DOCUMENT RESUME

ED 230 222 JC 830 211

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TITLE Can Colleges and Universities Supply an Adequate Skilled Workforce for High Technology Needs in 1990? Problems, Prospects, and Policy for the Eighties. Research Report No. 82-27.

INSTITUTION Prince George's Community Coll., Largo, Md. Office of Institutional Research.

PUB DATE Oct 82

NOTE 21p.

PUB TYPE Viewpoints (120) -- Statistical Data (110)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS Computer Science Education; *Employment Patterns; Engineering Education; Engineering Technicians; Labor Force; *Labor Needs; *Labor Supply; Postsecondary Education; *Technological Advancement

ABSTRACT

Industry's needs for students with high technology skills are increasing. Bureau of Labor Statistics forecasts project increases between 1980 and 1990 of 58% in the demand for computer professionals, 28% for engineers, and 24% for engineering technicians, compared with an increase of 17% for all workers. Industrial expansion and replacement of workers will produce an annual demand for 120,000 engineers (including 33,000 new openings) and 168,000 technicians (including 21,000 new openings). Graduation trends in high technology fields, however, indicate problems in filling these positions. Workforce needs have increased faster than labor supply due to poor planning and resource allocation at the college level and poor preparation of students in science and mathematics in elementary and high schools. These problems should be addressed through pressure from colleges and universities on local and state boards of education to improve math and science preparation in the schools; flexible provision of skills up-dating for adults in both credit and non-credit programs; and increased funding of high technology education at the state level. Tables showing workforce and educational trends and projections are included. (HB)

Research Report No. 82-27

Can Colleges and Universities Supply an Adequate Skilled Workforce for High Technology Needs in 1990? Problems, Prospects, and Policy for the Eighties

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October 1982

Abstract

Industry needs for high technology skills are increasing in the U.S., due in part to the exponential growth of activity in selected technologies. One would expect this demand for activity to generate an adequate supply of engineers, engineering technicians, scientists, and computer specialists. But there appear to be constraints on the supply side, as measured by degrees and formal awards. A Delphi study was conducted which suggested that faculty scarcities exist in high technolo-ogy skill areas. This scarcity, related to business and industry practices of hiring available workforce for immediate competitive advantage or short-term commercial gain, poses a problem of national policy and college/university staffing. Moreover, low priorities for education in science and math at the elementary and secondary level threaten America's role in high technology in the 1990's and in the 21st Century.

Sources: 1990 forecasts of employment demand from the Bureau of Labor Statistics; degrees and awards data from the National Center for Educational Statistics.

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Introduction

We need evidence for policy about higher education and high technology. Our need for scientific and technical mindpower is increasingly urgent. But how do we translate national employment information into college and university program priorities? The National Industry-Occupation Employment Matrix poses problems. The Bureau of Labor Statistics (BLS) forecasts to 1990 involve a huge database. The econometric model is so sophisticated, it takes an experienced user to use it.

To analyze the 1990 projections, the low level trend forecasts were collated with graduations related to high technology. The measure was graduations by degree level reported by the National Center for Education Statistics (NCES). This provided a picture of changing needs. With this frame of reference, we can now re-examine college and university policies and strategic planning.

1990 Forecasts of High Technology Occupations

The Bureau of Labor Statistics has recently completed a new run of its model forecasting employment by occupation and industry in 1990. This latest forecast incorporates actual employment through 1980, and economic insights more recent than that in the form of assumptions specifying the model. Compared with a 1980 workforce of 102.1 million persons, the low trend projection to 1990 gives a workforce of 119.6 million. (The high trend would be 127.9 million.) Thus the more modest forecast allows for an increase of 17 million workers during the 1980's, for a 17 percent increase over the decade. The high trend would involve a 26 percent increase if we should be able to break out of the no growth or slow growth economy of 1980-82. (See Table 1.)

Staying with the low trend estimate, we find the following forecasts for high technology jobs in 1990:

	1990	1980-1990 Increase
Computer Analyst/Programmers	680,000	250,000
Engineers	1,500,000	326,000
Engineering Technicians	1,580,000	310,000

Compared with 17 percent growth for all workers, this low trend estimate means a 58 percent growth for computer professionals, 28 percent for engineers, and 24 percent for engineering technicians. Compared another way, we see technology needs for personnel growing well above the 18 percent growth in needs for physical and life scientists. (See Table 2.)

