CONFERENCE BOARD OF THE MATHEMATICAL SCIENCES

REPORT OF THE SURVEY COMMITTEE

VOLUME VI

UNDERGRADUATE MATHEMATICAL SCIENCES IN UNIVERSITIES, FOUR-YEAR COLLEGES, AND TWO-YEAR COLLEGES, 1980-81

JAMES T. FEY
DONALD J. ALBERS
and
WENDELL H. FLEMING
with the technical assistance of
CLARENCE B. LINDQUIST

CONFERENCE BOARD OF THE MATHEMATICAL SCIENCES

REPORT OF THE SURVEY COMMITTEE

VOLUME VI

UNDERGRADUATE MATHEMATICAL SCIENCES IN UNIVERSITIES, FOUR-YEAR COLLEGES, AND TWO-YEAR COLLEGES, 1980-81

JAMES T. FEY
DONALD J. ALBERS
and
WENDELL H. FLEMING
with the technical assistance of
CLARENCE B. LINDQUIST

Supported by the National Science Foundation under grant SED7919946

Available from:
Conference Board of the Mathematical Sciences
1500 Massachusetts Ave., N.W., Suite 457-8
Washington, D.C. 20005

Price: $6.00 prepaid

Library of Congress Card Number 67-30335

JOHN W. JEWETT: A MEMORIAL TRIBUTE

John Jewett, the Chairman of the CBMS Survey Committee, died this summer at the age of fifty-six, while the preparation of this volume was in process. He was my own Ph.D. student, and a person I admired and respected. I was very proud of him and am glad to have the opportunity to write about him for this volume.

He was involved in these Surveys from the outset. I was the first chairman and promptly asked him to be executive secretary, knowing that this would assure the success of our first volumes. When I left the chairmanship, he replaced me. The success of the Surveys -- and they have been successful -- is due to a major extent to his dedication, hard work and wisdom.

John's doctoral thesis was one of the first in differential topology. I anticipated an outstanding research career for him, but he chose to put his talents into his teaching and his administrative and committee work. He had been raised as a faculty child at Oklahoma State University and it gave him great pleasure to return there as chairman of the mathematics department, where he remained for the rest of his life.

Gentle, and with a wry sense of humor, his wisdom and judgment were widely respected. He served on many committees of the Mathematical Association of America, such as the Committee on the Undergraduate Program in Mathematics, and was vice-president of that organization. The American Mathematical Society put him on such major policy committees as the Committee on Employment and Educational Policy, the Committee on Relations with Government, the Committee on Science Policy, and the Committee on Academic Freedom. To all these assignments he brought the same high qualities he brought to the Survey.

His death is a loss to us all, but particularly to me. I miss him greatly.

Gail S. Young
Professor of Mathematics
The University of Wyoming

PREFACE

At five year intervals, beginning in 1965, the Conference Board of the Mathematical Sciences (CBMS) has conducted four surveys of undergraduate course enrollments, faculty, and teaching patterns in the mathematical science departments of universities, four-year colleges, and two-year colleges in the United States. The basic purpose of these surveys has been to provide information useful for decision-making in mathematical science departments, professional organizations, and government agencies. In particular, the surveys have reflected the interests of the member organizations of CBMS* and have drawn on the expertise and experience of prominent individuals from the various areas of the mathematical sciences represented by those organizations. On the other hand, restricting the scope of the surveys to the mathematical sciences has provided a certain unity and coherence that would have been lacking had the surveys been aimed at a wider range of disciplines.

All four CBMS surveys, and a similar U.S. Office of Education survey for 1960, have addressed two basic questions:

1. What are the national undergraduate course enrollments in mathematics, statistics, and computer science, how are those enrollments distributed among various types of higher education institutions, and how do the enrollment patterns change over time?
2. What are the numbers, qualifications, personal characteristics, and teaching responsibilities of mathematical science faculty, and how do those variables change over time?

