extensive practice in certain skills (computation, for example) so that in subsequent, more complex units requiring those skills he is not hampered through lack of retention. Print-out 5 (Fig. 6) shows data relevant to this area of concern. Note how the number of tasks prescribed varies for the same pretest scores, depending in part upon who did the prescribing.

Another line of current concern is the structure of curriculum sequences. For only ten objectives there are over 3 million possible sequences. Fortunately, most of these sequences are ruled out by content structure and by concepts of the learning process. Instructional sequences can, however, also be empirically studied. Techniques similar to multiple scalogram analysis (*6*) of available placement and pretest results can assist in determining whether or not the skills are being taught in the order of their difficulty and in an order that facilitates the next learning stage. It is also possible to see whether or not the extent to which failure to present skills in the order of their difficulty affects (i) the time it takes students to master that particular sequence of skills and (ii) their eventual ability to use what has been learned.

A more fundamental task which MIS can facilitate is the development of alternative forms of instruction that can be adapted to the needs of particular students. Of course, at present a student can be assigned material in which he shows a lack of mastery and need not be assigned lessons in skills that he has mastered. But, in addition, lessons may involve different kinds of vocabularies; they may involve more closely or less closely sequenced instruction; or they may involve instruction which gives the student more, or less, responsibility for managing his own progress. Essentially, the problem is to determine different instructional alternatives that are related to different patterns of learning. The goal of the IPI/MIS is to help with empirical work which would determine the measures most efficient for assigning individuals appropriate alternatives and determine what alternatives should be made available.

Toward CAI

The development and adoption of the type of individualized model proposed here seems to be a necessary prerequisite for bringing CAI out of the "back room" and into the classroom. It seems unlikely that CAI will ever provide all of the instruction for all of the students all of the time. Yet it is virtually impossible to incorporate CAI into traditional schools where the classroom is the basis for instructional decisions and scheduling. On the other hand, it is easy to incorporate CAI lessons into IPI/MIS as those lessons become available for solving specific instructional problems. The computer is there, the terminal capability is there, and the flexibility of an individualized school organization is there. Most important, a model for individualization is there. It seems reasonable to believe that the same instructional model that guided the development of IPI and is guiding IPI's "automation" can guide the development and implementation of CAI in an individualized school. Some mix of these aspects seems to be the end toward which we are currently striving.

References and Notes

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2. ———, in *Proceedings of the 1967 Invitational Conference on Testing Problems* (Educational Testing Service, Princeton, N.J., 1968), pp. 3–36; C. M. Lindvall and J. O. Bolvin, in *Programed Instruction*, P. Lange, Ed. (National Society for the Study of Education, Chicago, 1967), pt. 2, pp. 217–254. Oakleaf is an elementary school in the Baldwin-Whitehall School District near Pittsburgh.
3. Although we are not completely happy with all of the connotations of the term *computer-managed instruction*, it does seem to be the term most frequently used by people currently working in this area of concern. It should be emphasized that the computer is used as a tool in the management of the information needed by teachers in planning individualized education.
4. See, for example, W. W. Cooley, "Computer systems for guidance," paper presented before the American Educational Research Association Annual Meeting, February 1968, Chicago, for a more detailed consideration of guidance in the individualized school.
5. J. O. Bolvin, "Evaluating teacher functions," Learning Research and Development Center, University of Pittsburgh, working paper No. 17 (1967).
6. J. C. Lingoes, *Educ. Psychol. Meas.* **23**, 501 (1963).

7. The specification of models for individualizing education, the development of IPI, the implementation of CMI, and the eventual incorporation of CAI in individualized schools are major activities at the Learning Research and Development Center, University of Pittsburgh. We thank our many colleagues and students who have contributed to these efforts. The preparation of this article and the research and development described were performed pursuant to a contract with the U.S. Office of Education, Department of Health, Education, and Welfare. Additional support has been provided by the General Learning Corporation, New York.