New Openings and Replacement Needs: Engineers and Technicians

Expanding industries open up new positions for high technology personnel. But replacement needs generate more demand for educated and trained people. The BLS model gives estimates of annual openings, divided into new slots and replacement needs. The estimated annual 1980's demand for engineers and technicians is as follows (See Table 3.)

	Replacement Demand	New Openings
Engineers	87,000	33,000
Technicians	147,000	21,000

Thus an annual demand for 120,000 engineers and 168,000 technicians arises mainly from replacement pressures. Such needs are often met by transfers of people qualified by related experience. Higher education credentials, in fact, are increasingly augmented by adult work experience, as students combine full time jobs with evening coursework.

Replacement demand is less strong for computer applications professionals. The 1990 forecasts estimated annual needs for 28,000 computer systems analysts and 36,000 computer programmers, subdivided as follows:

	Replacement Demand	New Openings
Systems Analysts	14,000	14,000
Computer Programmers	25,000	11,000

Programmers would seem to be more in demand due to replacement requirements. Experienced people with less credentials would be competing with recent graduates for job openings. We seem to be coming into a multi-tiered need for programmers. One kind of demand is for applications specialists with advanced skills and three or more years experience. The working community college student would meet this need, or the university student with adult work experience. Skilled people with degrees in other disciplines also transfer into these jobs.

Another kind of demand is for simpler, lower level applications. These applications require less knowledge of machine languages, and less experience. The high school student can meet many of these needs, and the microcomputer in the home or office is making many applications skills as common as automobile driving. In this situation, substantive knowledge in a field of technology becomes more important for getting a job in business and industry.

Graduation Trends in Related Majors

The number of graduations in technology-related areas will help us to assess trends in higher education impacting on high technology. The assumption here is that mindpower is what counts, and degrees awarded are a measure of increased mindpower.

Engineering Sciences and Technology degrees awarded are a useful measure of applied science in high technology. According to the National Center for Educational Statistics, there was a considerable 1970's increase in Associate and Bachelor's degrees graduates receiving engineer and technician credentials (data available were for the 1971-1981 period, see Table 4):

Degree	No. in 1981	1971-81 Change	% Change from 1971
A.A.	89,300	51,900	139%
B.A.	75,000	25,000	50%
M.A.	16,700	266	- 2%
Ph.D.	2,600	-1,100	-30%

Thus we see a tremendous thrust in A.A. degree trends, on the order of half as much thrust in bachelor's level production, and an actual decrease in graduate awards during the 1971-1981 period. Should this same kind of trend continue through the 1980's, we would be likely to see a different kind of workforce composition in the high technology team of the 1990's---with the obvious caution, "all other things being equal." We know that age cohort influences and national priorities are sure to result in many changes in direction across the spectrum of degrees awarded.

Computer Sciences and Technology graduations are another useful measure of trends. Information from NCES lets us know the following about 1971-1981 events in computer specialist awards (See Table 5):

Degree	No. in 1981	1971-81 Change	% Change 1971-1981
A.A.	19,000	10,300	117%
B.A.	12,200	9,800	410%
M.A.	3,900	2,300	143%
Ph.D.	240	115	90%

Thus the bachelor's degree production of computer professional credentials was the most vigorous. Both master's and associate degree winners saw hefty growth in numbers and percent gain. Overall, there was a growth rate of 175 percent in computer and information science or technology degrees. In contrast, there was a 27 percent increase in all degrees. If trends like this were to continue, we might see a lot more credentials awarded in the compute field by 1990. But a question needs to be raised about the nature of the technology in information and communications. Will the same skill mix be needed as the Seventies demanded? A qualitative look at micro-computer technology, satellite communications, hundred-channel cable communications systems, laser technology, and the like may lead us toward a richer perspective in looking toward 1990.