In addition to these fundamental issues, individual surveys have focused on questions of timely interest. In particular, the present survey has tried

*Listed in alphabetical order these organizations are the American Mathematical Association of Two Year Colleges, the American Mathematical Society, the American Statistical Association, the Association for Computing Machinery, the Association for Symbolic Logic, the Association for Women in Mathematics, the Institute of Mathematical Statistics, the Mathematical Association of America, the National Council of Teachers of Mathematics, the Operations Research Society of America, the Society of Actuaries, the Society for Industrial and Applied Mathematics, and The Institute of Management Sciences.

to quantify anticipated increases in remedial mathematics, statistics, and computer science enrollments as well as changing patterns in organizing mathematical science instruction and changes in the administrative structure of mathematical science departments.

Questionnaire design and overall advice and guidance for the present survey were provided by the CBMS Survey Committee. The eight members of that Committee and the executive secretary for the project are listed below.

Donald J. Albers, Menlo College
William F. Atchison, University of Maryland
Wendell H. Fleming, Brown University
John W. Jewett, Oklahoma State University
Don O. Loftsgaarden, University of Montana
Martha K. Smith, University of Texas
Robert J. Thompson, Sandia Laboratories
Joseph Waksberg, WESTAT Research Corporation
James T. Fey, University of Maryland, Executive Secretary

Professor Jewett, who co-authored several earlier volumes in the CBMS survey series and chaired the Survey Committee from 1975 through mid-1981, played a crucial role in the planning and initial data analysis for the present study. His sad death in July 1981 was a deep personal and professional loss for the Committee. Professor Fleming accepted the Committee chairmanship after Professor Jewett's death.

The work of survey sample design, data collection and organization, data analysis and report writing has been shared by several people. The design of the sampling and estimation procedures was chiefly the work of Joseph Waksberg, a nationally and internationally known figure in this area of statistics. The organization and compilation of data from the survey questionnaire responses and the computation of the resulting estimates were done by Clarence Lindquist. Dr. Lindquist has provided such technical assistance for each of the preceding CBMS undergraduate surveys. In addition, he designed and carried out the above-mentioned U.S. Office of Education study for 1960.

The analysis of the survey results and the writing of the present report have been primarily the work of James Fey and Don Albers. An expert on

mathematics education, Professor Fey was the executive secretary for both the present and the 1975 CBMS survey project. He also served in that capacity for the production of the Conference Board's highly regarded 1975 report Overview and Analysis of School Mathematics Grades K-12. Professor Albers, The Committee's principal source of knowledge and expertise regarding the mathematical sciences in two-year colleges, largely authored the chapters on that subject in both the present and the 1975 survey reports. In addition to designing the questionnaires for the present survey, the members of the Survey Committee have received drafts of the chapters of the report as they were produced and have made a number of helpful comments.

It is especially fitting that the tribute to Professor Jewett that appears in the front of the present volume should be contributed by Gail S. Young. In addition to being Professor Jewett's mentor and doctoral dissertation adviser, Professor Young worked closely with Professor Jewett on all the previous volumes of the CBMS survey series, chairing the Survey Committee from its inception in 1965 through the early 1970's and continuing as a member of of the Committee for the 1975 survey, when Professor Jewett took over the chairmanship.

CBMS and its Survey Committee are indebted to Helen Daniels of CBMS headquarters, who did the expert camera-ready typing of the report, and to CBMS Executive Director Truman Botts, who was the director of the project, as he was of the 1970 and 1975 survey projects. Special thanks and appreciation for grant support are due the National Science Foundation, which also supported the Conference Board's 1970 and 1975 undergraduate surveys.

October 1981

Wendell H. Fleming
Chairman, CBMS Survey Committee

CONTENTS

SUMMARY OF MAJOR FINDINGS

In this summary we present some highlights of the 1980 CBMS survey results, leaving detailed presentations of the data to the chapters that follow. Some trends were found to be common among all types of institutions, for instance, increased elementary service course loads and the rapid growth of computer science. Nevertheless, there were also significant differences according to type of institution (university, public or private four-year college or two-year college). The summaries of major findings for four-year institutions and for two-year colleges are presented separately.

