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The Challenge of Creating a 'University of Industry'

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This paper provides an overview of the key issues dealt with in the planning and development of a 'university of industry', namely training objectives, staff selection and recruitment, industrial links and quality control. The critical stages of the development in teaching, research and industrial interaction are highlighted.

OVERVIEW

IN 1980, a Ministerial Council reviewed the manpower situation in Singapore in relation to a drastic restructuring of the economy to be based more on high technology. It recognized the immediate need to produce many more highly trained graduates, especially in engineering. Prior to this, the only university in Singapore, the National University of Singapore, had an annual output of about 300 engineers. The Council recommended that this number be rapidly increased to 1,200. In addition, the majority of these engineers were to be practice-oriented; their main functions were to increase the productivity both in the factory and on construction sites, and regarding product design and maintenance work. The output of more than 1,000 engineers a year is significant in the context of Singapore because of the small population of about 2.5 million and low birth rate (about 40,000–50,000 per year). To meet this increase in enrolment and special requirements in training, a new institute of technology was to be created. The institute would concentrate on engineering initially; other disciplines like accountancy and business studies would be added in future expansion.

To put the plan into action, the author was appointed to draw up a master plan and to oversee the development of a new university. With the passing of the Nanyang Technological Institute Act 1981 by the Parliament, the Nanyang Technological Institute (NTI) came into existence on 8 August 1981. The target was to have the first intake of students in July 1982. The existing Faculty of Engineering in the National University of Singapore would continue to provide a traditional course. In terms of standard of the courses and the status of the graduates, both were ranked equal. In the national context, both streams of training were complementary to each other.

Ten years after its establishment, the NTI was renamed the Nanyang Technological University (NTU) in 1991 with a view to facilitate the introduction of other disciplines complementary to the established courses in engineering, technology and business. The intent was to enrich and diversify the offering of new courses without diluting the strong base in engineering and technology.

TASK OF STARTING A 'UNIVERSITY OF INDUSTRY'

The initial problems facing the creation of any institution of higher learning would be:

1. the building of infrastructure suitable for student and staff use;
2. the planning of a curriculum according to the vision of the university;
3. equipment purchase and commissioning; and
4. recruitment of staff with the right qualifications and motivation.

The above provisions were planned carefully as they were the core elements of any institution. Strong government support for such a task would be essential, which we were fortunate to obtain. In addition, we had a Council Chairman who was a leader of industry and was able to steer the University in the right direction.

Many of the issues will be covered by subsequent papers. There were, however, a number of important issues central to the vision of being an university of the industry which merit a separate discussion in this paper. They were the training objectives, staff selection and recruitment, establishment of industrial links and quality control.

It is also important to point out that we were given an extremely short planning period to start a project of this scale. The concept of starting a new institute of technology was initiated only in June 1980. Detailed planning took place in early 1981, followed by legislation in August 1981. The first intake of students was in July 1982. All the key staff worked hard and co-ordinated with each other extremely well to implement the tight program. On looking back, it is a wonder that no significant set-back took place.

TRAINING OBJECTIVES

In 1980, the Committee of Inquiry into the Engineering Profession in the United Kingdom, headed by Sir Montague Finniston made a number of recommendations with the intention of raising manufacturing industry in the light of national economic needs. Those recommendations on engineering education were of particular interest to Singapore as they provided a basis of comparison with the decision taken by our Ministerial Council and the University.

As a preamble to the detailed comparison, it is interesting to note that Finniston recommended streaming of engineers' training into a practice-oriented course with the degree designated as B.Eng. and an academic course as M.Eng. The former category of engineers will eventually be registered as 'Registered Engineer' (R.Eng.) while the latter as 'Registered Engineer Diplomate' [R.Eng. (Dip.)].

In order to keep this paper short, comparisons will be made on a few issues relevant to us.

Formation of engineers

Finniston. The distinction between R.Eng. and R.Eng.(Dip.) is intended to provide two coherent and complementary formation streams for engineers. The R.Eng. route is designed for those with the aptitude and capabilities needed by the main body of engineers in industry. The R.Eng.(Dip.) route is designed to provide a more advanced qualification for the minority who demonstrate a high level of intellectual, creative and personal qualities, which indicate a potential to lead manufacturing activities and to develop new technologies.

