY, 1970-71

	Doctorates in			Master's + 1 yr.in			Master's in			Bachelor's in			TOTAL
	Math Sci.	Math Ed.	Other Field	Math Sci.	Math Ed.	Other Field	Math Sci.	Math Ed.	Other Field	Math Sci.	Math Ed.	Other Field	
Public Junior Colleges	95	53	51	1,496	437	151	1,222	522	138	151	83	59	4,458
Private Junior Colleges	14	3	11	84	8	15	178	42	32	20	1	13	421
Total	109	56	62	1,580	445	166	1,400	564	170	171	84	72	4,879

Table 6.3

EDUCATIONAL QUALIFICATIONS OF PART-TIME TWO-YEAR COLLEGE MATHEMATICS FACULTY, 1970-71

	Doctorates in			Master's + 1 yr.in			Master's in			Bachelor's in			TOTAL
	Math Sci.	Math Ed.	Other Field	Math Sci.	Math Ed.	Other Field	Math Sci.	Math Ed.	Other Field	Math Sci.	Math Ed.	Other Field	
Public Junior Colleges	110	16	64	384	71	168	573	173	168	186	34	61	2,008
Private Junior Colleges	8	0	8	25	8	8	49	10	43	24	1	21	205
Total	118	16	72	409	79	176	622	183	211	210	35	82	2,213

Table 6.4

HIGHEST DEGREES HELD BY TWO-YEAR COLLEGE
MATHEMATICS FACULTY, 1966-67 AND 1970-71

		Doctorate	Master's + 1 yr.	Master's	Bachelor's
Full-Time Faculty					
Public Colleges	1970-71	4.5%	46.7%	42.2%	6.6%
Private Colleges	1970-71	6.7%	25.4%	59.8%	8.1%
All Junior Colleges	1970-71	4.7%	44.9%	43.7%	6.7%
All Junior Colleges	1966-67	3.7%	28.4%	55.8%	12.0%
Part-Time Faculty					
All Junior Colleges	1970-71	9.3%	30.0%	45.9%	14.8%
All Junior Colleges	1966-67	1.3%	19.9%	49.6%	29.2%

statistically is to use the normal academic measure of formal educational qualifications, and to try to interpret them in the light of their relationship to the assigned tasks. We will examine here three ways of looking at this data--total educational sophistication, interest in mathematics, and the amount of mathematics studied. In each of these aspects, whatever the faculty's real qualifications, we can at least make a comparison with the data for 1966-67 which are recorded in our previous volume [E], page 74.

General educational sophistication may be measured by the highest degree which has been achieved by an individual, whatever his field; Table 6.4 shows the highest degrees earned by the mathematics faculty covered in the two surveys. It may be noted that for the full-time faculty, the percentage of doctorates has increased somewhat, while the percentage of those with only a bachelor's degree has been cut almost in half; at the same time half of the master's degree holders now have had an additional year of studies, as compared with one-third in 1966-67. And the part-time faculty, which in 1966-67 was noticeably inferior to the full-time faculty in its degree qualifications, has improved considerably. In fact, the percentage of doctorates among the part-time faculty is now twice that of the full-time faculty; and although the percentage of bachelor's degrees--15 percent--is still distressingly large, it is only half of the former figure.

Table 6.5

FIELD OF HIGHEST LEVEL OF TRAINING OF TWO-YEAR COLLEGE MATHEMATICS FACULTY, 1966-67 AND 1970-71

Field of Highest Degree	Full-Time Faculty 1966-67	Full-Time Faculty 1970-71	Part-Time Faculty 1966-67	Part-Time Faculty 1970-71
Mathematical Sciences	63%	67%	47%	61%
Mathematics Education	23%	23%	21%	14%
Non-mathematical Fields	14%	10%	32%	25%

The choice of the mathematical sciences as their subject of primary interest is demonstrated by grouping faculty members according to the major field of their highest degree, as shown in Table 6.5. In this respect the full-time faculty has turned toward mathematics, but only slightly, over a four year period, but the part-time faculty shows a much greater change. Undoubtedly the greater availability of individuals with advanced mathematical training in recent years has facilitated this shift, and it is more pronounced among the portion of the faculty with part-time assignments--those to whom the institutions do not have a long term commitment for retention.

The amount of mathematics in the educational background of faculty members is harder to measure. As a rough estimate we have considered the typical amount of mathematics which might be expected as represented in the various degrees, and have grouped these in a hierarchical arrangement of the full-time faculty, as shown in Table 6.6. It is evident from this table that the subject matter background of teachers of the mathematical sciences has increased substantially, and especially so at the top level. At the other end of the scale, those who do not have even an undergraduate major in mathematics have not only decreased as a percentage but have not increased in absolute numbers--among the part-time faculty (not shown in the table) the number has been actually reduced by some 40 percent.

We thus conclude that the quality of the junior college mathematics faculty, as measured by its educational qualifications in any of the above aspects, has improved markedly during the

Table 6.6

MATHEMATICAL LEVEL OF FULL-TIME JUNIOR COLLEGE MATHEMATICS FACULTY, 1966-67 AND 1970-71

Mathematical Level of Faculty	Faculty in 1966-67		Faculty in 1970-71	
	Number	Percent	Number	Percent
Doctorate in Mathematical Science	11	0.4%	109	2.2%
Master's + 1 yr. in Math. Science or Doctorate not in Math. Science	626	23.4%	1,698	34.8%
Master's in Mathematical Science or Master's + 1 yr. not in Math.Sci.	1,176	44.0%	2,011	41.2%
Bachelor's in Mathematical Science or Master's not in Math. Science	711	26.5%	905	18.6%
Bachelor's not in Math. Science	153	5.7%	156	3.2%
	2,677		4,879	

four year interval. It seems highly probable that this improvement will continue at least for the near future, if we can judge from the increased availability of individuals with advanced training in mathematical subjects. As a straw in the wind, we note that the American Mathematical Society's annual salary survey [K] indicates that for 168 junior colleges which reported for both 1970-71 and 1971-72 the percentage of doctorates increased from 4.6 percent to 5.6 percent. It might be noted that, although the AMS "sample" is self-selected and not necessarily unbiased, the 1970-71 figure agrees essentially with the 4.7 percent obtained in our survey.