Graduate Supply and 1980's Needs

In summary, high technology credentials in 1981 showed great variety in growth rates, depending on degree level from the A.A. to the Ph.D. (See Table 6.) There was evidence of rapid growth in computer and information science, expecially at the B.A. degree level. Engineering and scientific technician credentials also grew rapidly in the Seventies. But the overwhelming volume of activity here was associated with the community college degrees, now providing the great bulk of new technician awards. On the basis of this evidence, we can now roughly compare annual demand estimates for the 1980's with indicators of certified new skill supply in 1981 (See Table 7):

	Demand Estimate	New Degrees as % of Need	Other Sources as % of Need
Computer Applications	64,000	55%	45%
Engineering Technicians	168,000	60%	40%
Engineers	120,000	69%	31%

Accordingly, among the categories considered, in 1981 employment demand for computer programmers and analysts was mostly being met by non-academic or else "other" academic sources of supply. This could mean anything from high school and proprietary school training, through on the job training and self-instruction, to transfers of people with degrees in science, mathematics, and the like.

More of the need for engineering and science technicians was being met in 1981 by colleges and universities, especially the community colleges. And the annual demand for engineers could be met in seven instances out of ten by the formal supply of new graduates.

Discussion of the Findings

From the perspective of higher education planning, the priority issue concerns resources to support graduates: how much of which kind? But first the problems of process have to be considered. Previous studies have brought out some of the problem areas (cf Larkin, Communication Industry Needs and Higher Education Programs: What Are We Doing Now to Prepare for 1990?, P.G.C.C., July 1982).

Among the examples of problems:

1. Needs have increased faster than formal supply can respond, due to poor planning and resistance to resource reallocation at the college and university level.

2. Longer term strategic planning for human resource skills has been subordinated to quick payoff solutions in industry. Establishments have competed with each other and with education by offering high salaries for skilled people.

3. There is a problem of poor preparation in science and math at the elementary and high school level. This problem is compounded by skilled people being hired away into industry.

Probabilities about the 1980's

Given what we know about resource constraints, age cohort differentials, and failure to plan for longer range purposes, the following seem likely scenarios for the 1980's:

1. The explosion of degreed high technology graduates into the jobmarket will diminish during the 1980's;

2. Fewer experts will have to do more with highly advanced technologies, due to shortages;

3. Low science and math standards in elementary and high schools will continue, due to teacher skill shortages;

4. Faculty availability will continue to be a problem at the college and university level, requiring special arrangements to provide classroom instruction needed;

5. Community colleges will continue the Seventies trend lines in computer applications graduates, but B.A. degrees will continue to increase only at a less rapid rate;

6. Engineering and science technician needs will be mostly met by community colleges, and partly by on the job training;

7. Four-year colleges and universities will focus on engineering skill development for high technology, mostly meeting the demand requirements by 1990.

Conclusions

Skills in using new systems will transfer to other systems. What is needed is a core of knowledge and skills for using new technologies, whatever direction they take. If we will get on with strategic planning, at every level of industry need and college supply, we will reduce the number of lost opportunities we face in international competition.

The most serious problem is our low national priority for science and math education in public elementary and secondary schools. No amount of remediation in college will make up for poor foundations. Colleges and universities need to assert the urgency of better preparation with local and state boards of education.

Changing workforce distribution in high technology industries will be another response. New infrastructures are forming, just as aviation employed many people in new ways in its early days. New networks of skilled people are another response to new technology needs, bypassing decision hierarchies of existing structures.

Higher education, especially community colleges, will be able to help with flexible provision of skill updates for adults, both as credit and non-credit programs. Videoconferencing via 100-channel cable systems is one example of how to meet local employer needs for training or re-training based at the local college.

Currently, federal dollars seem an unlikely source of new money to support new economic development proprities and human resource preparation. However tight cash flow is at the state level, this seems the best direction to turn with higher education items under the following headings:

1. Information,
2. Advocacy,
3. Strategic planning, and
4. Justifications for new funding of high technology education in support of state futures in economic development.

Paul Larkin

October 11, 1982

Table 1

ESTIMATES OF THE U.S. WORKFORCE, 1968-1990

(IN MILLIONS)

	1968	1980	CHANGE NUMBER	CHANGE PERCENT	1990	CHANGE NUMBER	CHANGE PERCENT
LOW TREND	83.9	102.1	18.2	22%	119.6	17.5	17%
HIGH TREND	83.9	102.1	18.2	22%	127.9	25.9	25%

Source: Bureau of Labor Statistics, unpublished data.

