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COMPUTER MANPOWER IN THE UNITED STATES - SUPPLY AND DEMAND

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ABSTRACT

At a time when new departments of computer science, data processing, information science, information systems, etc. are being created and existing departments are trying to grow and compete with more established disciplines for scarce resources, it seems imperative that we attempt to keep abreast of the needs of industry and government for the graduates of these programs. This need must be monitored and matched against the production of graduates at all appropriate levels. The author has assembled extensive data on the latter over the past eight years while at the Southern Regional Education Board in Atlanta, GA (USA) during the period 1965-72 and currently at the University of Missouri-Rolla. The data was collected and published with support from the National Science Foundation. In this paper the author also develops estimates of computer manpower need and compares these estimates of need with estimates on production. These comparisons are presented on a State-by-State basis as well as National.

BACKGROUND

In "The Job Gap for College Graduates in the 70s" (Business Week, Sept. 23, 1972), Howard Bowen was reported to have said that "What it will take, he says, is a realization that the problem is not overeducation but underutilization of educated people." This may be true in the case of computer manpower, the problem is not overeducation but over-utilization of undereducated people.

It is my intent then to present estimates of computer manpower based upon the best, though limited, data available, classified by job classifications and level of education which I estimate will be required for replacement of current personnel and to fill new positions. Better data is available on manpower production than on utilization through the efforts of SREB Computer Science Project and the American Federation of Information Processing Societies with support from the National Science Foundation. Data from the Bureau of Adult, Vocational, and Technical Education of the U. S. Office of Education are also utilized. Manpower production is then matched against estimated needs. Wherever possible, data relating to the States, individually and collectively, are reported. It is hoped that the net result will be useful to states, institutions, and federal agencies for planning purposes.

Throughout the paper, I have attempted to make my assumptions and subsequent model as transparent as possible. If my readers feel that their information or intuition is better, they can adjust the assumptions and make their own estimates of manpower needs.

During the period 1966-72 the Computer Sciences Project of the Southern Regional Education Board * (SREB) conducted three surveys** on Computers in U. S. Higher Education including their utilization and related educational programs. These studies have resulted in three publications.[1,2,3] The first was published by the SREB and the latter two by the National Science Foundation.

The first survey was a stratified random sample of 739 institutions, from a population of 2219, selected by systematic random sampling within strata by the U.S. Office of Education. Six hundred sixty-nine or 92 percent of the institutions in the sample responded.

The base year for data collection was 1964-65 and projections were requested from the institutions for 1968-69. The data collection instrument was designed by the Mathematical Sciences Section of NSF

*This paper is an adaptation and an extension of one prepared for the Southern Regional Education Board in 1973.

** Contracts NSF C465, 508 and 604.

to meet their existing program needs for planning. Consequently, emphasis was placed upon the financial aspects of college and university computer center operations and only limited information was gathered with regard to manpower training and utilization.

The second survey was much more comprehensive and was sent to all institutions of higher education listed on the U. S. Office of Education's Higher Education General Information Survey (HEGIS) file. Nineteen hundred sixty-five or 79 percent of the 2477 institutions responded. The data collection forms were designed with the advice and counsel of thirty or more national professional and institutional associations and government agencies. The base year for reporting data was 1966-67. Extensive modifications were made in the data collection forms for the third survey. The base year was 1969-70.

ASSESSMENT PROBLEMS

Problems resulting from lack of standardization in the computer industry are well-known. Unfortunately, the educational and occupational nomenclature also suffers this malady. The shifting of terms and definitions over the years can inject disastrous consequences on estimates and, particularly, projections. Attempts to make comparisons with other studies become even more hazardous. Projections based upon the three surveys described above will be presented. Two papers [4,5] by Gilchrist and Weber will be referenced for further data on supply and demand for computer personnel in the U.S.

MANPOWER PRODUCTION

Educational programs in Computer Science, Data Processing, Information Science, etc., exist in institutions of higher education at all levels. Two year programs terminate with an associate degree and four year programs with a bachelor's degree. Master's and doctorate programs exist at many institutions. Although computer science and data processing are by far the most populer names,[12] there appears still to be far too many different names used for educational programs in institutions of higher education. Further consolidation is necessary to ensure a healthy and unified development of the disciplines. The efforts of the ACM Committee on Computer Science[6] and the ACM Committee on Computer Education for Management [8,13] have and will continue to have a unifying influence on academic programs in computer and information science. The work of these committees was supported by the National Science Foundation.

Since 1966-67 the numbers of degree programs have doubled with the highest increase nearly threefold at the bachelor's level. Three out of five of the latter programs are called Computer Science and the next largest group (26) are designated as Data Processing. Twenty (20) new programs in Computer Science at the bachelor's level were expected to be started during 1971-72 and the next highest increase was expected to be at the master's level in Computer Science with sixteen new programs.

After the reports[8,13] of the ACM Curriculum Committee on Computer Education for Management have had a chance to be circulated and implemented I expect to see a surge in the master's and bachelor's level programs in Information Systems (Analysis and Design).

The numbers of majors enrolled in undergraduate programs have nearly tripled and numbers of graduates per year have increased fourfold between 1966-67 and 1969-70.[12] I do not expect significant changes in current trends for the next two or three years. Table I shows my estimates of degrees to be awarded during the year 1974-75.