Faculty Utilization

Teaching effectiveness is also related to the conditions under which faculty members work, and a major consideration is, of course, the work load. As a measure of this, we present in Table 6.7 some comparisons of total course enrollments in the mathematical sciences with the size of the faculty. Between

Table 6.7

COURSE ENROLLMENT AND FACULTY COMPARISONS, 1966-67 AND 1970-71

	1966-67	1970-71			Change
	All Junior Colleges	Public Junior Colleges	Private Junior Colleges	All Junior Colleges	1966-67 to 1970-71
Course Enrollments	348,000	534,000	50,000	584,000	+ 68%
Full-Time Faculty	2,677	4,458	421	4,879	+ 82%
Part-Time Faculty	1,318	2,008	205	2,213	+ 66%
FTE Faculty	3,116	5,127	489	5,616	+ 80%
Enrollments per Full-Time Faculty	130	120	119	120	- 8%
Enrollments per FTE Faculty	112	104	102	104	- 7%

FTE = full-time equivalent = full-time plus one-third of part-time.

1966-67 and 1970-71 the fall course enrollment increased by 68 percent, along with the total student enrollment in the junior colleges, but the full-time faculty in the mathematical sciences increased by 82 percent and the FTE faculty by 80 percent; this relative increase in the faculty as compared with course enrollments has resulted in a decrease of 7 percent in the student/faculty ratio from 112 to 104. It is however still true that the student/faculty ratio for junior colleges is much higher than the ratios of 68 and 70 which obtain in public and private four-year colleges (with 55 the ratio in universities), as shown in Table 3.21. Although this difference may be explainable in part by the larger number of small advanced classes in the four-year institutions, the individual attention which may be needed in the larger number of remedial courses given in junior colleges should properly lead to small sections for these students also.

It is more likely, however, that the higher student/faculty ratio for junior colleges is in large part related to the heavier

Table 6.8

PERCENTAGES OF TWO-YEAR COLLEGES HAVING GIVEN TEACHING LOADS FOR MATHEMATICAL SCIENCE FACULTY, 1970-71

Teaching Load	Large Colleges	Small Colleges	All Two-Year Colleges
9 to 11 Hours	0%	4%	2%
12 Hours	12%	16%	14%
13 or 14 Hours	5%	15%	11%
15 Hours	71%	45%	56%
16 or 17 Hours	9%	10%	10%
18 Hours or more	3%	10%	7%
Average	14.8 hrs.	14.8 hrs.	14.8 hrs.

credit-hour teaching loads which obtain in the junior colleges. Our survey indicates that a credit-hour teaching load of 15 hours per week is almost universal--71 percent of the larger colleges report this as their standard. The teaching load for both large and small colleges averages 14.8 hours, although, as Table 6.8 shows, there is greater variation in the load for small colleges because of the logistical problem of making assignments for a small faculty. This average teaching load has not changed since our survey of four years earlier, and it is in sharp contrast with that for four-year colleges (excluding universities), in which, as we have seen in Table 3.14, the median load is 12 hours with the mean slightly less.

If the typical professor in a four-year college teaches four sections for his 12 hours' load, his class size would average 17 students, and if he has only three sections for his 12 hours the class size would be 23. In contrast, the 15 hour teacher in a junior college would have either five classes of 21, four classes of 26, or possibly three classes of 35 each! It is evident that class size in junior colleges exceeds that in four-year institutions, even when the faculty teaches one more class.

Faculty Leadership

Although only 4 percent of the junior college faculty in mathematical science hold a doctorate in some field, these individuals are dispersed throughout the colleges in such a way that 31 percent of the 395 larger institutions and 14 percent of the 608 smaller ones have at least one full-time doctorate on the faculty--an individual who is presumably trained for educational leadership. At the other extreme, our projections indicate that about ten percent of the smaller institutions have no full-time mathematical faculty at all. The 395 large and medium junior colleges have an average mathematical faculty of 9 full-time individuals, aided by 4 part-time ones. If it is reasonable to suppose that at least one of the full-time members might be qualified at the doctorate level, this could be achieved with some 275 additional doctorates. The present availability of qualified mathematical scientists should make this possible in the relatively near future.

Faculty Supply and Demand

We have seen in Table 6.7 that the full-time faculty in junior colleges increased by 82 percent in the period between 1966-67 and 1970-71. This represents an annual increase rate of about 16 percent, and indicates that in the last year of this period the full-time faculty increased by a net of 650 to 700 individuals. According to our survey, this increase was accomplished by hiring some 878 new faculty members from sources outside of the existing full-time faculty, as shown in Table 6.9.

Particularly noteworthy among the (projected) figures in this table is the number of holders of doctorates, 138--about 15 percent of the new faculty. Since, by our figures in Table 6.2, the total full-time faculty in 1970-71 included only 227 doctorates, this appears to initiate a trend. However, there had been a total net increase in doctorates on the faculty of only 127 over the four-year period since 1966; there thus must have been a number who had left junior college teaching during that time. Furthermore, a study of new doctorates in the mathematical sciences awarded in 1969-70 (see the CBMS Newsletter, January 1971, pp. 2-4) revealed that few, if any, of these new doctorates took positions in junior colleges; the 79 doctorates shown in the table as coming from graduate school must have been

Table 6.9

SOURCES OF NEW FULL-TIME MATHEMATICS FACULTY IN TWO-YEAR COLLEGES, 1970-71

Source	Doctorates	Non-Doctorates	Total
From Graduate School	79	311	390
From Four-year Institutions	20	114	134
From Secondary School Teaching	0	151	151
From Part-Time Employment in Institution	0	38	38
From Non-Academic Positions	13	98	111
From Other Sources, or Unemployed	26	28	54
Total New Two-Year College Faculty	138	740	878
Transfers Between Two-year Colleges	0	55	55

almost all in mathematics education or some non-mathematical field. The remaining 59 newly-hired doctorates may, we think, include a number in mathematical science, including some who have been displaced from four-year colleges because of insufficient tenure positions being available there.