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

Our findings concern mathematical science enrollment trends, undergraduate majors, instructional formats, faculty, and administrative organization of mathematical science departments. The data given are estimates of national totals for fall 1980 in institutions of higher education. The estimates are based on responses to a questionnaire survey sent to universities and colleges in a sample of 416 institutions. The sampling and estimation procedure are explained in Appendix A. The table on the following page shows sampling and response rates in various categories of institutions and departments.

The generally high response rates give us confidence in most estimates. However, for some questions the actual reported numbers were so small that the data must be used with caution.

SAMPLING AND RESPONSE IN DEPARTMENTS OF MATHEMATICS, STATISTICS AND COMPUTER SCIENCE

	Population	Sample	Respondents	Response Rate
1. Universities				
Mathematics	160	60	57	95%
Statistics	42	20	14	70%
Computer Science	94	41	28	68%
2. Public 4-Year Colleges				
Mathematics	407	96	83	86%
Computer Science	85	26	14	54%
3. Private 4-Year Colleges				
Mathematics	830	100	73	73%
Computer Science	48	6	6	100%
4. 2-Year Colleges	1019	160	110	69%

Summary for Four-Year Institutions

For four-year colleges and universities, highlights of the survey results and prospects for the 1980's can be summarized as follows.

1. Mathematical science course enrollments grew substantially, with a dramatic growth in computer science. There was a 33% increase in total mathematical science course enrollments from 1975 to 1980, compared to an increase of only 8% in full-time-equivalent enrollments in all fields during the same five-year period. In contrast, during the previous five years 1970 to 1975 mathematical science course enrollments grew by only 8%, compared to an increase of 11% in all fields.

Most of this 33% increase in course enrollments from 1975 to 1980 was concentrated in elementary service courses and in computing courses. There was a 30% increase in calculus enrollments and a 196% increase for computing and related courses. Enrollments in remedial (high school level) courses were up 72%. Remedial courses now constitute 16% of all mathematical science enrollments. (For public four-year colleges the figure is 25% and, as noted below, it is even higher for two-year colleges.)

This substantial increase in the service course load from 1975 to 1980 was not indicated by trends during the years immediately preceding this period. One reason for the increase was the surge of student interest in such practically-oriented majors as engineering and business, where employment prospects have recently been excellent. The large increase in remedial mathematics confirms evidence from various other sources that a disappointingly large proportion of students in the U.S. come to college quite poorly trained in mathematics. Another factor contributing to increased elementary mathematics enrollments appears to be the growing use of quantitative methods in the social, biological, and management sciences.

2. Computer science grew rapidly, measured by any standard. As mentioned above, enrollments in computing courses nearly tripled from 1975 to 1980. There were estimated to be about 8900 computer science bachelor's degrees for the academic year 1979-1980, compared with only 3600 for 1974-1975. At the same time the number of bachelor's degrees in mathematics fell from 17,700 for 1975-1975 to 10,200 for 1979-1980. The number of mathematical science bachelor's degrees with majors in secondary teaching fell from 4800 in 1974-1975 to only 1750 for 1979-1980. At the same time, the rapid growth of the computer/high-technology industry in the U.S. has created excellent employment opportunities for computer science graduates at all levels (bachelor's through Ph.D.). This has made the recruitment and retention of computer science faculty difficult, particularly in institutions without graduate programs. Only about half of computer science faculty in four-year colleges hold doctoral degrees. Among 830 private colleges only about 220 mathematical science faculty have their highest degree in computer science, and only about 40% of those have Ph.D.'s in computer science.