COMPARISON WITH HEGIS DATA

Gilchrist and Weber[5] refer to classification differences which exist between the HEGIS data and the data which I collected at SREB. The main reason for differences in numbers of graduates reported is that HEGIS data, in general, reflect graduates of so-named departments only. For example, graduates of mathematics departments with computer science options would be classified as mathematics (or a subheading) and not computer science. The same would, in general, be true of graduates of other departments (EE, IE, etc.) with computer science options. Likewise, graduates of departments in business with options in systems analysis would not be reported under systems analysis. For this reason, the data reported in the inventory conducted by me at SREB should be considered to reflect more closely the actual numbers of graduates being produced in these computer related fields.

Computer Manpower Production by Higher Education by States

Table II gives the numbers of degree programs and graduates reported by the institutions of higher education in each of the fifty states. To obtain estimates of the total numbers of degree programs offered and total numbers of graduates, each of the reported totals were multiplied by the same factor, 1.34, (i.e. Total Number of Institutions/No. of Instituions Reporting).

It should be pointed out that several programs may be offered by a single institution. For example, the School of Information and Computer Science at the Georgia Institute of Technology accounts for all three doctorate programs in Georgia and three of the four master's programs. (Information Systems, Computer Science and Information Science.)

Computer Manpower Production by Post-Secondary Vocational Schools

The only data available on Post-Secondary Vocational Schools is from the Bureau of Audit, Vocational, and Technical Education, Division of Vocational and Technical Education, USOE, HEW. There is some duplication of institutions included in this data with those in the HEGIS file used for the higher education data. At present no estimate of the duplication is available. The Office of Education has recently developed a directory of vocational institutions. Perhaps at a later date, the duplication can be estimated with greater accuracy. In the meantime, I will adjust the post-secondary vocational enrollment and graduation figures downward by 10% to allow for the duplication with the higher education figures. Since I am concerned only with estimates relating to post-secondary education, I will not be concerned with the potential overlap which may exist in the secondary area with other studies.

Table II is obtained by using data from bulletins dated June and July, 1972, Vocational Education Information, No. I and No. II, respectively, and from state data obtained directly from Mr. Harold F. Duis, Reports and Statistical Data Section, Division of Vocational and Technical Education.

The Office of Education reports (1971) that 15% of those completing the post-secondary vocational program are unavailable for placement and 80% of those placed take jobs in the field for which they were trained or a related field. The net result is that at most 68% of those completing the post-secondary vocational program are placed in the job for which they were trained or a related field. Slightly over half (52.4%) of those unavailable for placement continue their education on a full-time basis. This would amount to about 8% of the total completions. We could argue that these percentages (68% and 8%) may be a little low for Business Data Processing and Scientific Data Technology, so let us use 75% and 10%. That is, three out of four of those completing the post-secondary program take jobs in a computer environment and one in ten continue their education. Since we do not have data on completions by state, we must estimate these. The post-secondary programs are primarily two-year programs. Therefore, no more than one-half of those enrolled in a given year should complete their program in that year. This is high due to drop-outs and extra length of time required for some students to finish. Thirty percent completion is probably closer and compares with data reported by Gilchrist and Weber for 1971.

OPERATIONS PERSONNEL

This group of job classifications associated with the operations of computer facilities usually require a two year college program or equivalent. Those described in "Occupations in Electronic Computing Systems" by the U. S. Department of Labor include:

- Digital Computer Operator
- Electronics Mechanic, Computer
- Manager, Electronic Data Processing (small installations)
- Supervisor, Computer Operations

Other jobs listed which usually require only high school graduation are:

- Coding Clerk
- Data Entry Operators
  - Card-Tape-Convertor Operator
  - Data Typist
  - Key-Punch Operator
  - Verifier Operator
- Computer-Peripheral-Equipment Operator
- High-Speed-Printer Operator
- Sorting-Machine Operator
- Tape Librarian (magnetic tapes, disks)

Many of the graduates of the two-year programs will enter these latter positions particularly at the supervisory levels simply because of supply and demand variations. I estimate that about 20% of these positions will be filled by persons with 2 years of college. Gilchrist and Weber estimated that there were 440,000 key-punch operators employed in the U. S. in the 1970s. With more efficient data-entry machines (magnetic tape encoders) becoming wide-spread and the increased use of optical readers (OMR), I doubt that the number of keypunch operators has increased at all and possibly has decreased. Assuming that each of the 35,000 computer installations averaged one tape librarian, one sorting-machine operator, one high-speed-printer operator or peripheral-equipment-operator, an estimate of 560,000 persons employed in this category is realistic. Therefore, 112,000 (20% x 560,000) jobs can be filled by persons with two years of college. (See Tables IV and V.)

ESTIMATES OF CURRENT COMPUTER MANPOWER

In order to estimate computer man-

power needs, I must first estimate existing manpower so that I can project needs in terms of growth and replacement. For the 35,000 computer installations in the U. S., I estimate that there is an average of three (3) administrators, five (5) analysts, three (3) systems programmers, seven (7) applications programmers and six (6) operators. (See Tables IV and Table V.) The previous estimate of 560,000 other operating personnel brings the average staff per installation to 40. This may appear a little high at first but we must keep in mind that each installation has on the average 2-1/2 computers, or looking at it in a different way, the estimated 35,000 computer installations include all of the major installations, i.e., installations with medium and large scale computers.

