CHAPTER 4

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

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

Summary of Major Results

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

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

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

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

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

These findings are elaborated in the balance of this chapter.

Mathematical Training and Ability of Undergraduates

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

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

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

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

Entrance and Placement Examinations

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

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

Table 4.1

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

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

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

Table 4.2

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

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

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

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

Course and Program Innovations

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

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

Table 4.3

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

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

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

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

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

Use of Computers and Calculators

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

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

Table 4.4

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

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

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

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

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

Table 4.5

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

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

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