It appears from the above calculations that some 200 individuals left the occupation of junior college teaching between 1969-70 and 1970-71, at least 50 of these being holders of the doctorate. Unfortunately, our junior college questionnaire did not seek information as to where they went.

Respondents to our questionnaire did indicate quite universally that they had no difficulty in recruiting new faculty members. In fact, the only reservations in their replies came from two chairmen in small private colleges who felt that their particular salary scales were insufficiently attractive. Except in a few cases, however, salaries for mathematical faculty in junior colleges, as shown in the American Mathematical Society's salary survey [K], appear to be quite competitive with those in institutions which grant the bachelor's as the highest degree, at all ranks from instructor to professor.

Asked how many additional full-time faculty members they planned to seek for 1971-72, the responding chairmen gave replies which, when projected, added up to 80 doctorates and 463 non-doctorates, exclusive of replacements for departing faculty. This is almost as many as the net hiring for the previous year, and the percentage of doctorates desired is also the same. The addition of this number would have provided an 11 percent growth in faculty positions, which is reasonably consistent with the 13 percent increase in total student enrollment which actually occurred. It may be noted that the AMS salary survey figures indicated a faculty increase of only 4 percent for the one-sixth of the colleges which reported; however, these reports were submitted in July and do not therefore include late hiring. The parallel survey made by AMS of new doctorates' placement would indicate that as many as 25 of these new doctorates in the mathematical sciences took positions in junior colleges for 1971-72; while this number is relatively small, it represents a radical departure from previous years and may be a harbinger of those to come.

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Conference Board
of the Mathematical Sciences

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

Telephone: (202) 293-1170

November 20, 1970

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, national organizations, or government bodies such as the National Science Foundation depends on having a base of accurate, current 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 members are named on the last sheet, 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 three reports: on undergraduate, graduate, and 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 branches of the mathematical sciences.

A pioneer survey of undergraduate programs in mathematics was made by Clarence B. Lindquist of the U.S. Office of Education in 1960. Our Survey Committee extended this work with a 1965 survey which is reported in the first of the volumes of our series. The present study, which is supported by the National Science Foundation, will give a timely re-assessment of undergraduate curricula, reflecting and highlighting the many changes which are taking place as a result both of the work of the many panels of the MAA Committee on the Undergraduate Program in Mathematics and of the computer revolution. The current situation in employment in the mathematical sciences adds urgency to this current study.

The Committee has made every effort to limit this questionnaire to those questions which are of the greatest significance to the mathematical community. We have, however, consulted a variety of sources to make sure that this survey will answer their needs and cut down on the number of separate questionnaires that might otherwise be sent. Questions for which the answers are easily available from other sources have been omitted, and the resulting questionnaire is in fact less than half the size of the one used in 1965. Your institution has been selected as one of 300 which form a scientific sample of the set of universities and four-year 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 December 15, 1970. We shall be pleased, in turn, to send you a copy of the resulting printed report.

Sincerely yours,

Gail S. Young
Chairman
CBMS Survey Committee

OMB No. 99-S70009
Approval Expires 12/31/71

SURVEY OF UNDERGRADUATE PROGRAMS IN THE MATHEMATICAL SCIENCES

1970-71

General Instructions

You are asked to report on programs in the mathematical sciences under your cognizance. Programs under the cognizance of other department heads, if any, will be reported by these department heads. Although many colleges will have a department of mathematics only, larger colleges and universities may have one or more of the following kinds of separate mathematical science departments: statistics, applied mathematics, computer science, actuarial science, mathematics education, and possibly others. Each such department is requested to fill out the entire questionnaire as it applies to that department, insofar as the questions are applicable to the department. Do not include data for branches or campuses which are administratively separate.

For each institution in the sample, this questionnaire is being sent to all heads of departments in the mathematical sciences which are listed in the 1970 Administrative Directory published by the American Mathematical Society.

(a) Does this Administrative Directory list all departments in the mathematical sciences at your campus or branch? ___ Yes ___ No

(b) If not (or if you do not have a Directory to check), please list the names of the other departments and their chairmen here:

__________________ __________________

__________________ __________________

Please complete and return one copy by

December 15, 1970

I. Name of your institution: ____________

Name of your department : ____________

Plan under which your institution operates:

1. ____ semester
2. ____ quarter
3. ____ trimester
4. ____ other (specify) ____________

II. Approximate enrollment of your branch or campus:

	Undergraduates	Total
Full-time Students		
Part-time Students		

III. Prerequisite Instruction

A. Is prerequisite instruction in mathematics (for credit or without credit) offered by your institution, now or in some following term, to correct the deficiencies of students who are beginning to take college mathematics for the first time? ___ Yes ___ No

B. If prerequisite instruction is not offered now, has it been offered at any time during the past 5 years as part of the regular college mathematics program? ___ Yes ___ No

C. If answer to (B) is Yes, in what year and for what reason was such prerequisite instruction as a part of the regular college mathematics program discontinued?

D. If prerequisite instruction is offered now, is this a new or additional offering begun during the last 5 years? ___ Yes ___ No

E. If answer to (D) is Yes, in what year and for what reason was prerequisite instruction introduced or enlarged?

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).

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 number of credit hours given for the courses (total number of credit hours if the course is given in two or more parts). In column (4) write the total number of students who enrolled in (any part of) the course in the fall term of 1970. For a course not offered in Fall 1970 but offered sometime, write "0".

c. In column (5) give the approximate number of freshmen, and in column (6) the approximate number of graduate students (no matter what their major) who are included among those counted in column (4).
Note: If it is quite impractical to supply reasonable estimates in either column (5) or column (6), or both, please check here, and omit these columns: (5)___; (6)___.

d. Indicate here the units in which credit is measured:

_____ semester-credit hours

_____ quarter-credit hours

_____ other; specify: ____________

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

GCMC: courses suggested by the Mathematical Association of America Committee on the Undergraduate Program in Mathematics, General Curriculum in Mathematics for Colleges. (1965). Available from CUPM, Box 1024, Berkeley, Calif. 94701.