3. Upper division mathematics courses experienced a modest enrollment increase, 4% overall from 1975 to 1980. Enrollments were up in courses with a more applied flavor, but down in mathematics courses for prospective teachers (-37%) and in advanced "pure mathematics" courses (-19%). As the number of mathematics majors has declined, an adequate spectrum of upper division mathematics courses is not available in many departments. This problem is more severe in four-year colleges than in universities. For example, among private

colleges only 13% offer a college-level geometry course, and the offerings in applied mathematics are quite meager. While logic is an important topic for computer science, only 30% of university mathematics departments and only about 7% of four-year college departments offer a course in mathematical logic.

4. Instructional formats. The 1980 survey inquired about the instructional format used in selected elementary courses (finite mathematics, calculus, computer programming, elementary statistics). Overall nearly 60% of all students in these courses are taught in small classes with fewer than 40 students. Most of the rest are taught in large classes of 40-80 students or in large lectures (with or without recitation sections). Fewer than 1% were taught using self-paced instruction or other modes. (This is in contrast to two-year colleges, where alternate instructional modes are used increasingly.)

The percentages of students in four-year institutions taught in small classes vs. large classes or lectures varied widely according to the type of institution. In universities only 36% of students in these selected courses were taught in small classes, compared to 79% in private four-year colleges.

5. Faculty loads, part-time vs. full-time faculty. Numbers of mathematical science faculty increased by about 13% from 1975 to 1980 measured on a full-time-equivalent (FTE) basis. Since this was substantially less than the 33% overall increase in course enrollments during the same five-year period, an increase in faculty loads resulted. Mathematical science course enrollments per FTE faculty member increased from 77 in 1970 to 83 in 1975 and to 98 in 1980. Thus course enrollments per FTE faculty increased by 27% during the decade 1970-1980, with most of the increase during the last half.

During the ten-year period 1970-1980 there has been an increase in faculty loads, measured in the number of credit hours taught per week, though the increase was more marked from 1970-1975 than in the period 1975-1980. For example, 80% of faculty in university mathematics departments taught less than 9 hours per week in 1970, but in 1980 only 62% taught less than 9 hours per week. In 1970, 47% of faculty in public four-year college mathematics departments taught less than 12 hours per week, but in 1980 this percentage had decreased to only 20%.

The survey data show other disturbing trends. There was a 75% increase

in the number of part-time faculty from 1975 to 1980, compared to only an 8% increase in full-time faculty during the same five-year period. The percentage of faculty granted tenure during 1980 was much lower than during 1975. These data presumably reflect the preoccupation of many institutions of higher learning with holding down costs, and with avoiding additional longer term commitments to faculty. On the other hand, some departments in four-year colleges are unable to hire (or to retain) full-time faculty with desired credentials, especially for positions in computer science, statistics, or another applied mathematical science. In such instances, hiring a part-time person is sometimes the best available alternative.

6. Faculty qualifications. A national goal during the 1960's was to raise the educational qualifications of college teachers up to the doctoral level. A great deal of progress was made toward that goal between 1965 and 1975, but more recently there has been slippage in the mathematical sciences. In 1980 over 90% of full-time mathematical science faculty in universities have doctorates. However, only 66% of those in four-year colleges have doctorates, compared to 71% in 1975.

The continued availability of enough qualified teaching assistants is in doubt, with many departments seeking TA's from other sources in addition to their own graduate students. In 1980 over 25% of all TA's employed by mathematical science departments were not mathematical science graduate students (graduate students in other fields, undergraduate TA's and others). The rapid decline in numbers of mathematics majors suggests that departments with traditional mathematics graduate programs may encounter still more difficulty in recruiting TA's in the years ahead.*

7. Faculty employment, demographic characteristics, mobility. The estimated total number of full-time mathematical science faculty in four-year colleges and universities in the U.S. increased from about 16,900 in 1975 to 18,300 in 1980. The addition of some 280 positions per year contributed to a better academic job market for mathematicians than during the bleak period

*On the other hand, annual American Mathematical Society Survey data indicate that numbers of mathematics graduate students were nearly stable during 1978-1980 following an earlier decline. See NOTICES AMS, February 1981, p. 172.

immediately preceding these years. From 1970 to 1975 there was essentially no change in the number of full-time mathematical science faculty, and numbers of new Ph.D.'s per year reached an all time high.