REPLACEMENT POTENTIAL FOR COLLEGE GRADUATES

The number of Ph.D.'s in Computer and Information Sciences required in staffing computer installations is difficult to estimate. For installations in the institutions of higher education four percent of the staff members held doctorates in 1966-67 and 1969-70. Even though the numbers nearly doubled (570 to 1003) the percentages remained about the same.[12] This percentage is higher than we would expect in general for computer installations. Even one percent, or 14,000, might be a little high and one-half percent (7000) a little low. Looking at it another way, if we assume that one out of five of the 35,000 installations average one Ph.D. per installation, this would be 7000 Ph.D.'s employed in computer installations. These are probably distributed between management and analysts in a ratio of about five to two, i.e., 5000 in management and 2000 as analysts (primarily operations research analysts). To these numbers we should add an additional 1500 (1273 reported in 1969-70) persons holding doctorates and employed by colleges and universities as professors and not associated with a computer installation.[12]

The master's degree is quite common in the management, analysts and systems programmers categories and not too uncommon among applications programmers, and some top supervisory positions attract M.S. graduates in the computer and information sciences.

Table V gives my estimate of the distribution of computer staff by level of education that I believe to be desired for replacement if an adequate supply of manpower is available at these levels. During the past years, companies have had to take what staff they could get and train or retrain them. This is an expensive route and therefore I believe that, given a choice, industry would prefer to hire trained personnel. In terms of formal education, I believe that we are overutilizing undereducated people in the computer related occupations.

My next step will be to construct similar estimates for the States with respect to total computer manpower by level of education desired for replacements. My basic assumption will be that non-higher education computer centers (hence staff) are distributed by States in the same proportion as higher education computer centers (staff) as reported in the 1969-70 NSF Inventory of Computers. Estimates for the number of computer installations in higher education in 1973 will then be obtained and related to the 35,000 U.S. computer installations estimated by Computers and Automation.

During the period 1966-67 through 1969-70, the number of computer installations in colleges and universities increased from 1106 to 1673 or at the rate of 189 per year.[2,3] If this rate is used to estimate the number of computer installations for 1972-73, we get 2240 or 6% of the 35,000 computer installations in the U.S. Assuming that the number of computer installations in institutions of higher education in each state increased at the same rate, we obtain the "Estimated Number of Installations, in Higher Education" for each of the States in Table VI. By applying these percentages to each of the entries in the Total row of Table V, I obtain the "Estimated Distribution of Computer Staff by Level of Education Desired for Replacements for each State, 1972-73," (see Table VII).

Future Computer Manpower Needs

The two principal factors which will determine future computer related manpower needs are replacement and growth. Replacement needs are largely due to deaths, retirement, change of field and emigration.

Needs for Replacement

For 1971 the overall U.S. death rate was estimated[10] to be 9.3 per 1000 and had been dropping by .1 per year since 1968 with fluctuations from a maximum of 9.7 since 1949. An overall death rate of 9.1 is a reasonable estimate for 1973. However, this is too high for the current computer manpower population. Reference [10] also gives the death rates for white males as follows:

Age Group	Rate
15-24	1.7
25-34	1.7
35-44	3.3
45-54	8.5
55-64	21.6

Since the model class for current computer manpower is probably the 35-44 age group with the 25-34 age group running a close second, 3 in 1000 is a good estimate of overall replacement needs due to deaths. However, we need estimates for each of the education levels.

The persons most likely to be replaced by the two-year and four-year graduates are those who have been in the data processing field before computers and are in the above 45 categories. This plus the fact that there is a tendency to promote from within will cause vacancies due to deaths to open up positions in the lower ranks for people just entering the field. For these reasons, a replacement rate of 5 per 1000 appears logical for the 2-year and 4-year groups. By the same reasoning, a rate of 2 per 1000 appears reasonable for the M.S. and Doctorate categories.

Retirement tends to impact the senior positions, hence, will provide a greater proportion of direct entry positions at the higher education levels. However, because of the promotion from within effects my estimate of replacement needs due to retirement will be uniform for all education levels. For this estimate, we need to know how many of those presently (1972-73) engaged in computer related jobs are age 65. For 1972[10], there were 42,340,000 persons in the 45-64 age group. Even after allowing for differences due to death rates, there were at least 2,000,000 people who were age 64 in 1972 and are now age 65. This is approximately 1.7% of the total population between ages 18-65. The manpower needs due to retirement would then be a rate of 17 per 1000.

For lack of any information to the contrary, I will assume that immigration to the U.S. and to the computer field is balanced by emigration from the computer field and from the U. S.

Computer Manpower Needs for Growth

According to the "Monthly Computer Census" published in Computers and Automation[9], the number of computers installed in the U.S. increased by approximately 60% during 1972 or from 50,000 plus to 80,000 plus. Some of this apparent increase must be due to improved reporting and, of course, the recent influx of mini-computers. Uses of the computers continue to spread. A 10% increase in computer manpower needs at all educational levels seems realistic for the next 5-10 years. Table VIII summarizes the above estimates for computer manpower needs due to replacement and growth.

These estimates say that we are producing enough two-year post-secondary graduates in the computer field, but only one-half of the needed doctorates and one-tenth the number of bachelor's and master's levels needed. This reinforces my earlier statement that we are overutilizing under-educated people in the computer related fields. Others may wish to take exception to the assumptions which led to these results. If so, I hope that I have made the procedures transparent enough so that they can produce their own estimates. Even if my estimates are off by 50%, we still would have severe shortages indicated at the 4-year and master's levels for some years. I will admit the possibility of as much as 10% error either direction on the "Estimated 1973 Production" figures and perhaps as much as 20% on the "Total New Personnel" needs estimates. The latter do contain subjective elements. The most debatable element in this regard is the "Estimated Distribution of 1972-73 Computer Staff by Level of Education Required for Replacements" given in Table VII.