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	No. of Credit Hours for the Course	Total No. of Students Enrolled Fall 1970	No. of Freshmen Included in No. in Col. 4	No. of Graduate Students Included in Col. 4
(1)	(2)	(3)*	(4)	(5)	(6)
1. Arithmetic for College Students					
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. Math Analysis (algebra, etc.) GCMC:0					
9. Basic Concepts (structure, logic, sets)					
10. General Math (basic skills, operatns)					
11. Finite Mathematics					
12. Math of Finance					
13. Business Math					
14. Math for Elementary School Teachers					
15. Other pre-calculus: specify					

*If this is a remedial or pre-requisite course, put "R" in this column after the number of credits.

Name of Course (or equivalent)	Title and Author(s) of Text	No. of Credit Hours for the Course	Total No. of Students Enrolled Fall 1970	No. of Freshmen Included in No. in Col. 4	No. of Graduate Students Included in Col. 4
(1)	(2)	(3)	(4)	(5)	(6)
16. Analytic Geometry					
17. Analytic Geometry & Calculus					
18. Calculus GCMC:1,2,4					
19. Advanced Calculus GCMC:5					
20. Differential Equations					
21. Partial Differential Equations					
22. Real Analysis GCMC:11,12					
23. Complex Variables GCMC:13					
24. Vector Analysis					
25. Advanced Math for Engineers & Physicists					
26. Fourier Series & Boundary Value Probs.					
27. Geometry Survey GCMC:9					
28. Projective Geometry					
29. Differential Geometry GCMC:9alt.					
30. Topology					
31. Graph Theory					

IV. Undergraduate Courses in Mathematics

Name of Course (or equivalent)	Title and Author(s) of Text	No. of Credit Hours for the Course	Total No. of Students Enrolled Fall 1970	No. of Freshmen Included in No. in Col. 4	No. of Graduate Students Included in Col. 4
(1)	(2)	(3)	(4)	(5)	(6)
32. Linear Algebra GCMC:3					
33. Modern Algebra GCMC:6					
34. Matrix Theory					
35. Theory of Equations					
36. Combinatorial Algebra					
37. Foundations of Math.					
38. Theory of Numbers					
39. Set Theory					
40. Operational Math.					
41. History of Math.					
42. Math Logic					
43. Math for Sec. School Teachers (methods, etc.)					
44. Calculus of Finite Differences					
45. Applied Math. (models) GCMC:10					
46. Theoretical Mechanics					
47. Ecological Mathematics					

Name of Course (or equivalent)	Title and Author(s) of Text	No. of Credit Hours for the Course	Total No. of Students Enrolled Fall 1970	No. of Freshmen Included in No. in Col. 4	No. of Graduate Students Included in Col. 4
(1)	(2)	(3)	(4)	(5)	(6)
48. Elementary Statistics (no calculus prereq.)					
49. Probability (& Stat.) (no calculus prereq.)					
50. Math. Statistics (Calculus) GCMC:7S					
51. Probability (Calculus) GCMC:2P/7P					
52. Applied Statistical Analysis					
53. Design & Analysis of Experiments					
54. Sampling Methods					
55. Analysis of Variance					
56. Stochastic Processes					
57. Time Series Analysis					
58. Multivariate Analysis					
59. Nonparametric Statistics					
60. Operations Research (Queuing/Optimization)					
61. Senior Seminar					
62. Independent Study or Honors Course					
63. Senior or Honors Thesis					

IV. Undergraduate Courses in Mathematics

Name of Course (or equivalent)	Title and Author(s) of Text	No. of Credit Hours for the Course	Total No. of Student Enrolled Fall 1970	No. of Freshmen Included in No. in Col. 4	No. of Graduate Students Included in Col. 4
(1)	(2)	(3)	(4)	(5)	(6)
64. Intro. to Computing ACM: B-1					
65. Computers and Programming ACM: B-2					
66. Intro. to Discrete Structures ACM: B-3					
67. Numerical Calculus ACM: B-4					
68. Data Structures ACM: I-1					
69. Programming Languages ACM: I-2					
70. Computer Organization ACM: I-3					
71. Systems Programming ACM: I-4					
72. Compiler Construction ACM: I-5					
73. Switching Theory ACM: I-6					
74. Sequential Machines ACM: I-7					
75. Numerical Analysis ACM: I-8&9					
76. Other: specify					

V. To what extent are courses in the mathematical sciences (comparable to those listed in Question IV) taught in divisions and departments <u>other than</u> 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 undergraduates in undergraduate-level courses:

	Enrollment in courses given by divisions specializing in:							
	Biol. Science	Physical Sciences	Engineering	Agriculture	Education	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 Programing								
8. Biomathematics								
9. Mathematics of Finance, etc.								
10. Other: specify								

VI. A. Does your institution have a requirement, institution-wide, that every student, in order to graduate with a baccalaureate degree, must have taken at least one college-level course in one of the mathematical sciences? ___Yes ___No

B. Do you wish that the answer to (A) were different? ___Yes ___No

C. If you do not have an institution-wide requirement that every student take a college-level course in a mathematical science,
(1) is there such a requirement in the liberal arts college? ___Yes ___No
(2) is there an institution-wide requirement of an alternative choice of either mathematics or some other subject? ___Yes ___No

VII. 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

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.____Students desiring advanced placement (See question IX 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

IX. 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:

X. 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 make 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: ____________________

XI. Check any techniques of instruction, other than the standard or traditional lecture-recitation system, used 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.____Courses by television (closed-circuit or broadcast)
5.____Courses by film
6.____Courses by programmed instruction
7.____Courses by computer-assisted instruction (CAI)
8.____Other; specify:

XII. Which innovations in undergraduate programs and requirements in the mathematical sciences have been introduced since 1960?

