

Chapter I

SCOPE AND METHODOLOGY

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

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

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

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

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

Sampling and Response

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

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

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

Table 1.1

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

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

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

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

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

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

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

Estimation Procedures and Reporting Results

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

Table 1.2

SAMPLING AND RESPONSE IN UNIVERSITY STATISTICS DEPARTMENTS

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

Table 1.3

SAMPLING AND RESPONSE IN UNIVERSITY COMPUTER SCIENCE DEPARTMENTS

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

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

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

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

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

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

appropriate subsamples. Treating each of the fifteen groups similarly, and adding, we get the estimated total enrollment in differential equations for all four-year institutions.

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

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