Table IX gives corresponding estimates for each of the States. To obtain the production estimates, I will assume that production at the various levels has increased at the same rate in each state as was used for all U.S. (see figure 1). For the "associate" graduates, the rate is (9000/7523) = 1.20, the bachelor's graduates (5800/3375) = 1.72, the master's level (2800/2069) = 1.35 and at the doctorate level (450/342) = 1.32. The post-secondary vocational institutions' production figures from Table III are added to the associate degrees to obtain the final 2-year estimates. Before applying these factors to the reported figures in Table II, each of those numbers should be multiplied by 1.34 to allow for production by non-reporting institutions. The combined multipliers are then (1.20 x 1.34) = 1.61 for associate degrees, 2.30 for bachelor's, 1.81 for master's and 1.77 for doctorates.

COMPARISON WITH BLS ESTIMATES AND PROJECTIONS FOR 1980

In the 1972-73 Occupational Outlook Handbook published by the Bureau of Labor Statistics it was reported that there were over 100,000 systems analysts in 1970, over 200,000 programmers and over 200,000 operators. Assuming a 10% annual growth factor (Gilchrist, Computerworld, McGovern of International Data Corporation, and U.S. Department of Labor in the U. S. Economy in 1980, Bulletin 1673, p. 47, et. al.) we can expect these numbers to double by 1980. This extrapolation would give 200,000 systems analysts, 400,000 programmers and 400,000 operators for 1980. However, the 1970 estimate for systems analysts does not agree with the 1968 figures given in the U. S. Economy in 1980, p. 59, which gives 150,000 system analysts for 1968 or when extrapolated to 1970, 180,000 systems

analysts for 1970 and 240,000 for 1973, as compared to my estimate of 175,000. The projections for 1980 are presented on the same page and are 425,000 for systems analysts, 400,000 for programmers and 400,000 for operators. Some of the differences result from definitions. I would guess that some of what I call systems programmers are counted by BLS as programmers and others as systems analysts since no such category as systems programmers appears in BLS publications referred to above. It is of interest to note (p. 59, also) that systems analysts, programmers and computer operators were expected to be the fastest growing occupations in the 1970's.

Management personnel are most likely to be counted under "Managers" in the BLS classifications and on page 293 of the 1972-73 Handbook there is an indication that what I call other operating personnel (excluding card punch operators) are included under Office Machine Operators. In particular, operators of tabulating machines and related equipment, where such equipment is an integral part of a computer installation, would fall under my classification of "other operating personnel".

In BLS Bulletin 1673 referred to above it was estimated that there would be 120,000 computers in use by 1980 and that the number of process computers would reach about 17,000. I believe that the 120,000 figure is conservative, depending upon one's definition of a computer. In the same publication it was estimated that for the period 1968-80 there would be annual openings for 23,000 programmers, 27,000 systems analysts and 20,400 operators, or a total of 70,400 in just these three classifications. Since these three categories account for about two-thirds of my total estimates, extrapolation of the 70,400 figure gives about 105,000 annual openings per year. This number compares very well under the circumstances with my estimated need of 117,000 per year.

POST SECONDARY AND 2-YEAR PROGRAMS

The post secondary vocational and 2-year programs are usually offered in isolation from each other and the higher level programs. Unless the computer facilities can be shared for administrative functions or other similar programs in other institutions, the minimum adequate computer installation costs of approximately $40,000 per year requires that there be a total enrollment of about 400 students to come close to the $100 per student per year figure. Allowing 40 (10%) for students in other majors taking courses in data processing, computer technology, etc., this leaves 360 as the minimum number of majors. Assuming that approximately one-third of these complete the program each year, gives 120 graduates per program per year. If all of the estimated 445 2-year programs going in 1970-71 produced at this (120) level, we would be producing 53,400 graduates per year in the 2-year programs alone. I estimated[3] that approximately half of the 2-year programs were weak in some respect. If these were discontinued and the remaining ones strengthened, we would still be producing 26,700 graduates per year in the 2-year programs alone in addition to the post-secondary vocational programs. As I see it, it is imperative that the two-year programs be examined carefully, the weak ones eliminated, the others strengthened and that close contact and cooperation be maintained with the 4-year programs in order that approximately half of the 2-year graduates can move into the 4-year programs with minimal loss of credits. The problems associated with transfer credits from the post-secondary vocational school to colleges and universities are more complex. Nevertheless, the same contact and cooperation with colleges and universities should be established and maintained wherever possible. If something is not done soon, we can expect to have a glut in the market for post-secondary vocational and 2-year graduates during the next 5 to 10 years.

FOUR YEAR PROGRAMS

Four-year programs grew from ninety (90) in 1966-67 to 276 in 1971-72 with graduates increasing from an average of 6 per program in 1966-67 to 14 per program in 1970-71.[12] Growth for the four-year programs was, and is, slow because no federal programs have been aimed directly at implementing these programs as has been done for the post-secondary vocational and 2-year programs. Another reason for the slowness of growth has been due to a lack of qualified staff (i.e., holders of advanced degrees) to man the programs. This situation is changing rapidly. There are many faculty now on the market who have doctorates in other areas, (Math, Physics, etc.) who are finding it more and more difficult to join a computer science department offering graduate programs but are well qualified to participate in stand-alone B.S. degree programs.

In Table IX my estimates show that we have a national potential annual need for 50,000 more B.S. graduates in computer science, data processing, and related areas. Programs producing nearly 100 graduates per year (enrollment of approximately 400 students) appears to me to be optimal. (Obviously the small four year colleges will not be able to attain programs of this magnitude.) This would mean that 560 programs would be needed. With only 276 during 1971-72 and half of these lacking in some manner[3], there is need for considerable activity at the

4-year level.