[Check Column A if an innovation was introduced between 1960 and 1965, and check Column B if it was introduced or expanded between 1965 and 1970.]

	A Introduced 1960 - 1965	B Introduced 1965 - 1970
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 mathematics preparation of elementary school teachers	. . . . .	. . . . .
10. Have introduced other innovations	. . . . .	. . . . .

If parts 6,7,8,9,or 10 are checked, please give a very brief description of changes introduced:

XIII. Questions on Mathematics Faculty (Graduate and Undergraduate)

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 one of the math. sciences	In mathematics education	In a different 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 one of the math. sciences	In mathematics education	In a different field (specify)
Doctor's degree			
Master's degree			
Bachelor's degree			

C. Teaching assistants employed in instruction (by highest degree):
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 percentages of the total undergraduate teaching load in your department, distributed by underclass and upperclass levels and by type of teaching personnel:

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

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

	Fall semester or quarter	Spring semester or quarter
(a) Professors		
(b) Associate Professors		
(c) Assistant Professors		
(d) Instructors with Ph.D.		
(e) Instructors without Ph.D.		
(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: ____

What percentage of your faculty (above the rank of instructor) meets, or exceeds, this expectation of research activity? ____

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:

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

	Ph.D.'s	Non Ph.D.
A. (1) How many faculty members did you employ full-time for the first time in 1970-71?	____	____
(2) How many additional full-time faculty members do you plan to seek for 1971-72 (exclusive of replacements)?	____	____
(3) Assuming you are successful in (2), how many additional faculty members do you plan to seek for 1972-73?	____	____
B. Of the new full-time faculty this year, counted in A(1) above, how many were during the previous year 1969-70--		
(1) enrolled in graduate school	____	____
(2) teaching, with Ph.D., in another institution	____	____
(3) teaching, without Ph.D., in another institution	____	____
(4) holding postdoctoral study/research appointments	____	____
(5) employed in non-academic positions	____	____
(6) otherwise occupied; specify:	____	____
C. Of the full-time faculty last year, who are no longer part of your full-time faculty, how many--		
(1) died, or retired from full-time teaching	____	____
(2) left for an academic position else where	____	____
(3) left for a non-academic position	____	____
(4) returned to graduate school	____	____
(5) are on (other) leave of absence	____	____
(6) (specify) ______________________	____	____

D. In seeking new faculty members for 1971-72 and 1972-73, as listed in A(2) and A(3), 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 1968 and June 1969? ____
(2) between July 1969 and June 1970? ____
(3) since July 1970? ____

XVII. How many bachelor's degrees with major in mathematical science were awarded by your department between July 1969 and June 1970? ____
Indicate the number of these with each specialty:

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

XVIII. During the course of the academic year the total student course enrollment load of your department changes. Based upon your previous years' experience, make an estimate of these changes:

Total student course enrollments, fall 1970 (essentially the sum of all items in Column (4) in question IV)	____
Estimated total student course enrollments for the second semester or second quarter	____
Estimated total student course enrollments for the third quarter (if applicable)	____

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 COLLEGE AND UNIVERSITY SURVEY

A: Public Universities with enrollment over 25,000; responding departments

Arizona State University	Mathematics
University of Arizona	Mathematics
University of California, Berkeley	Mathematics, Computer Science, Statistics
University of California, Los Angeles	Mathematics, Computer Science
University of Cincinnati	Mathematics
University of Houston	Computer Science
University of Illinois	Mathematics, Computer Science
Indiana University	Mathematics
University of Maryland	Mathematics, Computer Science
Michigan State University	Mathematics, Computer Science, Statistics & Probability
University of Michigan	Mathematics, Biostatistics, Computer & Communication Science, Statistics
University of Minnesota	Biometry, Statistics
Northern Illinois University	Mathematics
Ohio State University	Mathematics, Computer & Information Science Mathematics Education, Statistics
Pennsylvania State University	Mathematics, Statistics, Computer Science
University of Pittsburgh	Mathematics, Computer Science
Purdue University	Mathematics, Computer Science, Statistics
Southern Illinois University	Mathematics
Temple University	Mathematics
University of Tennessee	Mathematics
University of Texas at Austin	Mathematics, Computer Sciences
University of Washington	Mathematics, Computer Science, Quantitative Methods & Quantitative Science
Wayne State University	Mathematics
University of Wisconsin	Mathematics, Computer Science, Statistics

B: Public Universities with enrollment under 25,000; responding departments

Bowling Green State University	Mathematics
University of California, Riverside	Mathematics, Statistics
University of California, San Diego	Mathematics
University of California,Santa Barbara	Mathematics
Clemson University	Mathematics
University of Colorado	Mathematics, Computer Science
Florida State University	Mathematics, Mathematics Education, Statistics
University of Florida	Mathematics, Statistics
Georgia Institute of Technology	Mathematics, Information & Computer Science
University of Idaho	Mathematics
University of Illinois, Chicago Circle	Mathematics
Indiana State University	Mathematics
Kansas State University	Mathematics, Statistics, Computer Science

B: Public Universities with enrollment under 25,000 (continued)

Kent State University	Mathematics
Louisiana State University	Mathematics, Computer Science
University of Louisville	Mathematics
University of Maine	Mathematics
Montana State University	Mathematics
University of Nevada	Mathematics
University of North Carolina at Chapel Hill	Mathematics, Biostatistics, Computer & Information Science, Statistics
North Texas State University	Mathematics
University of Northern Colorado	Mathematics
Oklahoma State University	Mathematics & Statistics, Computer & Information Sciences
University of Rhode Island	Mathematics, Computer Science & Experimental Statistics
SUNY at Buffalo	Mathematics
SUNY at Stony Brook	Mathematics, Applied Math. & Statistics
University of Utah	Mathematics
Virginia Polytechnic Institute	Mathematics, Computer Science, Statistics
University of Virginia	Mathematics
Wichita State University	Mathematics

