Chapter 2

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

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

Summary of Major Results

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

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

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

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

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

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

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

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

General Enrollment Trends in Higher Education

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

Table 2.1 documents the continuing growth of two-year colleges. Their impact on undergraduate enrollment patterns is under

scored by the data on first time undergraduate enrollments in Table 2.2 which shows that from 1965 to 1975 growth in freshman enrollment has concentrated in the two-year colleges.

Table 2.1

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

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

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

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

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

Table 2.2

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

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

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

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

Table 2.3

PROBABLE MAJORS OF ENTERING FRESHMEN
IN ALL HIGHER EDUCATION

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

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

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

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

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

Table 2.4

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

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

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

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

Table 2.5

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

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

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

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

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

Table 2.6

FULL-TIME UNDERGRADUATE ENGINEERING ENROLLMENTS
(In Thousands)

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

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

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

Mathematical Science Course Enrollments

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

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

Figure 2.1

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

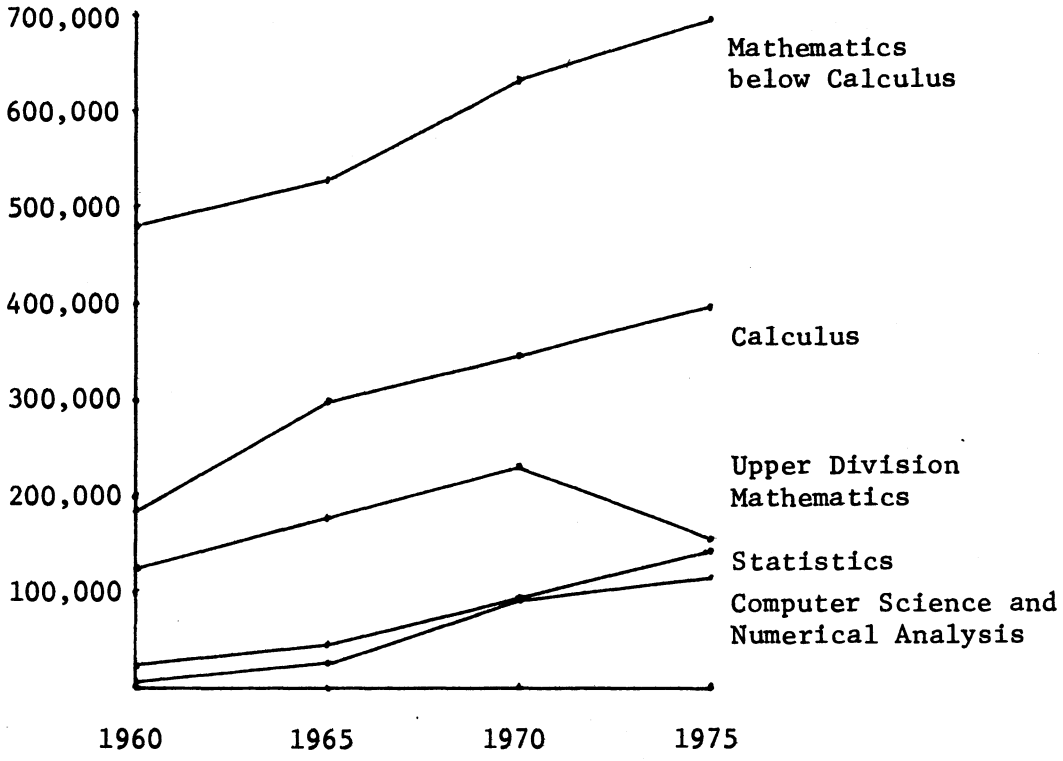

Table 2.7 also reveals trends in the relative importance of various levels and special topic areas in the overall instructional program of mathematical science departments. In 1960 mathematics courses below calculus (55%) and calculus (25%) accounted for 80% of all mathematical science enrollments. Upper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

Table 2.7

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

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

Table 2.8

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

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

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

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

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

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

Table 2.9

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

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

*Courses 1 through 5 in Table 2.8.

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

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

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

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

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

Mathematical Science Courses Taught in Other Departments

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

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

Table 2.10

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

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

Total 2.11

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

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

*L means less than 500

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

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

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

Bachelors Degrees in Mathematics

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

Table 2.12

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

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

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

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