PANEL: EDUCATIONAL FOUNDATIONS FOR CAREER FLEXIBILITY[a]

What are the effects of educational traditions, disciplinary styles, and early research training on laboratory work organization? How do they affect individual skilling, team collaboration, adaptability to change, and labor mobility?

Lan Xue describes dramatic changes in the prospects for research careers, and in the response of graduates, under various policies in China over the last thirty years. Flexibility and mobility are understatements for the shifting and buffeting of universities and intellectuals in the modern Chinese state.

In contrast, Lea Velho describes the rigid, if protected, careers of Brazilian scientists, recruited and promoted to civil service positions through a standardized process. Tenure gives these scientists the opportunity to speak their minds, and the governing structure of universities links them closely into the political life of the country.

Laurence Smaje describes the careers of British biomedical scientists, who choose their own paths at several choice points in the prescribed medical training. Perhaps their greatest resource for flexibility is confidence in their own decisionmaking capacity, bred into them by their ward experience.

In a similar vein, Jose Strubbe outlines the turn in Belgium toward practice-oriented science education, and Susan Cozzens follows with a description of a kindred ideal for the United States.

Lan Xue, People's Republic of China

These remarks concern the Chinese education system and some changes it has undergone in recent years. This subject is quite big, since the Chinese education system itself is very large, and there has also been a lot of change.

In China, the higher education system consists of two types of institution. One is the universities, which confer bachelors degrees, master's degrees, and Ph.D.s. The other type is the technical colleges, which give two or three years of training but do not confer any degree. An entrance examination is required to get into either type of institution, and the ratio of applicants to those who matriculate is usually one in eight to one in ten.

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At the undergraduate level, it is hard to change one's specialty, or to transfer to a different university. But the last half year of the undergraduate course is devoted to a research project, which is meant as a bridge between school and the real world. This will usually lead to a thesis or a practical engineering design.

After you graduate from one of these institutions you will be assigned to either a college, to industry, or to a research institution. Or you can take another entrance examination to get into graduate study, which is conducted either at a university or at a research institution.

The academic degree system at the graduate level was started in 1979, with doctors' degrees introduced in the early 1980s. It is very specialized. The entrance examination has two parts: general courses, such as Mathematics, Foreign Languages, and Political Education, which are given at the national level; and specialty courses, e.g., Magnetics, Fluid Dynamics, etc., which are given at individual institutions. Again, it is hard to change one's specialty or to transfer to a different university during graduate training.

In China, the government assures jobs for university and college graduates, but it does not find those jobs for them. There is a complicated procedure for assigning jobs. Industrial organizations and government agencies submit plans to the higher authorities, saying what type of graduates they would like to have next year. Their requests have to be justified to the national planning committee, which then sends back a recommendation. After this process, the personnel budget is settled and is sent to each university.

That was a structural description of the system. I now want to give a time series description. Considering simply the number of students entering universities each year, the period from 1949 through the 1950s was a time of boom in Chinese higher education. In the early 1960s there was a drop, and then a further rise, until 1966, when the sequence stops abruptly. From 1966, which was the start of the Cultural Revolution, to 1973 there were no students entering universities. This whole period is blank as far as higher education is concerned.

By 1973, some new students started to enter the system, but these were admitted more on the basis of political criteria than of academic merit. It was not until the official end of the Cultural Revolution in 1978 that the system went back to normal, and students again had to take entrance examinations to get into college. The numbers rose to a high point in the early 1980s, and then started to drop slightly. That is where we are now.

Now let us look at this system in terms of scientific careers. Of course there has never been a time or a country where careers followed either the pure "CUDOS" model or the pure "PLACE" model. (See Ziman, "Research as a Career," this volume, for the meaning of these terms.) It is always a mixture of the two. It is interesting, however, to note how the social and political environment has been changing this mixture in China over the past 20 years.

Traditionally the status of scientists in China has been quite high. The respect for knowledge and for intellectuals in Chinese tradition was kept alive after 1949. But there were two periods when this status was deliberately attacked and lowered by the government. The first was in 1958, during the anti-rightist movement. The second was the Cultural Revolution, during which all the intellectuals, including scientists, were literally put down to earth. They were sent to the countryside to do menial work, and were classified with landlords and others as being among the nine types of people with the lowest status in society. That's really down to earth!

After the Cultural Revolution there was a tremendous need to rehabilitate the scientists and re-establish them in research work. Scientists and other intellectuals were needed to reconstruct the country. There were two events that helped the government in this policy.

