Chapter 1

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

This chapter reports estimated national enrollments in university and four-year college mathematical science courses for fall 1980. The data are compared and contrasted with results of previous CBMS surveys and enrollment patterns in other fields of higher education. Special attention is given to the interaction of four-year and two-year mathematics programs and enrollments.

Highlights

- From 1975 to 1980 mathematical science course enrollments in universities and four-year colleges increased by 33%, compared to an increase of only 7% in full-time-equivalent enrollments of those institutions.
- The enrollment increases were concentrated in computer science, remedial mathematics, pre-calculus courses, and calculus for physical scientists and engineers.
- Largest enrollment decreases were in liberal arts mathematics and courses for elementary school teachers.
- Statistics and upper division mathematics enrollments increased slightly, with the mathematics increase concentrated in applied topics like differential equations.
- The number of bachelors degrees in mathematics and statistics decreased by 42%; in computer science there was an increase of 145% to a total nearing two out of five mathematical science degrees.
- Of the fall 1980 freshmen in higher education, only .6% plan to major in mathematics or statistics, but 4.9% plan to major in computer science, data processing, or computer programming.
- Two-year college mathematical science enrollments increased at about the same rate as enrollments in those institutions, with growth concentrated in remedial courses and computer science. The two-year college share of all undergraduate mathematical science enrollments is now 34%, compared to 37% in 1975.

The data elaborating these highlights and giving longer term trends are presented in the sections that follow.

1.1 Enrollment Trends in Higher Education

The numbers and distribution of mathematical science course enrollments are influenced by broader trends in higher education enrollment and by the curricular choices of those students. Since 1975, undergraduate enrollments have continued the long trend of growth, though projections for the next decade suggest that the growth might be coming to an end.

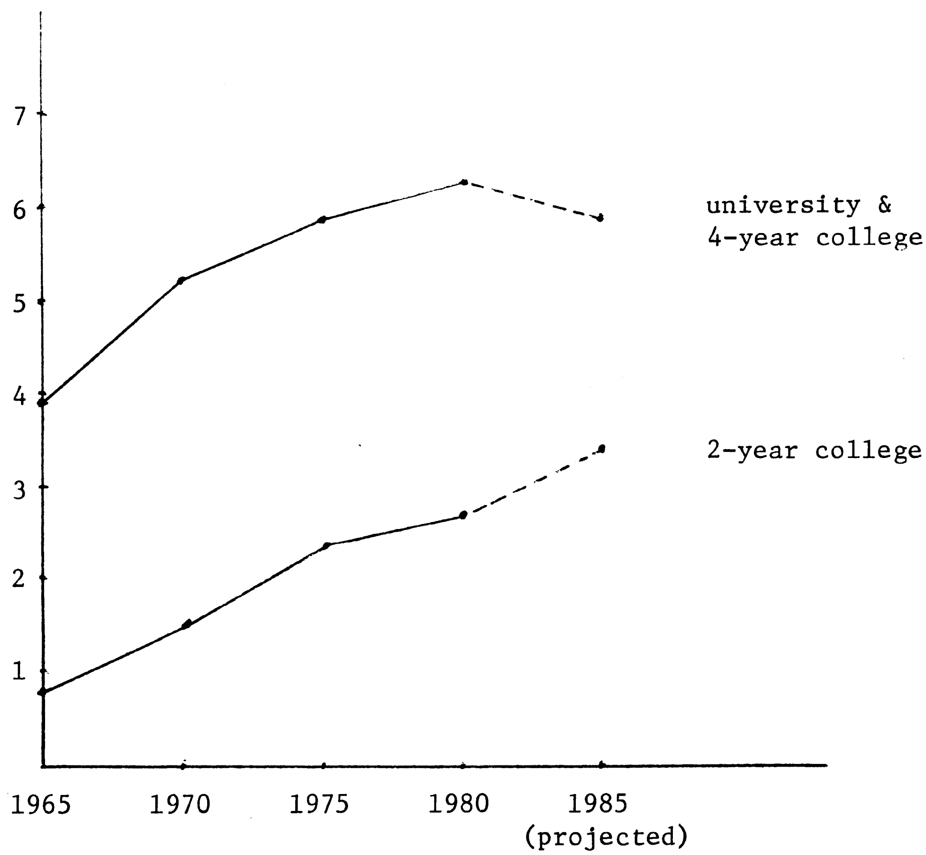
The curricular areas of concentration chosen by undergraduates have changed dramatically over the past decade, with consequent impact on the types of mathematical science courses offered and elected by undergraduates. The probable academic majors indicated by freshmen entering college in 1980 suggest further changes not yet fully reflected in the enrollment data collected for the present study.

The following tables and charts give details of such background enrollment information useful for explaining and interpreting the mathematical science data given later.

FULL-TIME-EQUIVALENT ENROLLMENTS IN ALL HIGHER EDUCATION

Since 1965, full-time-equivalent (FTE) enrollments in higher education have grown by 100%. The two-year college share of this enrollment has increased from 17% to 34%, but more than half of the TYC enrollment is in non-degree-credit occupational/technical programs. Current projections suggest levelling off and modest decline in total enrollments for higher education during the next decade.

Figure 1.1
(millions of students)



Source: Projections of Education Statistics to 1986-87.