The institutions involved and wanting to get involved in bachelor's level programs in computer science, data processing, etc., should study state and regional needs, strengthen, broaden and expand existing 4-year programs, delete other weak programs and initiate programs where state and regional need is indicated.

MASTER'S PROGRAMS

Master's degree programs grew in number from 98 in 1966-67 to 190 in 1971-72. Graduates increased from less than 8 per program in 1966-67 to 11 per program in 1970-71.[12] The optimum size for a master's degree program is one which produces about 50 graduates per year and averaging an enrollment of more than 100. This implies the need for about 680 programs at the Master's level or more than three times the existing number. This kind of growth at the graduate level is not in sight, unfortunately. With new monies for higher education so few, such expansion must come from a real location of existing resources by trimming the budgets of programs with decreasing enrollments. This is a slow and painful process for university administrators. Those "who have" are in a better position "to get and keep". With diminishing enrollment, teaching loads are lighter and time is available for a flurry of activity to keep what they have. A growing department (or one which has potential for growth) is burdened with teaching and activities associated with large numbers of majors and cannot compete on the same basis. The end result is "those who have--keep" and there is nothing available for "those who need". Only the boldest and bravest administrations can counter this situation.

My recommendations for institutions offering or wanting to offer master's level programs in computer science, information systems, etc., is the same as that for the institutions offering or wanting to offer programs at the bachelor's level. Study state and regional needs and then full speed ahead.

DOCTORATE LEVEL PROGRAMS

If we assume that a doctorate requires on the average of three years beyond the master's and that one-third of those who begin drop out after three years or less, then doctorate program with about 45 students enrolled would graduate about 10 per year. Although this is a little high for average production, it appears to be optimal to support the kind of master's and bachelor's programs I have stated as being optimal above. If the existing (1971-72) 114 programs were producing at this level in the years ahead (5-10) we would be producing about the number estimated to be needed. Some of my colleagues have expressed concern that my estimates of need for doctorates in systems programming should be 200-300 and not zero (see Table V). In light of this (they were convincing in their arguments) and the fact that an average of 10 graduates per year is probably high, we could easily stand to have another 20-30 doctorate programs in computer science. Since new doctoral programs in general are a no-no, in so far as state legislatures are concerned, emphasis should be placed upon state and regional cooperation to strengthen existing programs. Interstate and interinstitutional cooperation is strongly indicated. State and regional studies should be made on production vs. need and indicated necessary action taken.

SUMMARY

Upon further study of the data available I have reconsidered my appraisals of the need for new programs at the bachelor's and master's levels, and to a lesser degree at the doctorate level[12]. Large numbers of personnel have been able to enter the computer manpower pool in the past with little training. The proprietary schools had a "heyday". Only the best and largest have survived. Large amounts of federal and state funds were poured into the vocational and 2-year programs. I question the value of those operated at the secondary level and have estimated that there should be a weeding out of the weakest post-secondary vocational and 2-year programs. I differ with Gilchrist and Weber[4,5] in that I do not think that secondary schools will be significant producers of computer manpower. On the other hand, computer education at the secondary level should not be neglected. Secondary schools should provide enough computer education so that the student can learn to live comfortably in a computer assisted environment and also enough so that students pursuing post-secondary education can judge whether or not they wish to pursue a program of study which will prepare them for entry into the computer manpower pool.

Level	No.	To Enter Manpower Pool	Continue Education
Associate	11,000	9,500	2,000
Bachelor's	8,000	5,000	3,000
Master's	3,500	2,500	1,000
Doctorate	500	500	
	23,000	17,000	6,000

Table I - Estimates of Degrees to be awarded in Computer Sciences, Data Processing, Information Science, Information Systems, etc. During 1974-75.

TABLE II

REPORTED NUMBERS OF DEGREE PROGRAMS AND NUMBERS OF GRADUATES IN COMPUTER FIELDS

1970-71

State	Associate		Bachelor's		Master's		Doctorate	
	Programs	Graduates	Programs	Graduates	Programs	Graduates	Programs	Graduates
Alabama	5	97	5	15	2	12	1	3
Alaska	1	25	0	0	0	0	0	0
Arizona	5	67	3	48	3	35	4	8
Arkansas	1	20	0	0	1	3	0	0
California	31	720	12	312	11	230	12	57
Colorado	4	99	3	68	1	70	0	0
Connecticut	6	50	2	12	1	6	1	2
Delaware	3	36	1	12	1	15	1	2
District of Col.	0	0	2	7	1	0	0	0
Florida	21	196	8	185	3	38	0	0
Georgia	2	58	0	0	4	46	3	3
Hawaii	2	28	0	0	1	16	0	0
Idaho	0	0	0	0	0	0	0	0
Illinois	31	412	8	99	8	122	4	30
Indiana	6	221	7	93	4	43	1	10
Iowa	2	28	2	75	2	27	2	8
Kansas	4	76	4	62	2	14	0	0
Kentucky	4	15	4	14	1	0	0	0
Louisiana	1	35	7	87	3	22	3	2
Maine	0	0	0	0	1	2	0	0
Maryland	9	140	0	10	1	22	2	0
Massachusetts	7	135	5	14	5	50	2	15
Michigan	11	113	4	83	6	37	5	7
Minnesota	0	0	3	44	2	13	2	8
Mississippi	5	51	2	46	1	5	0	0
Missouri	6	126	7	93	6	84	4	6
Montana	0	0	1	3	0	0	0	0
Nebraska	0	0	1	10	1	5	0	0
Nevada	1	1	1	1	0	0	0	0
New Hampshire	1	28	0	0	0	0	0	0
New Jersey	7	130	5	69	4	55	3	6
New Mexico	3	37	5	34	5	38	0	0
New York	31	704	14	136	14	184	10	29

TABLE II (Cont.)