The first was the story of Chen Jingren, a research fellow at the Institute of Mathematics of the Academy of Science, who solved a very difficult mathematical problem and won world recognition. This achievement was widely publicized in newspapers and the media, in a way that strongly emphasized several aspects of his work. One was the originality of his approach to a problem that had been worked on for many years by many mathematicians around the world. Another was his devotion to the pursuit of truth, even in the hard times of the Cultural Revolution. The coverage also emphasized how disinterested he was, working so hard without any promise of monetary reward. Other scientists were also being glorified at this time, and his case was very typical, showing the connection with the CUDOS career model.

The other event that helped this policy was the visit by two very famous Chinese-American physicists from the United States, C.N. Yang and T.D. Lee. Their visit to China had a great impact on the Chinese system, and their advice to the government had great influence on the future development of both science and technology and of education.

After these two major events, basic scientists, especially in physics, mathematics, and chemistry, were seen as glorious symbols; and all the graduates wanted to join them. These role models had a profound impact on the new high school graduates. For a number of years, all the high school students wanted to study physics, chemistry, or mathematics, and the place of basic science in the curriculum was emphasized. This helped the scientists to improve their standing. They felt that they were interfered with too often by their party secretaries, so they took this opportunity to ask for more autonomy, saying "we are working for the country and for the sake of truth."

This movement from "earth" to "CUDOS" was followed by a second period which could be described as a movement from "CUDOS" to "business." That really started after 1984, when the economic reform reached a crucial stage.

One positive effect of the economic reforms was a fever to go abroad. But there was a negative effect, in that the income of other occupations increased in comparison with that of scientists and teachers, who were on fixed salaries.

There were also some major structural changes in the R&D system. For example, research institutions were no longer given substantial block funds to cover all their work. Instead they received only basic operational funds and the researchers themselves had to seek funding from outside--from business, from industry, or from wherever else they could get support.

One should also note the effect of a significant social trend away from the Chinese cultural tradition, where business men, or other people involved in commerce, were looked down upon in intellectual circles. In the 1980s, people have felt more and more that there is nothing wrong about making money. Indeed, making money is now the fashion.

The result of all these changes is that many new students, after they get a good first degree, don't want to go to graduate school: they want to go into business. As a result, not many students want to pursue a career in academe, and the quality of graduate students has dropped greatly.

Second, those who pass through graduate programs to their master's degree do not want to do research; they also want to go into business. I saw a newspaper report saying that in one year, in one specialty at Beijing University, they had twelve students who got their master's degree and only three of them went on to a research institution. The others went to joint-venture companies or to economic enterprises. Some went to the United States or other countries to study; the so-called "going abroad fever," which started in the early 1980s, has continued until very recently.

No one knows what will happen after the events of June 4th. But it seems to me that this change from "CUDOS" to "business" has some positive influence on the Chinese system. It has helped China to redistribute its talents, across the country and across different fields. There was a time when all the best students were concentrated in a very few areas, and this was really a waste of talent.

Losing some good people to business has helped to strengthen the link between industry and academia. Many of the graduate students who went into business have gone into venture companies, or companies that have started to use some new technologies to produce marketable goods. This movement is a positive influence on the mentality for a healthy R&D system.

But the blank period of entering graduates between 1966 and 1978 has not really been filled in. For the next 20 years, China will face a serious shortage of high quality R&D personnel. If the political and economic climate were to improve, the effect of this would be softened. But with people starting to leave, the impact on the system will be substantial. Personnel is going to be a major problem for China in the 1990s.

Lea Velho, Brazil

To talk properly about scientific careers in Brazil I would have to put the topic in historical perspective. I cannot provide a full description here, but I should mention three facts relevant to the full institutionalization and professionalization of science in that country.

The 1960s are considered a watershed between the old and the new university systems in Brazil. Before the 1960s, the system of higher education was organized according to the French model. Scientific activity was restricted to some institutions (faculties), most of them organized as professional schools. The natural sciences were under the faculties of Philosophy, Sciences, and Letters, together with the social sciences and humanities.

As far as career was concerned, the objective of a university teacher at that time was to become a *catediatico*--that is, to have a departmental chair. For this the teacher would need years of research experience, a thesis based on original research, and also a considerable number of researchers that he had trained and who remained around him as assistants. Most university professors in the natural and social sciences and humanities were full time; the ones in professional schools tended to be part time.