PROBABLE MAJORS OF ENTERING FRESHMEN IN HIGHER EDUCATION

From 1975 to 1980 student choices of academic major shifted toward business, engineering, and computer science and away from the physical sciences, arts and humanities, and education. Since 1966, the number of entering freshmen planning a major in mathematics has dropped from 4.5% to .6% of the total.

Table 1.1
(percent of all freshmen)

Subject Areas	1966	1970	1975	1980
Biological Sciences	10.9	12.9	17.5	17.8
Business	14.3	16.2	18.9	23.9
Education	10.6	11.6	9.9	7.7
Engineering	9.8	8.6	7.9	11.8
Humanities and Arts	24.3	21.1	12.8	8.9
Mathematics and Statistics	4.5	3.2	1.1	0.6
Physical Science	3.3	2.3	2.7	2.0
Social Sciences	8.2	8.9	6.2	6.7
Other Technical*	2.2	3.7	8.6	8.2
Undecided and Other	11.8	11.6	14.5	12.4
Total Number of Full-Time Freshmen (in thousands)	1,163	1,617	1,761	1,712

*Includes computer science; in 1980, 4.9% of entering freshmen indicated a probable major in computer science, data processing, or computer programming.

Source: Astin, A. W., King, M. R., & Richardson, G. T. *The American Freshman: National Norms for Fall 1980*, and earlier editions of this report.

NUMBER OF FRESHMAN PROBABLE MATHEMATICAL SCIENCE MAJORS IN HIGHER EDUCATION

Since 1970, the number of students planning to major in mathematics or statistics has declined by 80%. The number of students planning to major in computing has grown to over 84,000 in the same period. These planned majors can be compared to actual earned degrees in Table 1.4 and Table 1.12.

Table 1.2

(numbers of full-time freshmen)

Institution Type	1970 Mathematics and Statistics	1975 Mathematics and Statistics	1980 Mathematics and Statistics	1980 Computing*
Universities	15,600	6,400	3,178	15,098
Four-Year Colleges	27,600	9,300	5,712	28,560
Two-Year Colleges	9,200	3,000	1,359	40,781
All Institutions	52,400	18,700	10,249	84,439

*Comparable data not available for earlier years.

Source: Astin, A. W., King, M. R., & Richardson, G. T. The American Freshman: National Norms for Fall 1980 and earlier editions of this report.

FULL-TIME UNDERGRADUATE ENGINEERING ENROLLMENTS

From a relative minimum in 1973, undergraduate engineering enrollments have grown steadily to an all-time high of 365,000 in 1980. Since the number of freshman engineering students was also an all-time high in that year, the influence of engineering enrollments on mathematics course demand is likely to continue strong over the next several years.

Figure 1.2

(enrollments in thousands)

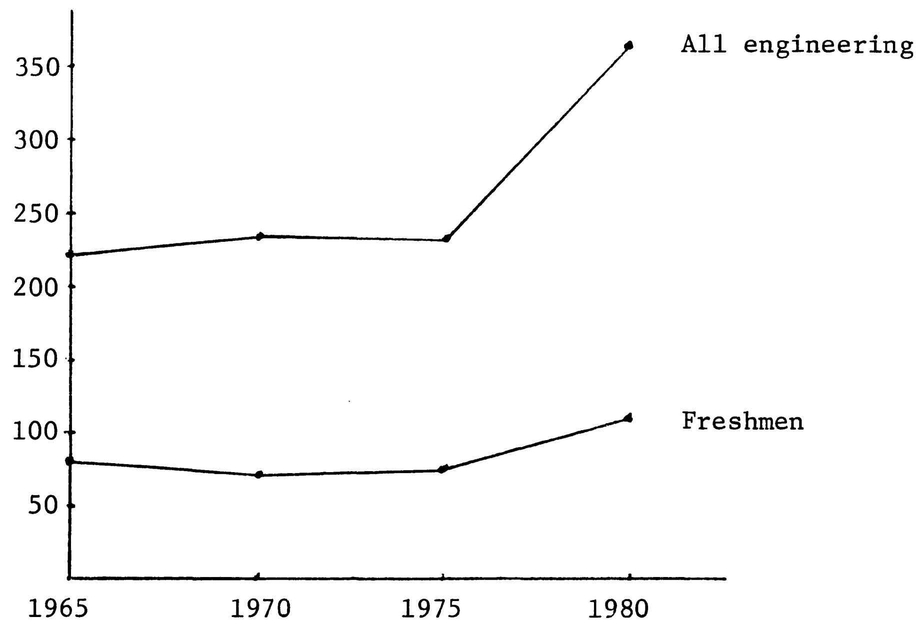


Table 1.3

(enrollments in thousands)

	1965	1970	1975	1976	1977	1978	1979	1980
Freshmen	80	72	75	82	89	96	104	110
All Engineering	220	232	231	258	289	311	340	365

Source: Engineering Manpower Commission. Engineering and Technology Enrollments, Fall 1980.

EARNED BACHELOR'S DEGREES FOR SELECTED FIELDS

Trends in the distribution of earned bachelor's degrees have roughly followed the projected majors of entering freshmen, with a time lag. Engineering and business have grown, while humanities, social sciences (including education), and mathematics have declined.