The CBMS survey data indicate little change in the total number of tenured mathematical science faculty between 1975 and 1980. Since the total number of full-time faculty increased by 1400, the percentage with tenure declined, from 72% in 1975 to 67% in 1980. Numbers of deaths and retirements are insufficient to account for this change. Among probable contributing factors are the growth of young computer science departments (only about half of computer science department faculty were tenured in 1980), stricter tenure policies of some institutions, and the development of opportunities in industry for Ph.D.'s during the 1970's which attracted some faculty away from academe. In 1980 greater movement between academic jobs in mathematical science departments and nonacademic jobs was observed than in earlier CBMS surveys. Among doctorate-holding faculty newly hired for fall 1980, about 125 came from nonacademic positions, while 290 left for nonacademic positions between the academic year 1979-1980 and fall of 1980. This resulted in a new outflow to nonacademic positions of about 1% of doctorate-holding mathematical science faculty during a single year.

The percentage of full-time mathematical science faculty who are women increased from 10% in 1975 to 14% in 1980, with a median age for women faculty about five years less than for men.

The AMS Survey monitors trends in faculty employment, demographic characteristics, and mobility annually.* AMS and CBMS surveys results indicate very similar trends, but do not agree in all details.

8. Administrative organization of mathematical science departments. In universities, mathematics and computer science are usually found in separate departments. There are often separate departments of statistics, operations research, or applied mathematics as well. However, in four-year colleges these various subjects are more commonly taught within a single department which includes traditional mathematics. This is particularly true in the smaller private colleges.

*Reported in February, October and November issues of the NOTICES AMS.

In universities rather few instances of administrative restructuring of mathematical science departments were reported. Most of these changes involved the formation of a new computer science department. In public four-year colleges a greater rate of administrative reorganization was reported. Reorganizations included consolidations of mathematical science departments into larger administrative units, creation of computer science departments and the addition of computer science programs and titles in many mathematics departments.

9. Prospects for the 1980's. Student enrollments in four-year institutions are expected to decline as the size of the 18-21 age group decreases. U.S. government sources project an overall enrollment decline by 1985 of some 7% from the 1980 peak. The impact in the mathematical sciences may be less, so long as present career-oriented attitudes among college students persist. Nonetheless, mathematical science enrollments may be expected to increase at a slower rate from 1980 to 1985 than from 1975 to 1980.

There is likely to be a continuing problem in obtaining adequate resources to cover the instructional load in the mathematical sciences. While there was some increase in numbers of faculty (full-time and part-time) during the late 1970's, the increase was by no means sufficient to cover the substantially heavier instructional loads. There is presently little evidence that, in the years immediately ahead, higher education will command enough priority in the competition for scarce public funds to alleviate matters.

The traditional role of upper division instruction in college and university mathematics departments has been the training of future mathematics teachers and researchers. These programs are being deserted by students more interested in careers in the computing field, or to a lesser degree, as practitioners in an applied mathematical field such as statistics or operations research. This poses a dilemma for mathematics departments regarding their instructional mission in the years ahead. Is it to be preponderantly elementary service courses, or can programs of broader appeal be introduced? For example, there are successful joint majors in mathematics-computer science, mathematics-economics, or mathematics-biology in many institutions. There are reports of shortages of high school mathematics teachers, as many teachers

leave for well-paying jobs in industry. How can student interest in teaching careers be rekindled? There is also the need to maintain a core of future researchers and college level teachers, to replace an aging national mathematics faculty. While numbers of mathematics professors retiring per year are expected to remain relatively low during the 1980's, there will be a large increase in retirements during the 1990's. Considering the nearly ten-year lead time from entry into graduate school until crucial tenure decisions are made, there should be many tenured positions in colleges and universities for students now at the point of starting graduate studies.*

In the shorter term, there is a critical problem of recruiting and retaining enough computer science faculty. If the explosive growth of enrollments in computing courses continues, the problem can only become more acute. More generally, many four-year college departments have difficulty recruiting doctorate-holding faculty in the applied mathematical sciences, to develop programs and teach courses in those areas. Numbers of new Ph.D.'s in both pure and applied mathematical fields have been declining, and there are attractive alternatives in industry.