NEWS AND COMMENT

A Surplus of Scientists? The Job Market Is Tightening

Is this country now producing more scientists than it can place in suitable scientific jobs?

The Bureau of the Budget seems to think so and is acting accordingly. Federal grants for the training of scientists have been cut by about 25 percent for this fiscal year. One reason for this cutback, in the words of a Budget official, is, "Why did we have to keep giving added inducements to train people when we were having trouble placing the people we did train? . . . The need for scientists has been exaggerated across the board."

Bureau of the Budget officials believe that recent expansion in graduate education has not been wholly beneficial to the universities involved. "The feeling we have is that graduate education has gotten too damn big for the good of the institutions," one explained, as he cited the recent Harvard faculty action to reduce the number of graduate students by 20 percent in the next 5 years (*Science*, 1 August). The official also said that graduate schools were having difficulties in recruiting good graduate students and were increasingly having to rely on recruitment of foreign students. Another added, "We privately get people in universities saying that there are too many scientists."

Of course, a primary reason for cutting back training grants, as well as for other cutbacks in federal scientific support, is to ease the federal budgetary problem which has been caused by the continuing increase in military spending. But whatever the initial motivation may have been for cutting back training grants, relevant Budget officials

seem to have concluded that there are too many scientists being produced in this country. Since the Bureau of the Budget is the key office in determining federal spending priorities, this attitude will doubtless continue to have an important effect on scientific funding.

Some scientists argue that the only reason there is a shortage of scientific jobs is that the rate of increase of federal R & D funding has been cut back. Governmental officials are likely to reply that this is a circular argument, that the demand for any profession's services, regardless of need, could be continually increased by a rising federal expenditure for that profession's activities.

What are the prospects for a scientist looking for a job? One thing the observer soon learns is that there seems to be no adequate compilation of figures on the current national demand for scientists. As Betty Vetter of the Scientific Manpower Commission comments, "Nobody has responsibility for high-level manpower demand; there is no central place where anyone keeps track of it."

Given the unsatisfactory nature of the data in this area, this article does not purport to be a comprehensive survey. This report is based on interviews with people in the national headquarters of scientific organizations and with scientists in various fields.

Physics Most Affected

Physics. From these interviews, it seems that physics is the scientific discipline most affected by an employment squeeze. Physics is also the scientific field in which the most detailed manpower studies have been made. Susanne D. Ellis, the manpower specialist for the American Institute of Physics, said in an interview that 30 percent of the "1200 to 1300 physics Ph.D.'s" who finished their doctoral work in June of 1968 were without jobs upon completion of their doctoral work. She added that one out of every ten of these unemployed physicists was still unemployed a year later, in June 1969. However, she noted, about a third of those unemployed in June of 1968 had obtained employment only by going back to the universities where they had worked for their doctorates and asking for temporary jobs. Presumably, most of these people were forced to find new jobs by the end of the academic year.

According to figures published by Mrs. Ellis in the March 1969 issue of *Physics Today*, 29.5 percent of the physicists awarded their Ph.D.'s in June 1968 received *no* job offer and 32.6 percent received only one offer. Of those awarded the master's degree at that time, 39.5 percent received *no* job offer and 26.9 percent received only one offer.

"There was an abundance of jobs for physicists a few years ago," Mrs. Ellis commented. "The trend has reversed." The physicists, she said, "were the first to feel the pinch," which started in earnest in 1967. The job shortage extends across the range of physics subdisciplines.

Some believe that physicists themselves and the narrow training they receive are factors in their ability to get jobs. "Physicists are so overspecialized," Mrs. Ellis laments, "they don't want to take any work that is not in their specialty. There are jobs for physicists if they want to do them."