Table 1.4
(degrees in thousands)

Subject Area	1960-61	1965-66	1970-71	1975-76	1979-80*
Humanities and Related Fields	52	87	140	140	129
Social Sciences and Related Fields	136	226	382	369	323
Business and Management	56	64	116	143	174
Natural Sciences and Related Fields**	114	126	172	216	253
-Biological Science	16	27	36	54	55
-Computer Science	-	-	2	6	8
-Engineering	36	38	50	46	74
-Mathematics and Statistics	13	20	25	16	9
-Physical Science	15	17	21	21	24

*Projected

**Includes agriculture and health fields in addition to those listed.

Source: Projections of Education Statistics to 1987-88.

1.2 Course Enrollments in Mathematics, Statistics, and Computing

For the past 20 years mathematical science course enrollments have grown faster than overall enrollments in higher education. However, during that period the areas of greatest growth have changed from time to time. During the 1960's the largest course enrollment increases were in calculus and upper division mathematics, with computer science and statistics making large percentage increases from relatively small bases. From 1970 to 1975 computer science and statistics continued their rapid growth, but upper division mathematics enrollment dropped by 32%.

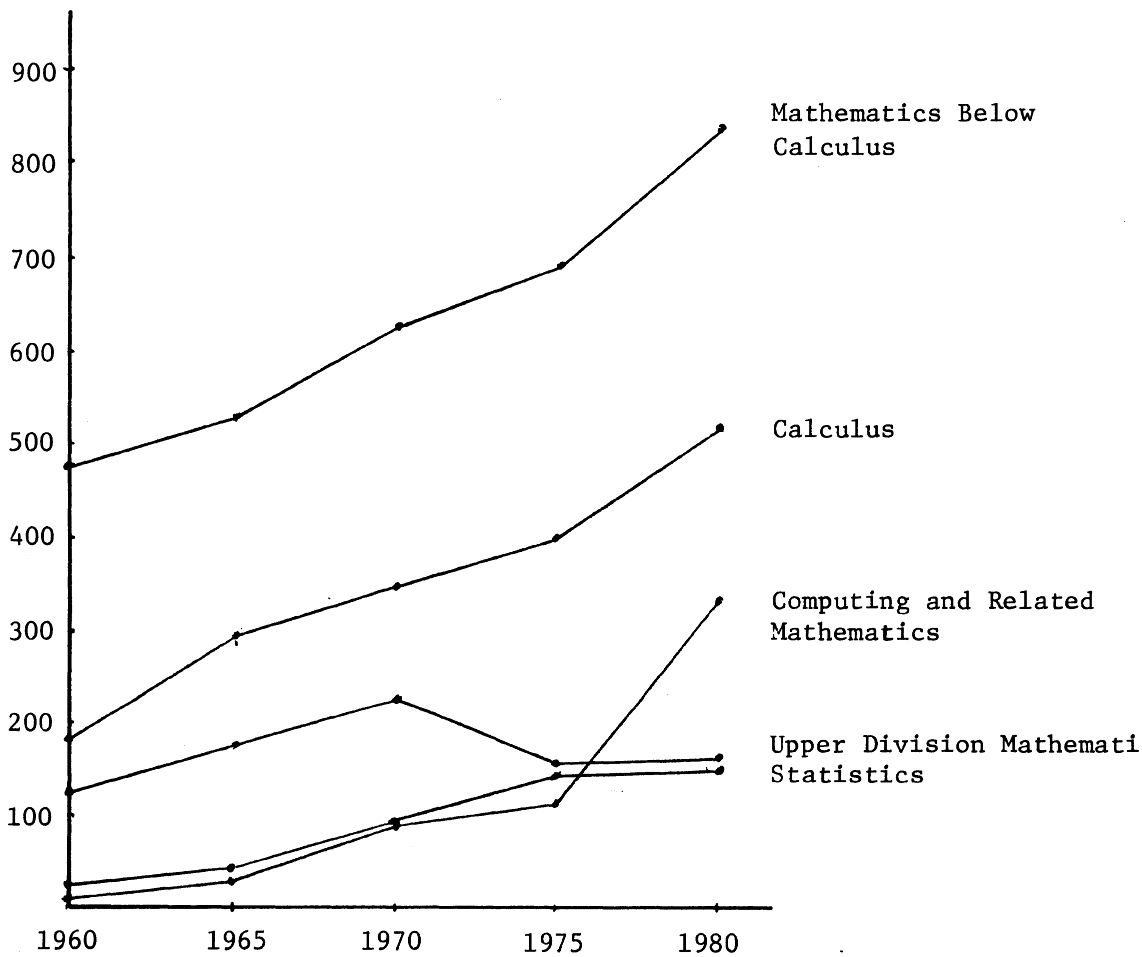
Between 1975 and 1980 course enrollment growth has been concentrated in computer science, remedial mathematics, and calculus, while upper division pure mathematics has continued to decline and statistics has experienced only modest growth. To knowledgeable readers none of these trends will be a surprise and some explanations are not hard to generate. The job opportunities in computing and engineering are attracting large numbers of students to these fields and thus the enrollment increases in computer science courses and calculus for physical science and engineering. However, it appears that calculus, for example, is becoming more widespread as a requirement for other fields as well. Those who choose to continue as mathematics majors are strengthening their background in applied areas, at the expense of traditional pure mathematics courses. Many mathematics educators have reported declining preparation of entering college students, and thus the increase in remedial offerings and enrollments is natural.

The clear overall impression from course enrollment data is a shift toward mathematical science courses that are applicable as preparation for specific post-college careers.

MATHEMATICAL SCIENCE ENROLLMENTS IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Between 1975 and 1980 all mathematical science enrollments increased by 33%, compared to 7% for FTE enrollments in all fields. The 30% increase in calculus and the 196% increase in computing courses led the way.