C: Private Universities; responding departments

American University	Mathematics
Boston University	Mathematics, Mathematics Education
Bradley University	Mathematics, Computer Science
Brigham Young University	Mathematics, Computer Science, Statistics
Butler University	Mathematics
Carnegie-Mellon University	Mathematics
Case Western Reserve University	Mathematics, Operations Research
Cornell University	Mathematics, Computer Science, Statistics
University of Denver	Mathematics
Drake University	Mathematics
George Washington University	Mathematics, Statistics
Harvard University	Mathematics, Statistics
Howard University	Mathematics & Astronomy
Illinois Institute of Technology	Mathematics, Information Science Center
Loyola University (Illinois)	Mathematics
Loyola University (Louisiana)	Mathematics
Marquette University	Mathematics
Massachusetts Institute of Technology	Mathematics
University of Miami	Mathematics
New York University	Mathematics (Washington Square), Mathematics Education
Northwestern University	Mathematics
University of Santa Clara	Mathematics
Seton Hall University	Mathematics

C: Private Universities (continued)

Stanford University	Mathematics, Computer Science, Operations Research, Statistics
Syracuse University	Mathematics
Tufts University	Mathematics
Tulane University	Mathematics
Wake Forest University	Mathematics
Yale University	Mathematics
Yeshiva University	Mathematics

D: Public Colleges with enrollment over 14,000; mathematics departments

Brooklyn College, City University of New York
California State College, Fullerton
California State College, Long Beach
California State College, Los Angeles
Central Michigan University
Cleveland State University
Fresno State College
Illinois State University
Memphis State University
Queens College, City University of New York
Sacramento State College
San Diego State College
San Fernando Valley State College
San Francisco State College
San Jose State College
University of Texas at Arlington
Youngstown State University

E: Public Colleges with enrollment under 14,000; mathematics departments

University of Alabama in Huntsville
Appalachian State University
State College of Arkansas
Bemidji State College
Cameron State Agricultural College
Humboldt State College
Indiana University & Purdue University at Indianapolis
Lehman College, City University of New York
Lock Haven State College
University of Maine at Portland-Gorham, Gorham Campus
Midwestern University (Texas)
New Mexico Institute of Mining and Technology (Mathematics, Computer Science)
North Carolina State University, Fort Bragg Branch
University of North Carolina at Greensboro
University of North Carolina at Wilmington
Northeast Louisiana University
Northern State College (South Dakota)
Northwestern State University (Louisiana)
Oklahoma Panhandle State College
University of Puerto Rico, Mayaguez

E: Public Colleges with enrollment under 14,000 (continued)

Purdue University, Calumet Campus
Purdue University, Fort Wayne Campus
St. Mary's College of Maryland
Southern University
SUNY College at Oneonta
SUNY College at Plattsburgh
Stephen F. Austin State University
Tarleton State College
United States Naval Academy
Weber State College
Western Carolina University
University of Wisconsin, Parkside

F: Private Colleges; mathematics departments

Adrian College
Albertus Magnus College
American International College
Arkansas College
Assumption College
Belmont College
Bethel College (Indiana)
Bethel College (Kansas)
Biola College
Biscayne College
Bishop College
Blackburn College
Bucknell University
  (Mathematics, Computer Science)
Carroll College (Wisconsin)
Central Wesleyan College
Church College of Hawaii
Clarke College
Columbia Union College
Dakota Wesleyan University
University of Dayton
Denison University
Dominican College (Texas)
Eureka College
University of Evansville
Fairleigh Dickinson University,
  Teaneck Campus
Golden Gate College
Goucher College
Gustavus Adolphus College
Hanover College
  (Mathematics, Computer Science)
University of Hartford
Heidelberg College
Hobart and William Smith Colleges
Hofstra University
Le Moyne College (New York)
Marietta College
Dr. Martin Luther College
Mercy College of Detroit
Methodist College
Muskingum College
North Central College
Notre Dame College (Ohio)
Oakland City College
Our Lady of Angels College (Pennsylvania)
Pace College
Rochester Institute of Technology
  (Mathematics, Computer Services)
Rosemont College
Saint Francis College (Pennsylvania)
College of Saint Rose
University of San Francisco
  (Computer Science)
Smith College
University of the South
Tennessee Temple College
Trinity College (Illinois)
Trinity University (Texas)
Upper Iowa College
Warren Wilson College
Westmont College
William Woods College

APPENDIX C
QUESTIONNAIRE FOR TWO-YEAR INSTITUTIONS

OMB No. 99-S70009
Approval Expires 12/31/71

SURVEY OF PROGRAMS IN MATHEMATICS IN TWO-YEAR COLLEGES

1970-71

General Instructions

This questionnaire should be completed by that 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, although 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 do indeed exist.

Please complete and return one copy by December 15, 1970

* * * * * * * * * * * * * * * * * * * *

I. A. Name of institution: ______________________

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

B. Plan under which your institution operates:

1. _____ semester
2. _____ quarter
3. _____ trimester
4. _____ other (specify) ______________________

C. 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/Terminal	
	Full-time Students	Part-time Students	Full-time Students	Part-time Students
Freshmen				
Sophomores				
Unclassified or other				
Totals				

III. Prerequisite Instruction:

A. Is prerequisite instruction in mathematics (for credit or without credit) offered by your institution, now or in some following term, to correct the deficiencies of students who are beginning to take college mathematics for the first time? ___ Yes ___ No

B. If prerequisite instruction is not offered now, has it been offered at any time during the past 5 years as part of the regular college mathematics program? ___ Yes ___ No

C. If answer to (B) is Yes, in what year and for what reason was such prerequisite instruction as a part of the regular college mathematics program discontinued?