REPORTED NUMBERS OF DEGREE PROGRAMS AND NUMBERS OF GRADUATES IN COMPUTER FIELDS

1970-71

State	Associate		Bachelor's		Master's		Doctorate	
	Programs	Graduates	Programs	Graduates	Programs	Graduates	Programs	Graduates
North Carolina	11	146	5	75	1	6	1	1
North Dakota	2	68	2	9	0	0	0	0
Ohio	8	229	12	221	4	62	2	11
Oklahoma	6	120	2	25	1	6	1	0
Oregon	6	68	2	4	1	14	1	0
Pennsylvania	10	172	7	147	6	52	4	9
Rhode Island	2	102	2	15	2	13	1	5
South Carolina	7	73	3	58	3	10	2	2
South Dakota	1	50	2	15	0	0	0	0
Tennessee	7	123	3	24	3	15	1	0
Texas	22	413	11	169	10	122	8	28
Utah	2	11	3	66	0	0	0	0
Vermont	1	35	0	0	0	0	0	0
Virginia	7	165	1	9	1	0	0	0
Washington	11	105	2	13	1	8	1	2
West Virginia	3	23	5	0	0	0	0	0
Wisconsin	4	43	4	35	1	2	1	1
Wyoming	2	15	0	0	0	0	0	0
Sub Totals (Reported)	322	5609	182	2517	129	1504	83	255
Service Schools	0	0	1	2	2	40	0	0
Guam	1	5	0	0	0	0	0	0
Puerto Rico	0	0	1	0	0	0	0	0
Totals (Reported)	323	5614	184	2519	131	1544	83	255
Estimated Totals	445	7523	276	3375	190	2069	114	342

TABLE III

ESTIMATES OF COMPUTER MANPOWER PRODUCED BY POST-SECONDARY VOCATIONAL EDUCATION INSTITUTIONS

	Total 1971* Enrollment	1971* Post-Secondary Enrollment	Estimated 1973* Post-Secondary Enrollment	Estimated 1973 Post-Secondary Completions (30%)	Adjusted (-10%) For Overlap With HEGIS	No. Entering Computer Manpower Pool (75%)	No. Continuing Education
Alabama	1840	935	1122	337	303	227	30
Alaska	10	10	12	4	3	2	0
Arizona	2386	1514	1817	545	491	368	49
Arkansas	326	159	191	57	51	38	5
California	39830	22135	26562	7969	7172	5379	717
Colorado	2740	1363	1636	491	442	332	44
Connecticut	3453	599	719	216	194	146	19
Delaware	436	67	80	24	22	17	2
District of Col.	184	128	154	46	41	31	4
Florida	1982	793	952	286	257	193	26
Georgia	5333	931	1117	335	302	227	30
Hawaii	612	284	341	102	92	69	3
Idaho	121	29	35	11	10	8	1
Illinois	24282	9720	11664	3499	3149	2362	315
Indiana	1343	363	436	131	118	89	12
Iowa	1914	954	1145	344	310	233	31
Kansas	1703	559	671	201	181	136	18
Kentucky	454	82	98	29	26	20	3
Louisiana	2711	495	594	178	160	120	16
Maine	443	3	4	1	0	0	0
Maryland	4230	1806	2167	650	585	439	59
Massachusetts	6410	635	762	229	206	155	21
Michigan	7606	3683	4420	1326	1193	895	119
Minnesota	3329	509	611	183	165	124	17
Mississippi	1302	611	733	220	198	149	20
Missouri	2988	1148	1378	413	372	279	37
Montana	228	161	193	58	52	39	5
Nebraska	393	237	284	85	77	58	8
Nevada	400	34	41	12	11	8	1
New Hampshire	215	99	119	36	32	24	3

TABLE III (Cont.)

ESTIMATES OF COMPUTER MANPOWER PRODUCED BY POST-SECONDARY VOCATIONAL EDUCATION INSTITUTIONS

	Total 1971 Enrollment	1971* Post-Secondary Enrollment	Estimated 1973* Post-Secondary Enrollment	Estimated 1973 Post-Secondary Completions (30%)	Adjusted (-10%) For Overlap with FEGIS	No. Entering Computer Manpower Pool (75%)	No. Continuing Education
New Jersey	7309	1268	1522	457	411	308	41
New Mexico	664	312	374	112	101	76	10
New York	14722	3438	4126	1238	1114	836	111
North Carolina	4777	2575	3090	927	834	626	83
North Dakota	534	339	407	122	110	83	11
Ohio	5835	1062	1274	382	344	258	34
Oklahoma	878	53	64	19	17	13	2
Oregon	1673	637	764	229	206	155	21
Pennsylvania	9984	1815	2178	653	588	441	59
Rhode Island	367	114	137	41	37	28	4
South Carolina	256	212	254	76	68	51	7
South Dakota	84	20	24	7	6	5	1
Tennessee	3041	1999	2399	720	648	486	65
Texas	11870	7137	8564	2569	2312	1734	231
Utah	1627	269	323	96	86	65	9
Vermont	86	0	0	0	0	0	0
Virginia	5111	1101	1321	396	356	267	36
Washington	3149	2095	2514	754	679	509	68
West Virginia	310	53	64	19	17	13	2
Wisconsin	5321	2537	3044	913	813	610	81
Wyoming	304	240	288	86	77	58	8
American Samoa	0	0	0	0	0	0	0
Guam	0	0	0	0	0	0	0
Puerto Rico	156	120	144	43	39	29	4
Trust Territories	0	0	0	0	0	0	0
Virgin Islands	0	0	0	0	0	0	0
Totals	197265	77442	92933	27877	25078	18818	2503