Figure 1.3
(enrollments in thousands)



MATHEMATICAL SCIENCE ENROLLMENTS BY COURSE LEVEL
AND TYPE OF INSTITUTION, 1970-1980

Enrollments in mathematics below calculus, calculus, and computing have increased steadily in universities and four-year colleges. However, only private colleges experienced growth in upper level mathematics during the past five years and only public colleges had growth in statistics during that period.

Table 1.5
(Enrollments in thousands)

Type of Course	Universities 1970	Universities 1975	Universities 1980	Public College 1970	Public College 1975	Public College 1980	Private College 1970	Private College 1975	Private College 1980
Mathematics Below Calculus	224	243	277	293	333	408	113	116	152
Calculus	185	193	247	99	114	154	61	90	116
Upper Level Mathematics	114	67	61	65	50	51	50	38	49
Statistics	49	67	58	22	45	61	21	29	30
Computing and Related Mathematics	57	61	116	17	31	130	16	20	86
Total	629	631	759	496	573	804	261	293	433

MATHEMATICS COURSE ENROLLMENTS IN UNIVERSITIES AND FOUR-YEAR COLLEGES
BY TOPIC AREA, 1960-1980

Recent large enrollment increases have been in remedial courses (+72%), pre-calculus and calculus courses (+31%), and advanced applied courses including differential equations (+55%). Mathematics courses for teachers (-37%) and advanced pure mathematics (-19%) continued their decline from 1970 peaks.

Table 1.6*
(enrollment in thousands)

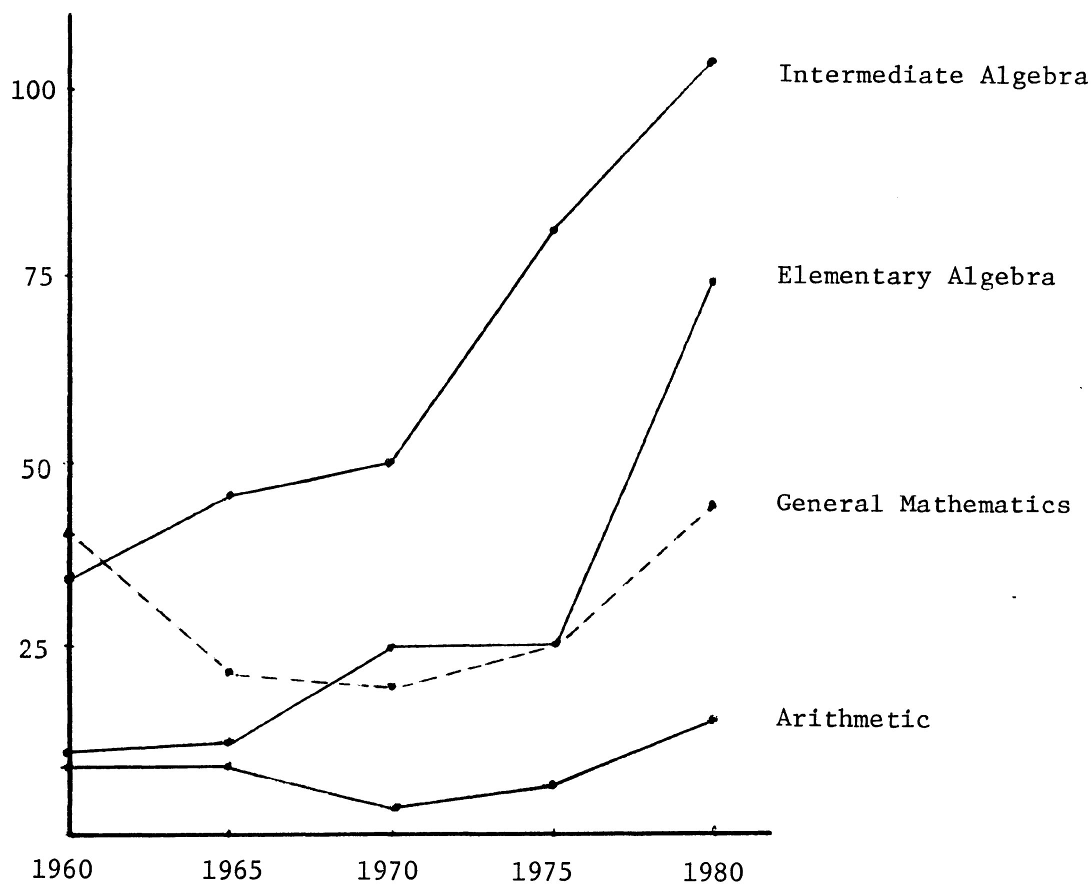
Subject	1960	1965	1970	1975	1980
1. Arithmetic/General Mathematics	48	29	23	32	63
2. High School Algebra & Geometry	48	60	78	109	179
3. Business Mathematics	17	21	18	47	48
4. Liberal Arts Mathematics	36	87	74	103	63
5. Mathematics for Elementary Teachers	23	61	89	68	44
6. College Algebra, Trigonometry, Analysis	235	262	301	259	345
7. Finite Mathematics	1	7	47	74	95
8. Analytic Geometry & Calculus	184	295	345	397	517
9. Differential Equations	29	31	31	29	45
10. Linear & Matrix Algebra	4	19	47	28	37
11. Modern Algebra	11	20	23	13	10
12. Advanced Calculus	17	20	20	14	11
13. Applied Mathematics	19	21	20	18	28
14. Numerical Analysis	3	5	11	8	10
15. Other Advanced Mathematics	42	67	88	53	30
Total	717	1,005	1,215	1,252	1,525

*Enrollment data for each course in each control/type stratum are given in Appendix E. Statistics and computer science are not included here.