D. If prerequisite instruction is offered now, is this a new or additional offering begun during the last 5 years? ___ Yes ___ No

E. If answer to (D) is Yes, in what year and for what reason was prerequisite instruction introduced?

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 number of credit hours given for the courses (total number of credit hours if the course is given in two or more parts). In column (4) write the total number of students who enrolled in (any part of) the course in the fall term of 1970. For a course not offered in Fall 1970 but offered sometime, write "0".

c. In column (5) give the approximate number of freshmen who are included among those counted in column (4).

d. In column (6) give the approximate number of students from vocational (occupational) curricula who are included among those counted in column (4). For this purpose, consider a vocational or occupational curriculum as one which is intended to prepare students for employment rather than transfer to a four-year college.

e. Indicate here the units in which credit is measured:

_____ semester-credit hours

_____ quarter-credit hours

_____ other; specify: ______________________

IV. Courses in Mathematics

Name of Course (or equivalent)	Title and Author(s) of Text	No. of Credit Hours for the Course	Total No. of Students Enrolled Fall 1970	No. of Freshmen Included in No. in Col. 4	No. of Vocational Students Included in Col. 4
(1)	(2)	(3)*	(4)	(5)	(6)
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. Math Analysis (algebra, etc.)					
9. Basic Concepts (structure, logic, sets)					
10. General Mathematics (basic skills, operatns)					
11. Finite Mathematics					
12. Mathematics of Finance					
13. Business Mathematics					
14. Math for Elementary School Teachers					
15. Technical Mathematics (pre-calculus)					

*If this is a remedial or prerequisite course, put "R" in this column after the number of credits.

-3-

Name of Course (or equivalent)	Title and Author(s) of Text	No. of Credit Hours for the Course	Total No. of Students Enrolled Fall 1970	No. of Freshmen Included in No. in Col. 4	No. of Vocational Students Included in Col. 4
(1)	(2)	(3)*	(4)	(5)	(6)
16. Analytic Geometry					
17. Analytic Geometry & Calculus					
18. Calculus					
19. Technical Mathematics (calculus level)					
20. Differential Equations					
21. Elementary Statistics					
22. Probability (& Stat.)					
23. Programming of Digital Computers					
24. Other Computer-Oriented Mathematics					
25. Linear Algebra					
26. Modern Algebra					
27. Slide Rule					
28.					
29.					
30.					

V. To what extent are courses in mathematics taught in divisions 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 1970
1. Computer programming	____	____	____
2. Data Processing	____	____	____
3. Statistical assistant	____	____	____
4. Other mathematical specialty; specify: ____	____	____	____

VII. Does your institution require an admissions examination of some sort 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) _____ 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. 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 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: ____________

X. Check any techniques of instruction, other than the standard or traditional lecture-recitation system, used by your department:
1. _____ Large lecture classes with small quiz sections
2. _____ Large lecture classes with help sessions
3. _____ Organized program of independent sutdy
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. _____ Other; specify:

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

1. Are your course offerings and/or curricula subject to 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 departments 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 one of the math. sciences	In mathematics education	In a different field (specify)
Doctor's degree			
Master's degree plus 1 year			
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 one of the math. sciences	In Mathematics education	In a different field (specify)
Doctor's degree			
Master's degree plus 1 year			
Master's degree			
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

	Ph.D.'s	Non Ph.D.
A. 1. How many faculty members did you employ full-time for the first time in 1970-71?		
2. How many additional full-time faculty members do you plan to seek for 1971-72?		
3. If you are successful in 2, how many additional faculty members would you need for 1972-73?		

B. For full-time faculty members who were first employed on a full-time basis this year, how many were during the previous year 1969-70--

	Ph.D.'s	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:		

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

D. Do you have difficulty in recruiting and keeping an adequate mathematics faculty? ___ Yes ___ No

If so, please comment:

XIV. During the course of the academic year the total student course enrollment load of your department changes. Based upon your previous years' experience, make an estimate of these changes:

Total student course enrollments, fall 1970 (essentially the sum of all items in Column (4) in question IV) ______
Estimated total student course enrollments for the second semester or second quarter ______
Estimated total student course enrollments for the third quarter (if applicable) ______

XV. 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 JUNIOR COLLEGE SURVEY

(Department or Divisions which are responsible for instruction in mathematics)

<u>Group A: Public Junior Colleges with enrollment over 9,600</u>

Cerritos College, Norwalk, California
Chabot College, Hayward, California
Cuyahoga Community, Metropolitan Campus, Cleveland, Ohio
Diablo Valley College, Pleasant Hill, California
East Los Angeles College, Los Angeles, California
El Camino College, El Camino College, California
Fresno City College, Fresno, California
Fullerton Junior College, Fullerton, California
Henry Ford Community College, Dearborn, Michigan
University of Kentucky Community College System, Lexington, Kentucky
Laney College, Oakland, California
Los Angeles Pierce College, Woodland Hills, California
Los Angeles Trade-Technical College, Los Angeles, California
Los Angeles Valley College, Van Nuys, California
Miami-Dade Junior College, North and South Campuses, Miami, Florida
Milwaukee Area Technical College, Milwaukee, Wisconsin
Mount San Antonio College, Walnut, California
Nassau Community College, Garden City, New York
New York City Community College, Brooklyn, New York
Phoenix College, Phoenix, Arizona
Portland Community College, Portland, Oregon
Queensborough Community College, Bayside, New York
Sacramento City College, Sacramento, California
St. Petersburg Junior College, St. Petersburg Campus, St. Petersburg, Florida
San Antonio College, San Antonio, Texas
San Bernardino Valley College, San Bernardino, California
San Diego Evening College, San Diego, California
City College of San Francisco, San Francisco, California
San Jose City College, San Jose, California
College of San Mateo, San Mateo, California
Santa Monica College, Santa Monica, California
SUNY Agricultural and Technical College, Farmingdale, New York
West Valley College, Campbell, California

<u>Group B: Public Junior Colleges with enrollment 1,500-8,800</u>

Bellevue Community College, Bellevue, Washington
Bristol Community College, Fall River, Massachusetts
Broome Technical Community College, Binghamton, New York
Catonsville Community College, Catonsville, Maryland
Central Arizona College, Coolidge, Arizona
Chaffey College, Alta Loma, California
Cochise College, Douglas, Arizona

Group B: Public Junior Colleges with enrollment 1,500-8,800 (continued)