The military coup in 1964 considerably centralized power in the hands of the federal government. In addition, in 1968 the University Reform Act reorganized the university system according to the American model. A credit system was established and the basic disciplines, such as mathematics, physics, and chemistry, were taken out of the professional schools and organized into separate departments, each of which was supposed to be responsible for teaching the subject to students entering all relevant careers.

Another effect of the University Reform Act was that in each state, with the exception of the State of Sao Paolo, the old institutions of higher education were grouped together under the title of "federal university," with at least one for each state. We had twenty four states in the country and all those federal universities were directly attached to the Ministry of Education and Culture. So they are all supported by the federal government.

The third important feature of the 1960s was establishment of graduate schools. Up to the beginning of the 1980s, these grew exponentially. This was a major step towards the full institutionalization of a scientific career. It created simultaneously both the requirement of a formal academic degree for a research career and the opportunity to be trained for such a degree inside Brazil. Before then, university researchers received their Ph.D.s either in Europe or the United States, or through the "old" procedure of defending a piece of research after many years of experience.

So much for this fragment of history. Scientific research in Brazil is concentrated almost exclusively in the public sector: there is practically no research in industry. The current structure is as follows.

- 30 federal universities (at least one for each state), which receive their funds from the federal Ministry of Education. Some of these are small, with perhaps 15,000 students, but others are very big, around 70,000 students.

- 6 state universities, belonging to different states, from which they receive their funds. The University of Sao Paolo is the best known in the country and has around 100,000 students.

- 2 private universities do research. Both are Catholic universities, one in Rio and the other in Sao Paolo. But student fees are not enough to support them, and the state has to subsidize them heavily, although it does not play any part in their management.

- 300 other universities in which there is some research, mostly concentrated in the southeast. These universities run something like 1000 postgraduate programs--30% doctoral, 70% masters.

In addition to the universities, there are a number of specialized research institutes for agriculture, medicine, industrial enterprises, etc., most of which offer a structured research career. But university research comprises around 80% of the research activity in the country. An account of scientific careers in Brazilian universities thus covers most of the system. Also, because most research universities are federal, they all have exactly the same career structure, which is very similar to that of the state universities.

Scientific careers in Brazilian universities have a number of distinctive features. In the first place, to be a researcher in the university you have a "public career," just like a civil servant. The second feature is that access to the public service is by a public examination. If there is a place in the university, it has to be announced in every newspaper and a "concourse" set going. Applicants submit their curricula vitae, and are subjected to an oral exam and a written exam. Then they have to give a presentation and report on their degree results and research, and so on. The strongest candidate is then chosen, but if other places become open during the next two years they may be filled by the second or third candidates among those who have passed the examination.

The third significant feature is that "tenure" is absolute at the moment of entrance into a university post. Once you are included in the university system you have a job for life. There's no way anyone can push you out, except for serious misconduct.

Within the system there are four grades, with increasing salary. Advancement between these grades depends on time, and on various formal requirements, i.e.,

- Assistant I, for which the qualification is a Master's degree;
- Assistant II, requiring a Ph.D.;
- Associate Professor, requiring publications, oral and written exams, and in some universities a thesis;
- Full Professor, for which there is competition for a limited number of posts in each department, as well as publications and oral and written exams.

In effect, everyone can eventually reach the grade of associate professor, provided they pass the requisite degrees and examinations.

I must also stress that salaries for the same grade are the same for all universities, all fields of science, and all professional schools. Salaries are defined solely according to position in the academic career, and to the proportion of time given to the university. Thus, a full time assistant professor in physics in Rio will receive the same salary as a full time assistant professor in Engineering in Aere. So when your salary comes in the end of the month you don't have to hide it from anyone. Everyone knows what her salary is; it's exactly the same on all accounts.

What are the incentives for a scientific career? The first consideration is the market--or, rather, the absence of a wider market for some professions. In the basic sciences and humanities the only choice is between teaching in a high school and pursuing a scientific career. In general, there is no other employment for physicists, chemists, historians, etc. The same applies to women in "men's professions": for example, in my own case, I was trained as an engineer but could not get a job outside the university.

It is worth adding that many people go for a scientific career because it gives them space for criticism and some degree of "dissidence." You have this space from the time you are admitted, even under a military regime. You are very free to say anything, and to express the things that you believe in. You don't have to compromise inside the department or the university.