REMEDIAL MATHEMATICS* IN UNIVERSITIES AND FOUR-YEAR COLLEGES

Since 1960, enrollment in remedial arithmetic, general mathematics, and algebra has increased by 165%. Those courses now constitute 16% of all mathematics enrollments, compared to 13% in 1960. The biggest increase occurred between 1975 and 1980, matching a period of widespread reports that high school preparation in mathematics has declined sharply.

Figure 1.4
(enrollments in thousands)



*High school level courses; courses 1-5 in list of Appendix E.

ENROLLMENT IN REMEDIAL MATHEMATICS COURSES

In public colleges remedial courses include 25% of all mathematics enrollments; for universities and private colleges the shares are only 10% and 9% respectively.

Table 1.7

(enrollments in thousands and % of all mathematics)

Course	Universities 1975	Universities 1980	Public Colleges 1975	Public Colleges 1980	Private Colleges 1975	Private Colleges 1980
Arithmetic for College Students	-	2(-)	5(1%)	11(2%)	1(-)	1(-)
General Mathematics (Skills, Operations)	-	4(1%)	23(5%)	37(6%)	3(1%)	8(3%)
High School Geometry	-	-	1(-)	1(-)	1(-)	-
Elementary Algebra	4(1%)	13(2%)	22(4%)	54(9%)	L(-)	7(2%)
Intermediate Algebra	26(5%)	44(7%)	46(9%)	48(8%)	9(4%)	12(4%)

AVAILABILITY OF REMEDIAL MATHEMATICS COURSES

Very few private colleges offer remedial courses, but nearly half the universities offer intermediate algebra and over half the public colleges offer elementary algebra.

Table 1.8

(percent of institutions offering course)

Course	Universities	Public Colleges	Private Colleges
Arithmetic	6%	15%	2%
General Mathematics	11%	28%	7%
High School Geometry	0	10%	2%
Elementary Algebra	27%	45%	10%
Intermediate Algebra	41%	43%	21%

AVAILABILITY OF SELECTED UPPER LEVEL MATHEMATICS COURSES IN UNIVERSITIES AND FOUR-YEAR COLLEGES, 1980

As the number of mathematics majors has declined, upper division enrollments and course offerings have been diminished. For instance, only a third of all universities offer history of mathematics and only an eighth of all private colleges offer advanced geometry.

Table 1.9

(% of institutions offering course in 1980*)

Course	Universities	Public Colleges	Private Colleges
1. Theory of Numbers	45%	29%	8%
2. Combinatorics	28%	11%	3%
3. Foundations of Mathematics	19%	19%	3%
4. Set Theory	20%	13%	2%
5. History of Mathematics	31%	29%	7%
6. Geometry	54%	50%	13%
7. Mathematics for Secondary School Teachers	29%	30%	9%
8. Mathematical Logic	30%	13%	4%
9. Applied Mathematics/ Mathematical Modelling	38%	20%	4%
10. Biomathematics	2%	8%	1%
11. Operations Research	23%	13%	4%

*Estimate based on number of institutions reporting enrollment or L for later offering in the year.

PROBABILITY AND STATISTICS COURSE ENROLLMENTS IN UNIVERSITIES AND FOUR-YEAR COLLEGES

From 1975 to 1980 enrollments increased in elementary statistics but declined in elementary probability. Overall, statistics enrollments in mathematics or statistics departments increased only 5.6%, less than the FTE enrollment growth for four-year institutions and in contrast to rapid growth rates observed in previous surveys. However, statistics is also taught for special audiences in a variety of other academic departments.

Table 1.10

(enrollments in thousands*)

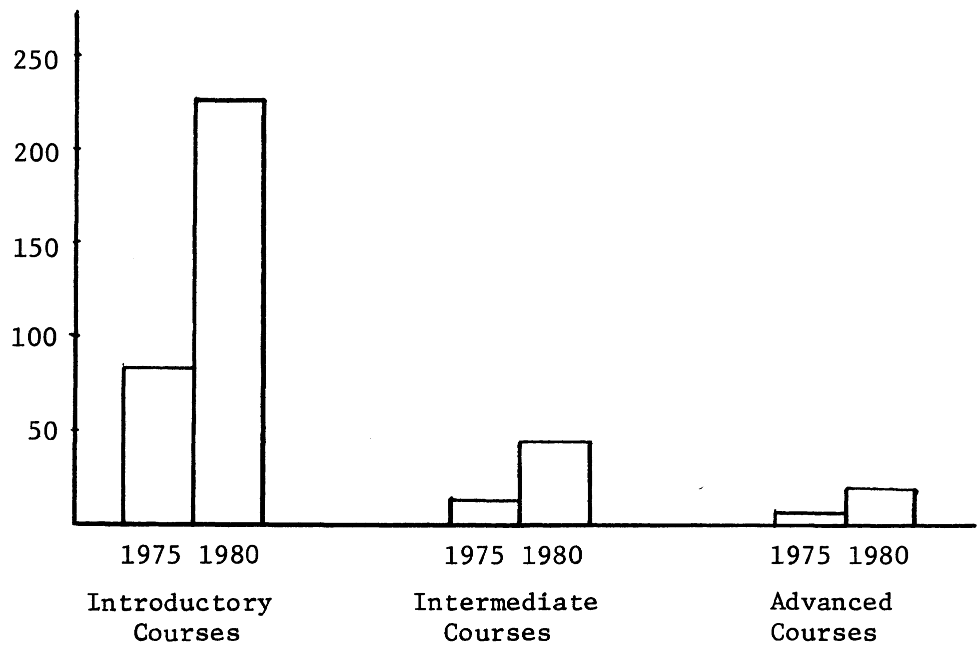
Course	1975	1980
1. Elementary Statistics	74	87
2. Elementary Probability	25	17
3. Mathematical Statistics	14	16
4. Probability	8	13
5. Applied Statistical Analysis	10	8
6. Design and Analysis of Experiments	2	2
7. Other	8	6
Total	141	149