Singapore. Two distinct types of engineers will be required: (i) practice-oriented engineers; and (ii) academically biased engineers.

Ratio of dual formulation

Finniston. We envisage this stream [i.e. R.Eng. (Dip.)] providing around one-quarter of future qualified engineers, which in our judgment reflects the likely relative requirement of industries.

Singapore. The ratio of academically biased engineers to practice-oriented engineers is 1:3.

Common first-year course

Finniston. Selection (to the M.Eng. course) would usually follow a *diagnostic first year* on a common course with B.Eng. entrants, designed, *inter alia*, to identify those with the potential to undertake the M.Eng. programme and to succeed as engineers at the R.Eng.(Dip.) level. There is evidence that ultimate attainment, at least in academic terms, is better predicted on the basis of first-year performance than it is on entry qualifications, and for this reason selection upon entry to higher education would be premature; selection after the first year should take account of *more than academic attainment*, and consider also candidates' personal aptitudes.

Singapore. All students will undergo a *common first-year course* to be conducted at the faculty of the NUS. At the end of the first year, students will be allowed to make their choices. If there are more applicants than the number of places, selection will be based on *relevant subjects* in the first-year examination.

Curriculum structures

Finniston. The whole B.Eng. programme should be firmly set in a context of purpose, with the primary emphasis on the synthesis of basic subjects and on developing students' design and problem-solving capabilities. This should be taught through progressive project work incorporating such elements of engineering science and mathematics as are required to provide a foundation for instruction in practice and applications. Design practice should be a prominent and unifying theme of the course (as is achieved in continental engineering training) and not an isolated expertise through the strong emphasis, particularly in the later years of their courses, on a specialized project which focuses on more general engineering theory and applications previously taught. The aim should be for a more detailed confrontation with the specific engineering problems in a particular field which will make the students' knowledge and practical skills operational.

The B.Eng. course will place more emphasis upon engineering practice and rather less on the academic aspects of advanced engineering science, which will be more in keeping with the aptitudes and career requirements of the majority of potential engineers.

Those who apply for B.Eng. courses will not be committing themselves finally to careers as engineers but will be opening the door to such careers. The technical appreciation and skills of analysis, synthesis and problem solving which the B.Eng. course will instil in them should also stand graduates in very good stead for a range of non-engineering careers.

Singapore. The objectives and design of the engineering courses in the NTU are very similar.

Course duration

Finniston. We believe that a critical review of the engineering science and mathematics content of many current engineering B.Sc.courses will identify material being taught which is superfluous to the working requirements of mainstream engineers, and which could without loss be dropped to allow more time for teaching in engineering applications. Thus, although the B.Eng. course will certainly require more teaching time than the 3 × 30 weeks of most current full-time courses, just how much more can only be resolved in practice after some actual B.Eng. courses have been designed and accredited.

Singapore. The engineering courses in the NTU are of four years duration.

Industrial interaction

Finniston. There are several approaches to these staffing problems and to the related issue of expanding academic/industrial collaboration, all of which should be pursued. First, the expertise of practising engineers in industry needs to be made available to academic establishments on a sustained basis. There must be continuous involvement by industry in the new courses, with practising engineers of standing in their companies assuming specific teaching commitments and helping to plan courses as well. The second line of approach to be pursued is to provide for the regular updating of the industrial experience of engineering teachers through industrial sabbaticals.

We recommended the introduction of a system of recognition, accorded by the teaching institution and endorsed by the engineering authority, for engineering teachers who are registered engineers and who meet criteria laid down regarding their industrial experience, and their continuing involvement with industry, as well as their academic standing. Accreditation of B.Eng. and M.Eng. courses should then take into account the number of 'recognised' teaching staff on the course.

To develop an easy interchange between educational institutions and industry, senior engineers must be encouraged to return to universities and polytechnics to assist in preparing future generations of engineers. Appointments should be made at professorial or lecturer level on pay scales negotiated to reflect the industrial earnings of engineers who will divide their time between industry and education in this way. The criterion for appointment should be industrial achievement as an engineer.