* USOE reported number

** USOE assumed a 50% increase over five years

TABLE IV

Estimates of Computer Manpower Being Utilized in U.S.
January 1973

	Positions	College Education Required for Replacement
Management	105,000	105,000
Analysts	175,000	175,000
Systems Programmers	105,000	105,000
Applications Programmers	245,000	245,000
Operators	210,000	210,000
Other Operating Personnel	560,000	112,000
	1,400,000	952,000

TABLE V

ESTIMATED DISTRIBUTION OF 1973 COMPUTER STAFF BY LEVEL OF EDUCATION REQUIRED OR DESIRED FOR REPLACEMENTS

	PS VOC and 2-year	4-year	M.S.	Ph.D.	Total	Percent of Total
Teaching	200	1,500	2,000	1,500	5,200	.5
Management	3,000	37,000	60,000	5,000	105,000	11
Analysts	1,000	62,000	100,000	2,000	175,000	18
Systems Programmers	2,000	33,000	70,000	---	105,000	11
Applications Programmers	10,000	200,000	35,000	---	245,000	26
Operators	100,000	100,000	10,000	---	210,000	22
Other Operating Personnel	100,000	12,000	---	---	112,000	12
Total	216,200	445,500	287,000	8,500	957,200	
Percent of Total	23	46	30	1		

TABLE VI

ESTIMATED DISTRIBUTION OF COMPUTER INSTALLATIONS BY STATES, 1972-73

State	Installations Reported for H.E. 1969-70	Estimated Number Installations for H.E. 72-73	% of all U.S.
Alabama	28	38	1.7
Alaska	1	1	.1
Arizona	19	25	1.1
Arkansas	7	9	.4
California	127	170	7.6
Colorado	19	25	1.1
Connecticut	27	36	1.6
Delaware	5	7	.3
District of Col.	15	20	.9
Florida	46	62	2.7
Georgia	44	59	2.6
Hawaii	7	9	.4
Idaho	8	11	.5
Illinois	105	141	6.3
Indiana	50	67	3.0
Iowa	28	38	1.7
Kansas	27	36	1.6
Kentucky	15	20	.9
Louisiana	23	31	1.4
Maine	13	17	.8
Maryland	33	44	2.0
Massachusetts	70	94	4.2
Michigan	65	87	3.9
Minnesota	38	51	2.3
Mississippi	20	27	1.2
Missouri	44	59	2.6
Montana	7	9	.4
Nebraska	15	20	.9
Nevada	6	8	.4
New Hampshire	11	15	.7
New Jersey	39	52	2.3
New Mexico	10	13	.6
New York	137	184	8.2
North Carolina	46	62	2.7
North Dakota	9	12	.5
Ohio	56	75	3.3
Oklahoma	21	28	1.3
Oregon	28	38	1.7
Pennsylvania	92	123	5.5
Rhode Island	11	15	.7
South Carolina	26	35	1.6
South Dakota	7	9	.4
Tennessee	35	47	2.1
Texas	86	115	5.1
Utah	6	8	.4
Vermont	9	12	.5
Virginia	36	48	2.1
Washington	29	39	1.7
West Virginia	15	20	.9
Wisconsin	36	48	2.1
Wyoming	3	4	.2
Service Schools	9	12	.5
Canal Zone	0	0	.0
Guam	0	0	.0
Puerto Rico	4	5	.2
Virgin Islands	0	0	.0
TOTALS	1673	2240	99.9

TABLE VII

ESTIMATED DISTRIBUTION OF COMPUTER STAFF BY LEVEL OF EDUCATION DESIRED FOR REPLACEMENTS BY STATES, 1972-73

State	Post Sec. Voc. and 2-year	4-year	M.S.	Ph.D.	Total
Alabama	3675	7574	4879	145	16273
Alaska	216	446	287	9	957
Arizona	2378	4901	3157	94	10530
Arkansas	865	1782	1148	34	3829
California	16431	33858	21812	646	72747
Colorado	2378	4901	3157	94	10530
Connecticut	3459	7128	4592	136	15315
Delaware	649	1337	867	26	2879
District of Columbia	1946	4010	2583	77	8616
Florida	5832	12028	7749	230	25839
Georgia	5621	11583	7462	221	24887
Hawaii	865	1782	1148	34	3829
Idaho	1081	2228	1435	43	4787
Illinois	13621	28067	18081	536	60305
Indiana	6486	13365	8610	255	28716
Iowa	3675	7574	4879	145	16273
Kansas	3459	7128	4592	136	15315
Kentucky	1946	4010	2583	77	8616
Louisiana	3027	6237	4018	119	13401
Maine	1730	3564	2296	68	7658
Maryland	4324	8910	5740	170	19144
Massachusetts	9080	18711	12054	357	40202
Michigan	8432	17375	11193	332	37332
Minnesota	4973	10247	6601	196	22017
Mississippi	2594	5346	3444	102	11486
Missouri	5621	11583	7462	221	24887
Montana	865	1782	1148	34	3829
Nebraska	1946	4010	2583	77	8616
Nevada	865	1782	1148	34	3829
New Hampshire	1513	3119	2009	60	6701
New Jersey	4973	10207	6601	196	22017
New Mexico	1297	2673	1722	61	5753
New York	17728	36531	23534	697	78490
North Carolina	5832	12028	7749	230	25839
North Dakota	1081	2228	1435	43	4787
Ohio	7135	14702	9471	281	31589
Oklahoma	2811	5792	3731	111	12445
Oregon	3675	7574	4879	145	16273
Pennsylvania	11891	24503	15785	468	52647
Rhode Island	1513	3119	2009	60	6701
South Carolina	3459	7128	4592	136	15315
South Dakota	865	1782	1148	34	3829
Tennessee	4540	9356	6027	179	20102
Texas	11026	22721	14637	434	48818
Utah	865	1782	1148	34	3829
Vermont	1081	2228	1435	43	4787
Virignia	4540	9356	6027	179	20102
Washington	3675	7674	4879	145	16373
West Virginia	1946	4010	2583	77	8616
Wisconsin	4540	9356	6027	179	20102
Wyoming	432	891	574	17	1914
Service Schools	1081	2228	1435	43	4787
Canal Zone	0	0	0	0	0
Guam	0	0	0	0	0
Puerto Rico	432	891	574	17	1914
Virgin Islands	0	0	0	0	0