*Does not include statistics taught outside of mathematical science departments.

COMPUTER SCIENCE ENROLLMENTS IN UNIVERSITIES AND FOUR-YEAR COLLEGES

The most striking result of the course enrollment survey is the nearly 200% increase in computer science. Those courses now generate over 16% of all mathematical science enrollments and they are increasingly given by separate departments of computer science. As in mathematics and statistics, the largest share of computer science enrollment is in lower level courses.

Figure 1.5
(enrollments in thousands*)



*Includes only enrollments in mathematical science departments (including computer science departments). In the 160 universities there are an estimated 94 separate departments of computer science. There are an estimated 85 computer science departments in the 407 public colleges, and 48 computer science departments in the 830 private colleges. However, computer science courses are often taught by mathematics departments.

The mathematical science departments responding to the survey also reported 30,000 computer science course enrollments not categorizable by one of the ACM Curriculum '78 labels and thus not covered by Figure 1.5.

COURSE ENROLLMENTS IN COMPUTER SCIENCE AT UNIVERSITIES AND FOUR-YEAR COLLEGES

There was strong enrollment growth in nearly every computer science course offering. However, the bulk of the increase from 1975 to 1980 occurred in beginning programming courses. The new course "Computers and Society" established a substantial enrollment.

Table 1.11

(enrollments in thousands)

Subject	1975	1980
1. Computer Programming I (CS1)*	50	154
2. Computer Programming II (CS2)	13	32
3. Introduction to Computer Systems (CS3)	13	16
4. Discrete Structures	3	9
5. Computer Organization (CS4)	3	12
6. File Processing (CS5)	3	7
7. Operating Systems and Computer Architecture (CS6)	2	7
8. Data Structures and Algorithm Analysis (CS7)	3	12
9. Organization of Programming Languages (CS8)	7	6
10. Computers and Society (CS9)	NA	16
11. Operating Systems and Computer Architecture II (CS10)	NA	2
12. Database Management Systems Design (CS11)	1	4
13. Artificial Intelligence (CS12)	1	1
14. Algorithms (CS13)	1	2
15. Software Design and Development (CS14)	NA	2
16. Theory of Programming Languages (CS15)	NA	1
17. Automata, Computability, and Formal Languages (CS16)	1	2
18. Numerical Mathematics (CS17, 18)	1	6
19. Other Computer Science	5	30
Totals	107	321

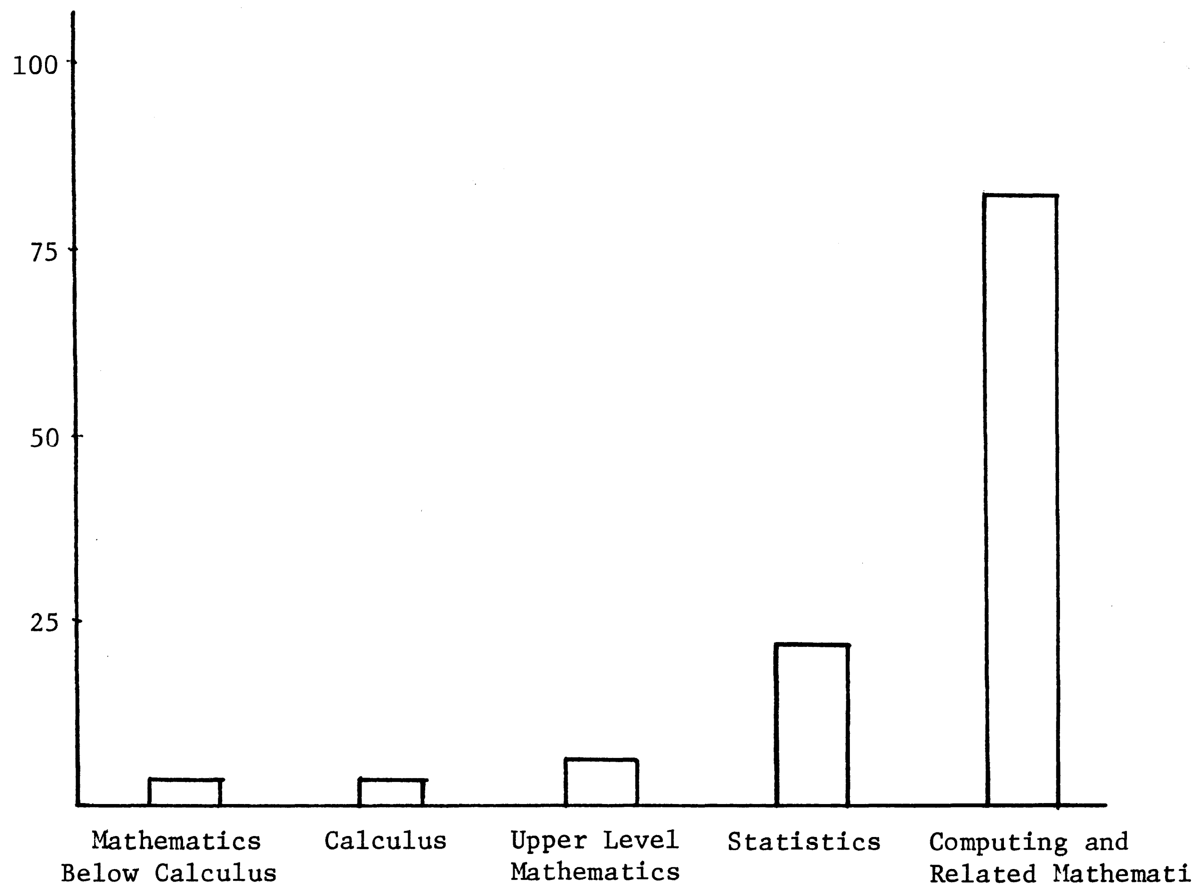
*CS numbers refer to courses described in Curriculum '78, Communications of the Association for Computing Machinery, 1979, 22(3), 147-166. The 1975 data are for comparable courses in the 1975 CBMS survey list.