Singapore. The NTU recruits engineers with higher degrees and they must have some years of relevant industrial experience. The expectation of the staff will be to participate in meaningful teaching, a constant interaction with industry and participation in applied research.

Industrial attachment leave will be provided to tenured staff for a period of eight months after every five years.

The NTU has Advisory Committees consisting of industrialists, government advisers and academic staff. The main function of these committees is to ensure the courses are related to the needs of industry.

The similarity between our approach and that advocated by Finniston was remarkable, indicating that the NTU approach was one of common sense. It is also appropriate to point out that subsequent developments at the university made a number of changes and adjustments, but the overall philosophy remained.

STAFF SELECTION AND RECRUITMENT

The initial recruitment of academic staff was critical because it was through the deliberation of those staff that the curriculum was designed. Being engineering schools, the type of laboratory equipment to be purchased would have to be given careful consideration since the laboratory facilities could determine the orientation and objective of the courses. Secondly, the equipment was likely to be expensive, and once purchased would offer little flexibility for future changes.

We were careful in the selection and recruitment of the first 20 or so key academic staff. They were proven professionals with a breadth of experience in industry and outstanding academic achievements. The balance between practice and academic orientation had to be delicately maintained in order to fulfil our vision of being the university of industry. It was observed that such people were also well sought after by the high-growth industries and therefore our salary package had to be competitive to attract them. Fortunately, the Singapore Government recognized the problem and gave the NTU flexibility in determining the salary and the level of appointment, as long as the high standard was maintained. Other than the attractive salary, the early staff were also motivated by the challenge of developing a school of engineering well respected locally and world-wide. Another feature foremost in our minds was to ensure the academic staff came from a good spread of countries. We were then able to consider the adoption of good practices from many sources.

The selection of subsequent academic staff was more flexible while maintaining the same high standard. We recognized that in some specialized areas of engineering there was the need of recruitment of staff with a theoretical bent. These were typically academics with a Ph.D. in engineering science. They were complementary to the staff with a flair for industrial application. It was nevertheless necessary to ensure that the majority of the academic staff were of the latter category in order to fulfil the mission of the University.

ESTABLISHING INDUSTRIAL LINKS

Traditional engineering training is still very much class-room based and most engineering schools feel isolated from the real industrial world. Proactive actions have to be taken to close the gap by establishing good industrial links for the benefit of students and the schools.

We modelled the teaching and the operation of the engineering schools on medical schools. The significance of industry reflects the relationship of hospitals to medical schools. It is interesting to note that the linkage between medical schools and hospitals is taken for granted, but effort is needed in the case of engineering.

The NTU had a number of formal and informal links to local industry. The most important mechanism was the Advisory Committee for each school. The Advisory Committee had equal representation from academia, industry and government departments. The Committee met regularly and proceedings were reported to the University Council. The Committee deliberated on many issues, ranging from course materials to graduate employment. The feedback from members had been favourable since all parties benefited from such discussions.

Another linkage to industry was through student participation. All engineering students had to spend a six-month period of industrial attachment before graduation. Grades were given for their performance in the attachment. Another avenue was through final-year projects, many of which were through direct suggestions and participation from local industry.

The University staff were also active in industrial consultancy, joint research with industrial partners and giving continuing education courses to practitioners. The academic staff annual performance review paid much attention to their industrial interaction.

All the above policies were fundamental to the vision of the NTU becoming the 'University of Industry'.

QUALITY CONTROL

The quality of teaching and research is of prime concern to all universities. However, the method used for monitoring quality varies and therefore it is useful to give an account of our process.

As Singapore is a small country with only two universities, we were sensitive to the need to have external validation of our performance pegged at an international level. All our engineering courses were accredited by British professional institutions although there was no likelihood of our graduates working in Britain. We benefited from the validation procedure of these professional institutions.

We adopted the external examination system for each course and derived valuable feedback on our teaching and research. All our external examiners came from overseas universities with good reputations.