TABLE VIII

Future Computer Manpower Needs Per 1000
Estimated 1973 Personnel

Cause:	Education Level			
Replacement	2-yr.	4-yr.	M.S.	Doctorate
Deaths	5	5	2	2
Retirements	17	17	17	17
Growth	100	100	100	100
Total Rate	122	122	119	119
Total New Personnel	26,376	55,571	34,153	1,012
Estimated 1973 Productions	27,816	5,800	2,800	450

TABLE IX

ESTIMATED COMPUTER MANPOWER NEEDS AND ESTIMATED PRODUCTION FOR 1972-73

BY POST-SECONDARY INSTITUTIONS BY STATES

State	PS VOC and 2-year		4-year		Master's		Doctorate	
	Need	Production	Need	Production	Need	Production	Need	Production
Alabama	448	383	924	35	581	22	17	5
Alaska	26	42	54	0	34	0	1	0
Arizona	290	476	598	110	376	63	11	14
Arkansas	106	70	217	0	137	5	4	0
California	2005	6538	4131	718	2596	416	77	101
Colorado	290	491	598	156	376	127	11	0
Connecticut	422	226	870	28	546	11	16	4
Delaware	79	75	163	28	103	27	3	4
District of Col.	237	31	489	16	307	0	9	0
Florida	712	509	1467	426	922	69	27	0
Georgia	686	320	1413	0	888	83	26	5
Hawaii	106	114	217	0	137	29	4	0
Idaho	132	0	272	0	171	0	5	0
Illinois	1662	3025	3424	228	2152	221	64	53
Indiana	791	445	1631	214	1025	78	30	18
Iowa	448	278	924	172	581	49	17	14
Kansas	422	258	870	143	546	25	16	0
Kentucky	237	44	489	32	307	0	9	0
Louisiana	369	176	761	200	478	40	14	4
Maine	211	0	435	0	273	4	8	0
Maryland	528	664	1087	23	683	40	20	0
Massachusetts	1108	372	2283	32	1434	91	42	26
Michigan	1029	1077	2120	191	1332	67	40	12
Minnesota	607	124	1250	101	786	24	23	14
Mississippi	316	231	652	106	410	9	12	0
Missouri	686	482	1413	214	888	152	26	11
Montana	106	39	217	7	137	0	4	0
Nebraska	237	58	489	23	307	9	9	0
Nevada	106	10	217	2	137	0	4	0
New Hampshire	185	69	381	0	239	0	7	0
New Jersey	607	517	1245	159	786	100	23	11
New Mexico	158	136	326	78	205	69	7	0
New York	2163	1969	4457	313	2801	333	83	51

TABLE IX (Cont.)

ESTIMATED COMPUTER MANPOWER NEEDS AND ESTIMATED PRODUCTION FOR 1972-73

BY POST SECONDARY INSTITUTIONS BY STATES

State	PS VOC and 2-year		4-year		Master's		Doctorate	
	Need	Production	Need	Production	Need	Production	Need	Production
North Carolina	712	861	1467	173	922	11	27	2
North Dakota	132	192	272	21	171	0	5	0
Ohio	870	627	1794	508	1127	112	23	19
Oklahoma	343	206	707	58	444	11	13	0
Oregon	448	264	924	9	581	25	17	0
Pennsylvania	1451	718	2989	338	1878	94	56	16
Rhode Island	185	192	381	36	239	24	7	9
South Carolina	422	169	870	133	546	18	16	4
South Dakota	106	86	217	36	137	0	4	0
Tennessee	554	684	1141	55	717	27	21	0
Texas	1345	2399	2772	389	1742	221	52	50
Utah	106	83	217	152	137	0	4	0
Vermont	132	56	272	0	171	0	5	0
Virginia	554	533	1141	21	717	0	21	0
Washington	448	678	936	30	581	14	17	4
West Virginia	237	50	489	0	307	0	9	0
Wisconsin	554	679	1141	81	717	4	21	2
Wyoming	53	82	109	0	68	0	2	0
Service Schools	132	0	272	5	171	72	5	0
Canal Zone	0	0	0	0	0	0	0	0
Guam	0	8	0	0	0	0	0	0
Puerto Rico	53	29	109	0	68	0	2	0
Virgin Islands	0	0	0	0	0	0	0	0

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