The most obvious incentive for career advancement is money. In addition to the normal salary increases as one goes up the professional academic ladder, the Brazilian government is trying to induce people to stay in research, so they are paying differentials for those with Ph.D.s and for full-time researchers. Highly qualified researchers can also complement their salary with a research scholarship from the national research council.

Needless to say, another motive for career advancement is power. As an associate professor you can be the head of a department or the director of a unit, and this leads on to influential positions on committees and boards inside the university or in research councils and other government agencies.

Many people complain that the structure of scientific careers in Brazil is very rigid. In the first place, "vertical" advancement is solely on the basis of research activity. The considerable time and effort that some people invest in teaching, or extension classes, or in other service to the community does not count. In many professional schools, such as nursing or engineering, this is resented. Even physicists are caught up in artificial situations, trying to boost their research profiles. For example, there is no way that a department can bring in someone to work there without a public "concourse." There is no way that the department head can recruit someone whom is known to be good but who doesn't have a title. On one can call that person to the department and say, "I can pay you X to work here."

At the present time, we are observing several new trends, associated with new problems, or new solutions to old problems. As in many other countries, our universities are undergoing evaluation by the Ministry of Education, and are also trying to evaluate themselves. This has a significant impact on individual scientific careers. People are concerned about the use that will be made of the results of evaluation. There is unhappiness about the available conventional bibliometric indicators. What is to count as a scientific publication, or as scientific output, in different fields of knowledge?

There is also concern about the relationship of the university researcher to industry, especially in the high technology region of Sao Paolo. Researchers may be involved either through contracts with industry or as entrepreneurs themselves. They are then seen by some people as selling their souls to capitalism, or as using public money for private ends, and things like that. In fact, what is happening is that the power structure in science is being shaken up. Researchers can get money from industry without having to go through the higher organizational levels of the university and even without having the formal qualifications for such salaries and responsibilities. In other words, having access to these funds, they are freer to make decisions for themselves.

Finally, I would like to mention a very particular Brazilian issue, party politics inside the university. ANDES, the National Association of Teachers of Higher Education, has played an important role in shaking the established academic power structure. The rector or president of each university was to be chosen by the President of the Republic from a list of six names presented to him by the Minister of Education. Under the terms of 1980s Brazilian "glasnost," the names on this list are sent to the Minister of Education by each university after an electoral process where the votes of faculty, other staff, and students, as groups, each has the same weight. In practice, the winner in this election is named first, and the President is bound to appoint this person, otherwise there will be a strike.

This process produces a campaign where the general political parties--Workers' Party, Communist Party, Democratic Party, etc.--present their candidates. The campaigning goes much beyond academic concerns to matters such as free transportation, child care centers, and things of that sort.

In effect, the traditional scientific career power structure is being displaced. Some universities are worried about this process, which for many of them is in the second round. After 25 years of military regime, everybody wanted to be totally immersed in democracy at first. But now the euphoria is passing away, and attempts are being made to give much greater weight to the faculty relative to the other groups. I don't know how it's going to be in future, but one thing is sure: no professional manager has a chance in a Brazilian university. Perhaps we will just go back to the old power structure.

Laurence Smaje, United Kingdom

Speaking about career development in the biomedical sciences in the U.K. reminds of the story of a western diplomat who was visiting Ghandi in India. The diplomat said to Ghandi, "What do you think of western civilization?" After a moment's thought, Ghandi replied, "Yes, I think it would be an excellent idea." Similarly I think a career structure in biomedical sciences in the U.K. would be a good idea. At the moment it's in something of a shambles, but there is some structure left.

There are two main entrances into biomedical research. One is via a degree in the sciences--normally the biological sciences, although there are quite a substantial number coming through the physical sciences. The other is via medicine. Since the medical route is not so familiar, I shall concentrate on that.

In order to read medicine in Britain, young men and women--in about equal numbers--are taken straight from high school, which ends at age 18 in our system. The number of places is limited, and entrance is competitive. There are approximately four applications from qualified students per place. That's probably an underestimate, since there is a lot of selection in the schools to prevent mediocre students from applying. As a matter of interest, medicine is not the most difficult subject to get into in Britain: veterinary medicine is.

The first two years of the medical course are sometimes known as the preclinical period. In the first two years of medical school, students study anatomy, biochemistry, pharmacology, physiology, psychology, sociology, and statistics. All of these subjects are examined independently. Incidently, mixed up with the others, they will be studying cell biology,