A more fundamental national problem is to upgrade pre-college mathematics in the schools.** To a considerable extent this lies outside the scope of the present report, although college and university departments can help through their role in training teachers. It is in their own self-interest to help as they can. The continuing flood of entering students poorly prepared in mathematics threatens to distort the normal educational goals of mathematical science departments in institutions of higher education.

Summary for Two-Year Institutions

During the period 1975-1980, mathematics programs in two-year colleges underwent significant changes. Combined trends in enrollments, programs, student populations, and faculty populations do not bode well for the mathematical

*This issue is discussed further in the NOTICES AMS, February 1979, pp. 111-112

**Detailed recommendations on this issue are made in the 1980 NCTM report, An Agenda for Action: Recommendations for School Mathematics of the 1980's.

sciences in two-year colleges. Summaries of these trends follow.

1. Enrollment Trends -- Computer Science Gains. Mathematical science enrollments grew by 20%, keeping pace with overall enrollment gains of 19%. This gain was much less than the 50% growth in the previous five-year period, 1970-1975. Nearly all of the 20% gain was due to explosive growth of computer science courses and continued expansion of remedial courses. Computer science gains alone accounted for 43% of the total gain in enrollments. Remedial courses (arithmetic, elementary high-school algebra, general mathematics, and high-school geometry) now account for 42% of all two-year college mathematics enrollments. *Dealing with remediation* was identified by survey respondents as far and away the biggest problem facing two-year college mathematics faculty in 1980.

2. Program Trends -- Shift Away From Liberal Arts. Enrollments in occupational/technical programs grew to more than one-half of all full-time equivalent enrollments, outdistancing college-transfer enrollments. In 1975, by way of contrast, occupational/technical programs accounted for slightly more than one-third of all full-time equivalent enrollments. These shifts in student preferences away from liberal arts were mirrored in enrollment gains of applied courses and sharp declines in courses such as mathematics for liberal arts.

3. Population Trends -- Part-Timers in the Majority. Part-time enrollments increased from 53% of all enrollments in 1975 to 63% in 1980. This trend to an increased part-time majority may help to explain the program trends noted above.

4. Faculty Trends -- Full-Time Faculty Declined in Size. Although enrollments in mathematical science courses grew by 20%, the full-time faculty decreased by 5%. For whatever reasons -- burnout, economic exigencies, frustrations with remediation, increased teaching loads -- the full-time faculty of 1980 was smaller than that of 1975. Our age distributions indicate that those leaving the profession tend to be at least 45 years of age, which strongly suggests that experienced teachers are finding employment other than teaching. The financial problems of full-time faculty are underscored by the fact that nearly one-half of them are teaching *overloads* for extra money. The

typical faculty member is now teaching 30 more students than he taught in 1970.

During the same time frame, the *part-time faculty nearly doubled in size*. Part-timers now outnumber full-timers. If the full-time faculty teaching overloads had been smaller, then it is likely that the part-time fraction would have been even larger.

5. Instruction Trends -- Self-Pacing Methods Continue to Expand. Every alternative instruction mode that we monitored showed a gain in usage from 1975 to 1980. In particular, *independent study, modules, PSI, computer-assisted instruction*, and several other alternative techniques registered gains. The standard lecture-recitation format is still strongly dominant, but experimentation clearly is growing. It's interesting to note that although computers and calculators are now widespread among two-year colleges, their impact on the teaching of mathematics seems to be slight at best.