Elgin Community College, Elgin, Illinois
Essex Community College, Essex, Maryland
Essex County College, Newark, New Jersey
Florida Junior College at Jacksonville, Jacksonville, Florida
Gadsden State Junior College, Gadsden, Alabama
Honolulu Community College, Honolulu, Hawaii
Jackson Community College, Jackson, Michigan
Jackson State Community College, Jackson, Tennessee
Lake Land College, Mattoon, Illinois
McLennan Community College, Waco, Texas
Mercer County Community College, Trenton, New Jersey
Meridian Junior College, Meridian, Mississippi
Modesto Junior College, Modesto, California
Montgomery College, Rockville Campus, Rockville, Maryland
Northern Essex Community College, Haverhill, Massachusetts
Northwest Mississippi Junior College, Senatobia, Mississippi
Odessa College, Odessa, Texas
Onondaga Community College, Syracuse, New York
Orange Coast College, Costa Mesa, California
Santa Fe Junior College, Gainesville, Florida
State Technical Institute at Memphis, Memphis, Tennessee
Tarrant County Junior College, South Campus, Fort Worth, Texas
Texarkana College, Texarkana, Texas
Thomas Nelson Community College, Hampton, Virginia
Utah Technical College at Salt Lake, Salt Lake City, Utah
Victoria College, Victoria, Texas
West Los Angeles College, Culver City, California
Yuba College, Marysville, California

Group C: Public Junior Colleges with enrollment under 1,500

Blue Ridge Community College, Weyers Cave, Virginia
Cape Fear Technical Institute, Wilmington, North Carolina
Cisco Junior College, Cisco, Texas
Clarendon College, Clarendon, Texas
Clemson University, Sumter Branch, Sumter, South Carolina
Colorado Mountain College, East Campus, Leadville, Colorado
University of Connecticut, Hartford Branch, Hartford, Connecticut
Connors State College, Warner, Oklahoma
Dixie College, George, Utah
Frederick Community College, Frederick, Maryland
Gogebic Community College, Ironwood, Michigan
Highland Community Junior College, Highland, Kansas
Iowa Central Community College, Webster City Center, Webster City, Iowa
Itawamba Junior College, Fulton, Mississippi
John A. Logan College, Herrin, Illinois
Kishwaukee College, Malta, Illinois
Langlade County Teachers College, Antigo, Wisconsin
College of the Mainland, Texas City, Texas
Midlands Technical Education Center, Columbia, South Carolina

Group C: Public Junior Colleges with enrollment under 1,500 (continued)

Motlow State Community College, Tullahoma, Tennessee
Muskingum Area Technical Institute, Zanesville, Ohio
New Mexico State University, San Juan Branch, Farmington, New Mexico
University of North Dakota, Ellendale Branch, Ellendale, North Dakota
North Florida Junior College, Madison, Florida
Northeast Mississippi Junior College, Booneville, Mississippi
Ohio University, Lancaster Branch, Lancaster, Ohio
Palo Verde College, Blythe, California
Pennsylvania State University, Berks Campus, Wyomissing, Pennsylvania
Pennsylvania State University, Fayette Campus, Uniontown, Pennsylvania
College of the Siskiyous, Weed, California
University of South Carolina, Coastal Carolina Regional Campus, Conway, S. C.
Southeastern Illinois College, Harrisburg, Illinois
Southwestern Michigan College, Dowagiac, Michigan
Sumter Area Technical Education Center, Sumter, South Carolina
University of Virginia, Eastern Shore Branch, Wallops Island, Virginia
Wilkes Community College, Wilkesboro, North Carolina

Group D: Private Junior Colleges with enrollment over 1,000

Academy of Aeronautics, Flushing, New York
Brandywine College, Wilmington, Delaware
Bryant & Stratton Commercial School, Boston, Massachusetts
Central YMCA Community College, Chicago, Illinois
Chamberlayne Junior College, Boston, Massachusetts
Chowan College, Murfreesboro, North Carolina
Ferrum Junior College, Ferrum, Virginia
Goldey Beacom Junior College, Wilmington, Delaware
Kendall College, Evanston, Illinois
Mitchell College, New London, Connecticut
Puerto Rico Junior College, Rio Piedras, Puerto Rico
Ricks College, Rexburg, Idaho
South Texas Junior College, Houston, Texas
Union College, Cranford, New Jersey
Wentworth Institute, Boston, Massachusetts
Wingate College, Wingate, North Carolina
Worcester Junior College, Worcester, Massachusetts

Group E: Private Junior Colleges with enrollment under 1,000

Ancilla Domini College, Donaldson, Indiana
Bradford Junior College, Bradford, Massachusetts
Concordia Lutheran College, Austin, Texas
Dean Junior College, Franklin, Massachusetts
Don Bosco Technical Institute, Rosemead, California
Freed-Hardeman College, Henderson, Tennessee
Green Mountain College, Poultney, Vermont
Gulf Park Junior College, Long Beach, Mississippi
Harriman College, Harriman, New York
Hilbert College, Hamburg, New York
Immaculata College of Washington, Washington, D. C.

Group E: Private Junior Colleges with enrollment under 1,000 (continued)

Inter-American University, Aguadilla Regional College, Aguadilla, Puerto Rico
Jacksonville College, Jacksonville, Texas
Keystone Junior College, La Plume, Pennsylvania
Kirkland Hall College, Easton, Maryland
Lees-McRae College, Banner Elk, North Carolina
Leicester Junior College, Leicester, Massachusetts
MacCormac College, Chicago, Illinois
Maria Regina College, Syracuse, New York
Missouri Baptist College, Main Campus, Hannibal, Missouri
Morristown College, Morristown, Tennessee
Mount Vernon College, Washington, D. C.
Muskegon Business College, Muskegon, Michigan
Palmer College, Columbia Campus, Columbia, South Carolina
Penn Hall Junior College, Chambersburg, Pennsylvania
Robert Morris College, Carthage, Illinois
Saint Mary's Junior College, Minneapolis, Minnesota
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Villa Maria College, Buffalo, New York
Wesley College, Dover, Delaware

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