Table 2

FORECASTS OF EMPLOYMENT BY OCCUPATION FOR HIGH TECHNOLOGY JOB TITLES TO 1990

	1980	1990	PERCENT CHANGE	ANNUAL OPENINGS*
COMPUTER ANALYSTS & PROGRAMMERS	433,000	683,000	58%	64,000
ENGINEERS	1,178,000	1,504,000	28%	120,000
ENGINEERING TECHNICIANS	1,268,000	1,578,000	24%	168,000
ALL OCCUPATIONS	102,107,000	119,591,000	17%	23,248,000

*Includes replacement as well as expansion opportunities.

Source: B.L.S., unpublished data.

Table 3

ANNUAL REPLACEMENT AND EXPANSION DEMAND FOR SELECTED TECHNOLOGY JOBTITLES IN THE 1980'S

	ANNUAL OPENINGS	REPLACEMENT NEEDS	NEW OPENINGS
COMPUTER ANALYSTS	28,000	14,000	14,000
COMPUTER PROGRAMMERS	36,000	25,000	11,000
ENGINEERS	120,000	87,000	33,000
ENGINEERING TECHNICIANS	168,000	147,000	21,000
ALL OCCUPATIONS	23,248,000	21,500,000	1,748,000

Source: B.L.S.

Table 4

Engineering Sciences and Technology Graduates: 1971-1981

Degree Level	1971	1981	Change	% Change
A.A. and other formal awards	37,437	89,315	51,878	139%
B.A.	50,046	75,000	24,954	50%
M.A.	16,443	16,709	266	2%
Ph.D.	3,638	2,561	-1,077	-30%
All Awards (Eng./Tech.)	107,564	183,585	76,021	71%

Source: N.C.E.S.

Table 5

COMPUTER SCIENCE AND TECHNOLOGY GRADUATES: 1971-1981

DEGREE LEVEL	1971	1981	CHANGE	% CHANGE
A.A. AND OTHER FORMAL AWARDS	8,745	19,003	10,258	117%
B.A.	2,388	12,180	9,792	410%
M.A.	1,588	3,859	2,271	143%
PH.D.	128	243	115	90%
ALL AWARDS	12,849	35,285	22,436	175%

Source: N.C.E.S.

Table 6

Comparison of Academic Awards by High Technology Disciplines: 1971-1981

	1971	1981	1971-1981 Change Number	Percent
Associate Degrees and other formal awards	307,880	533,926	226,046	73%
Computer Technologies	8,745	19,003	10,258	117%
Engineering Technologies	37,437	89,315	51,878	139%
Bachelor's Degrees (total)	839,730	935,140	95,410	11%
Computer & Information Sciences	2,388	12,180	9,792	410%
Engineering Technologies	5,148	11,713	6,565	128%
Engineering Sciences	44,898	63,287	18,389	41%
Physical Sciences	21,412	23,952	2,540	12%
Life Sciences	35,743	43,216	7,473	21%
Master's Degrees (total)	230,509	295,739	65,230	28%
Computer & Information Sciences	1,588	3,859	2,271	143%
Engineering Technologies	134	325	191	143%
Engineering Sciences	16,309	16,384	75	0.5%
Physical Sciences	6,367	5,284	-1,083	-17%
Life Sciences	5,728	5,978	250	4%
Doctor's Degrees (total)	32,107	32,958	851	3%
Computer & Information Sciences	128	243	115	90%
Engineering Technologies	1	10	9	900%
Engineering Sciences	3,637	2,551	-1,086	-30%
Physical Sciences	4,390	3,141	-1,249	-28%
Life Sciences	3,645	3,718	73	2%
All Awards Combined (total)	1,410,226	1,797,763	387,537	27%
Computer & Information Sciences	12,849	35,285	22,436	175%
Engineering Technologies	42,720	101,363	58,643	137%
Engineering Sciences	64,884	82,222	17,338	27%
Physical Sciences	32,169	32,377	208	1%
Life Sciences	44,846	52,912	8,066	18%

SOURCE: National Center for Educational Statistics

Table 7

ANNUAL OPENINGS OF THE EIGHTIES AND 1981 GRADUATE SUPPLY LEVELS COMPARED

	ANNUAL DEMAND ESTIMATE	DEGREE GRADUATE SUPPLY
COMPUTER PROGRAMMERS AND ANALYSTS	64,000	35,300
ENGINEERS	120,000	82,200
ENGINEERING TECHNICIANS	168,000	101,400

Source: Research and Analysis, PGCC, based on B.L.S. and N.C.E.S. data.