But it is obvious that a person who has spent years acquiring specialized knowledge and skills will be reluctant to write off such experience as partially irrelevant to his career. The kind of anger that is building up among some young physicists may increasingly be felt in other disciplines. People who decided upon scientific careers on the assumption that there would always be an ample number of jobs will not take kindly to the prospect of having to scramble around a shrinking job market. In a letter to *Physics Today*, in September, William Lockeretz of Harvard University wrote, "There are many young physicists who are very bitter about the fact that a field which makes itself out as a 'glamour' field cannot absorb its new members. As recently as 1967 the American Institute of Physics informed would-be physicists that 'an increasing shortage of physicists is threatening the nation's scientific progress.' " With some acidity Lockeretz quoted H. William Koch, director of the American Institute of Physics, who said in 1967, "There are now five to ten jobs seeking every physicist." Lockeretz concluded, "I guess the real consolation for a jobless physicist is that the right to be unemployed is one of the joys of a free society."

Chemistry. In the past couple of years the job market in chemistry also seems to have constricted. At American Chemical Society meetings from 1956 to 1967, for example, there were almost always significantly more employers looking for job candidates than there were job applicants. At the New York City meeting in 1966, for instance, there were only 544 job applicants registered for the job placement service, as compared to 1180 employers. At this year's New York meeting, the balance had shifted in the other direction—only 481 employers were present, and they had a pool of 880 applicants from which to choose.

"We have about four good chemistry Ph.D. graduates this year who are still looking for a job," comments Tony Streiff, the administrative officer for the chemistry department at Carnegie-Mellon University in Pittsburgh. "This is the first time that this has ever happened to us." Another chemist at the university said, "The boys have had it pretty easy in the past, they could pick and choose. Now they are damn glad if they can get one job offer."

Lagging Corporate Profits

Several of those interviewed attributed the job shortage in chemistry and other disciplines in part to lagging corporate profits and a consequent unwillingness of industry to hire as many people as it has done in past years. J. Dennis Ryan of the Carnegie-Mellon placement office notes that about 15 percent of the employers scheduled to interview applicants at the university have already canceled visits for this year because they have no jobs to offer. A few years ago, he notes, a 1- or 2-percent cancellation at this time in the academic year would have been considered high. Ryan notes that the tightening of the job market is "pretty much a national phenomenon, particularly for the person who wants to combine research and teaching." Carnegie-Mellon, a superior institution which specializes in the physical sciences and in engineering, has had particular difficulty placing Ph.D.'s in physics and chemistry but has not yet had trouble placing job applicants with only a bachelor's degree in lower-level jobs.

Psychology. Judith Cates, research associate in manpower studies for the American Psychological Association, comments, "My general impression is that we're in a much tighter job market. In 1960 we had a 7-to-1 ratio of positions to applicants; now it is much more like 1 to 1. In fact, there is even a slightly greater number of applicants than of positions." Dr. Cates queried department chairmen around the country this year about the employment situation; one impression gained from the responses sent her was that "the

good departments are becoming saturated." One department chairman sent in a comment which was echoed by many others. He wrote that in several areas of psychology "there were fewer positions to be filled last year than the year before, and still fewer this year. . . . I have the impression that outstanding people in several areas are having more than usual difficulty in finding appropriate positions. These areas include particularly physiological psychology, psychology of language, and experimental social psychology."

A job shortage adversely affects people of all ages who want to move from their current jobs. The shortage does, however, strike young scientists with special severity. Christiana Morison Leonard, a talented neuropsychologist doing postdoctoral work at Rockefeller University, said that her colleagues were "having enormous difficulty finding jobs." She noted that people she knew with Ph.D.'s from universities such as Harvard, M.I.T., or Michigan and with postdoctoral experience and publication records were finding it almost impossible to find desirable openings. She noted the case of one colleague who had had job offers from three leading universities 2 years ago but was finding it difficult now to obtain one suitable offer. "The job market has just dried up," she said.

More Demand for Ecologists

Biology. "The situation is much tighter this year than in preceding years," thinks Elwood B. Ehrle, associate director of biological education for the American Institute of Biological Sciences in Washington. "Where there were once 3 or 4 applicants per position, there are now 12 to 15 applications per known vacancy." Ehrle said that the situation varied greatly by specialty in the life sciences—that the demand in systematic biology and comparative anatomy had fallen off in the last decade and that molecular biology had passed its peak demand about 1968. He noted that there seemed to be a growing demand for ecologists and that the market for microbiologists, for whom there was great industrial need, remained "as strong now as ever."