Enrollments are only those reported by mathematical science departments, thus not including computer programming taught by a business or engineering school, for example.

COMPUTER USE IN MATHEMATICAL SCIENCE COURSES, 1980

Very few mathematics students use computers as part of their course-work. Applied mathematics (16%), linear algebra (12%), and liberal arts mathematics (12%) are the most likely to use computers. About one-fifth of statistics students use computers.

Figure 1.6
(% of students using computers)



*Primarily numerical analysis

1.3 Bachelor's Degrees in Mathematical Sciences

In 1974-75 the CBMS survey reported 27,817 bachelor's degrees in various special areas of the mathematical sciences, including 19,043 in mathematics and statistics, 3,636 in computing, and 4,778 in secondary teaching. In that same year, only 18,700 entering college freshmen planned a major in mathematics or statistics and the number planning to enter teaching had begun its recent decline. These projections foretold a sharp drop in mathematics and secondary teaching degrees to be completed four years later.

The anticipated drop in completed mathematics and statistics (-37%) and secondary teaching (-63%) majors has occurred, bringing those numbers to roughly the level of 1960-61 when the college population was much smaller. At the same time, bachelor's degrees in computer science increased by 145% to constitute nearly two of five degrees in mathematical sciences. The projections of academic majors for 1980 entering college freshmen suggested further drastic growth in this sector lies ahead.

There are indications that many of the remaining mathematics majors are "doubling" in computer science and that employment for mathematics graduates is commonly in computer-related positions. Taken together, these trends raise fundamental concerns about the "traditional" mathematics majors. The sharp decline in undergraduates preparing for secondary teaching has already aggravated a shortage of qualified teachers.

SPECIALIZATION OF EARNED BACHELOR'S DEGREES IN MATHEMATICAL SCIENCES

From 1975 to 1980 earned bachelor's degrees in mathematics, statistics and secondary teaching decreased by 42%. Computer science degrees increased by 145%. In universities 83% of computer science degrees are from computer science departments; in public colleges the fraction is 56%. However, many public colleges have joint mathematics and computer science departments.

Table 1.12

(numbers of bachelor's degrees)

Special Area	1974-75	1979-80
Mathematics	17,713	10,160
Statistics	570	467
Computer Science	3,636	8,917
Actuarial Science	70	146
Applied Mathematics	886	801
Secondary Teaching	4,778	1,752
Other	164	580

1.4 Mathematical Sciences in Four-Year and Two-Year Institutions

Over the past twenty years the two-year college sector of undergraduate enrollment has increased rapidly to now include 29% of all FTE students in higher education. These two-year college students now provide over 34% of all undergraduate mathematical science enrollments, all at the lower division level. However, this fraction has declined since 1975 when two-year college mathematical science enrollments were 37% of the total for all higher education.