Another informal check on quality was to have a continuous stream of visiting professors and scholars. They provided an indirect feedback on whether the NTU was moving in the right direction. At the same time, they brought with them new ideas to enhance our own efforts. Due to such benefits, the NTU has adopted a liberal policy to encourage the presence of visitors.

STAGES OF DEVELOPMENT

As in the history of most universities, the main emphasis in the initial years was on the teaching programmes. Great pains had to be taken to ensure the training given to the students would enable them to find satisfying employment on graduation. With regard to this, we were extremely gratified to learn from a number of survey feedbacks that employers had found our graduates very acceptable for a wide range of jobs. We were surprised that our graduates were equally well suited to R&D positions although the training was largely practice-oriented. The implication was that our course covered enough basic engineering science to enable them to perform more fundamental work.

In 1985, our engineering programmes received the distinct honour of being commended by the Commonwealth Engineering Council as among the best in the world. We were commended for our practice-oriented training and staff recruitment policy:

> "Students were given a sound grounding in engineering theories and the opportunity of real-life hands-on experience. . . The Institute has also a rigorous recruitment policy where the teaching staff must satisfy the requirements of having higher degrees as well as relevant industrial experience."

This accolade came early in our academic development and gave us the assurance that our training, though highly innovative, had the international stamp of approval.

Having established the undergraduate training, we look forward to the next phase of strengthening our graduate programmes and research.

The NTU has a flourishing set of taught master degrees, ranging from hospitality management to geotechnical engineering. More such courses are in the pipeline. It is envisaged that within this decade, postgraduate students will constitute 15–20% of the student population.

Research and higher degrees by research in the Schools are co-ordinated by a research committee headed by the Director of Research. While research in most specialized areas in engineering is encouraged, the University promotes interdisciplinary research. Mission-oriented researches in areas of strategic importance to Singapore are also identified and promoted. The NTU pools resources for the above purposes by creating 'centres'. Examples are the GINTIC Institute of Manufacturing Technology, the Centre for Graphics Imaging Technology and the Network Technology Research Centre where staff from all Schools participate actively. The Centres are also encouraged to work with outside partners such as Grumman International, Silicon Graphics and Digital Equipment. The success of this set-up was seen in the case of GINTIC which won the *1993 LEAD Award,* which was given by the Society of Manufacturing Engineers of America for the most innovative CIM education and research. This was the first time a LEAD award had been presented to a university in Asia and only the second time outside North America.

The NTU is always conscious of its role as a 'university of industry': the research it conducts must make a useful contribution to industry. To implement this policy, the University has a unique arrangement of allocation of university research funding through a committee consisting entirely of industrialists except for its Chairman. Most of the funding goes to industry-related projects.

While research is important and the University has the will to establish a name for its research achievement, we will always be conscious of our ultimate role of producing useful graduates. Teaching will be an important activity and staff will be given every encouragement to improve their teaching quality. We shall make full use of the latest technology, especially advances in information technology, to enhance teaching and learning effectiveness.

We have high hopes that the Nanyang Technological University will make a mark as one of the leading universities in the Asia/Pacific region if not in the world.

REFERENCES

1. M. Finniston, *Engineering Our Future: Report of the Committee of Inquiry into the Engineering Profession*, HMSO, London (1980).

The culmination of Dr **Cham Tao Soon**'s education was a Ph.D. in fluid mechanics at the University of Cambridge, England, in 1968. He began his career as an academic in the National University of Singapore, rising to the position of the Dean of the Faculty of Engineering. Subsequently, he proceeded to start the Nanyang Technological University as the founding President in 1981. Other than academic endeavours, Dr Cham is active in the local industrial scene. He is on the board of some of the major companies in Singapore, including the Wearne Brothers Group, the Keppel Corporation, the NatSteel Group and the Singapore Mass Rapid Transit Ltd. He was the President of the National Institution of Engineers from 1980 to 1982. Dr Cham's contributions to government included membership of the Economic Planning Committee, Construction Industry Development Board, Design Council, Ministerial Committee on Science and Technology, and the National IT Committee.