"The situation is somewhat more difficult," comments Norman S. Kerr, associate dean of the college of biological sciences at the University of Minnesota; "Our Ph.D.'s used to get three or four offers; now they feel lucky to get one." Kerr said that people in field biology had had the most trouble, but that there was now an "across-the-board shortage" of job opportunities in the biological sciences.

Mathematics. "It is tighter than two years ago," noted Truman A. Botts, executive director of the conference board of mathematical sciences in Washington, D.C. "At the most recent meeting of the American Mathematical Society in January, there was a general impression that young Ph.D.'s weren't getting jobs in droves or at least not the kind they wanted. The hotshot young researcher from Harvard, Berkeley, or the University of Chicago now may have to accept a job in an institution below the top ten. There is a growing saturation at the top."

Social Sciences. Some of those interviewed in sociology, anthropology, and political science expressed the opinion that it was a little more difficult to obtain jobs, but complaints were less severe than in the natural sciences. Of course, student enrollments have been rising more rapidly in the social sciences than in the natural sciences, thus stimulating the creation of many new university teaching positions.

Among the natural sciences, the brightest spot for jobs seems to be in the geological sciences. Among those disciplines shepherded by the American Geological Institute—geology, geophysics, oceanography—the job situation is "excellent," according to manpower specialist Bonnie Henderson, who reported that the geological sciences had now fully recovered from the manpower surplus of a decade ago, when there were far fewer jobs than people to fill them.

From the information that can be obtained, it seems that job prospects are dimmer this year in most natural science disciplines. The reasons seem to be manifold: (i) severe cutbacks in the rate of growth of public support of R & D, especially at the federal level; (ii) a rapidly rising increase in Ph.D. production, coupled with a slower rate of growth in the number of science students; (iii) a lessening of willingness by corporations to hire scientists in certain areas.

What can be done? In this writer's opinion, one thing that should be done, for every scientific discipline, is to begin accumulating much more comprehensive data on the supply-demand situation for scientific manpower. One would hope that the federal government (perhaps the National Science Foundation) could assume this task. Failing that, private scientific organizations could do much better in this regard than they are now doing. It is impossible to ascertain future need for scientists if there is no clear idea of what is happening now to recent graduates.

Second, the attitude of young scientists and their mentors may have to change. It is obvious that the nation's capacity to assimilate basic researchers is limited, and scientists will increasingly have to consider teaching in community colleges, junior colleges, and high schools as legitimate career choices. Moreover, young scientists will have to overcome what seems to be a growing prejudice against working in industry.

Better Persuasive Efforts Needed

Third, it is obvious that the scientific community is going to have to work harder to convince political Washington to spend the money to create more scientific jobs. Rather than wait for the federal government to come to scientists, scientific groups should present plans detailing how increased funding for science could help abate some of the social, environmental, and health problems of the nation.

Finally, if one accepts the probability that federal science spending will not greatly increase in the years ahead, it is apparent that those scientists who are still trumpeting the "golden future" of science as a career should, at least temporarily, lower their voices. The days of a salary and security "gravy train" for the scientist of only average abilities seem to be drawing to a close. Unless the tendency to cut back on federal science spending is reversed, it may well be that the scientific profession will be winnowed to those able scientists who are driven primarily by love of their work. Although such a forced sifting would be hard on many of the scientifically mediocre, it seems unlikely that it would drastically reduce the high quality of American science. A brisk winnowing might even help.

—BRYCE NELSON

Nelson Joining L.A. Times

Bryce Nelson, who has written for News and Comment for the past 3 years, has joined the national news staff of the Los Angeles *Times*. He will report on political and social topics in the midwestern states from Chicago.