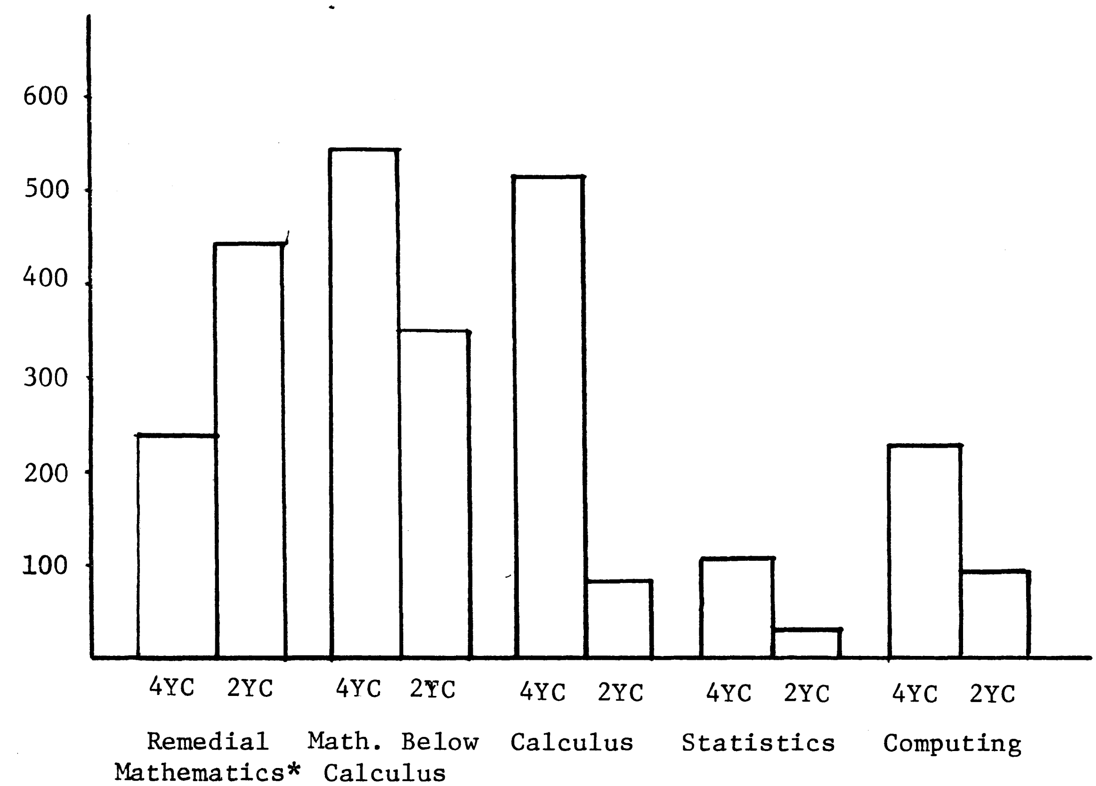
During the past ten years, two-year college enrollments have shifted markedly from degree-credit or transfer programs to non-degree-credit or occupational/technical programs. This change has been reflected in the distribution of mathematics enrollments in those colleges.

LOWER DIVISION MATHEMATICS, STATISTICS, AND COMPUTER SCIENCE AT
FOUR-YEAR AND TWO-YEAR INSTITUTIONS, 1980

The two-year colleges devote a greater fraction of their teaching to remedial and occupational/technical service courses than do four-year schools

Figure 1.7

(enrollments in thousands)



*Includes common high school courses through intermediate algebra; courses 1-5 in list of Appendix E.

TRENDS IN DISTRIBUTION OF LOWER DIVISION MATHEMATICAL SCIENCE COURSE ENROLLMENTS

Patterns of growth and decline in specific course enrollments are similar in four-year and two-year institutions. However, there are indications that many two-year occupational/technical programs are providing their own mathematics service courses, making the figures given here an underestimate of actual mathematics instruction.

Table 1.13

(enrollments in thousands)

Subject	Four-Year			Two Year		
	1970	1975	1980	1970	1975	1980
Remedial Mathematics*	101	141	242	191	245	440
Business Mathematics	18	47	48	33	79	61
Liberal Arts Mathematics	74	103	63	57	72	19
Mathematics for Elementary School Teachers	89	68	44	25	12	8
Finite Mathematics	47	74	95	12	12	19
College Algebra/Trigonometry	301	259	345	124	149	174
Analytic Geometry and Calculus	345	397	517	68	73	86
Technical Mathematics	---	---	---	29	53	80
Computer Science**	NA	85	230	13	10	95
Statistics***	NA	99	104	16	27	28

*Courses 1-5 in Appendix E
**Courses 55-61 in Appendix E
***Courses 46, 47 in Appendix E

1.5 Summary

Over the past five years undergraduate mathematical science course enrollments in universities and four-year colleges increased by 33%, a rate far greater than overall enrollment increases in those institutions. However, the increase was not evenly distributed among subject areas within the field. The growth in computer science was spectacular and nearly all the remaining increase was concentrated in two areas -- remedial mathematics and calculus or advanced mathematics for scientists and engineers. There were sharp declines in liberal arts mathematics, courses for prospective teachers, and advanced pure mathematics. The number of bachelor's degrees in computer science more than doubled, while the degrees in mathematics and statistics dropped sharply.

Projection of these trends, and planning to respond effectively, are very difficult tasks. The expressed educational objectives of current entering freshmen suggest continued growth in engineering and computer science and declines in education and mathematics. However, engineering enrollments have been cyclical in the past and there are predictions that developments in computing will reduce the need for highly trained personnel in that area. There is a national shortage of secondary school mathematics teachers that might soon entice greater numbers of students back into those college programs. The additional factor to be considered in projections is demographic data which predict declines in the number of college-age Americans. Returning and continuing students have confounded this effect in the past decade, but we may be reaching boundaries of the potential audience for collegiate mathematical science courses.

Taking numbers of course enrollments as a measure, the mathematical science departments are currently prospering. Reasonable projections suggest that this prosperity will continue into the near future. However, the pattern of enrollments is far from optimal for the preferences of most faculty -- with the decline in advanced mathematics students and increase of less attractive, lower level courses. Those students, greatly reduced in number, who continue to elect a mathematics major are concentrating in applied areas, statistics, and computing which are not the specialties of most current faculty. The decline in numbers of potential secondary school mathematics teachers is also an ominous sign for the long-term improvement of school mathematics.