



As we approach the dawn of a new millennium, it is essential that we equip our students with the necessary skills to cope with the challenges of a knowledge-based economy. In this issue of CDTL Brief on the theme of 'Preparing Students for the 21st Century Workplace', we present several perspectives of how various NUS departments have modified, or perhaps should modify, their curricula and teaching methods to achieve this goal.

NEED FOR Structural Reforms

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The call to inspire students to greater heights is often directed at academic staff members because they are the ones who have to stand before the class to deliver lectures, conduct tutorials or even supervise experiments. Relying solely on individual staff members to incorporate various innovative techniques into their teaching, however, is not enough; there is also a concomitant need for each academic department or centre to consider introducing structural changes so as to pave the way for further improvements.

Recognising this, the Dept of Electrical Engineering (EE) has been exploring how best to restructure its curriculum and train students to meet the challenges of the future. With an emphasis on process skills instead of knowledge content, the Dept took great pains between 1996 and 1998 to trim its curriculum by 25%, thereby opening up opportunities for other features that are able to enhance the creativity and independent-study elements of the Electrical Engineering programme. Listed below are three of the major structural changes that have recently been implemented:

A EE1000 Independent Study

The most radical measure thus far is the EE1000 Independent Study module introduced in January 1998. Unlike regular modules, there are no prescribed lectures, tutorials, experiments or examinations for EE1000. Instead, the onus is on the student to plan for himself a series of independent-study activities that, if competently executed, will allow him to satisfy the requirements of this module (which carries a total of 6 Module Credits). Although the Dept has identified various generic categories of independent-study activities that the student may undertake under the EE1000 umbrella (e.g. literature survey, student competitions, group discussions, hardware design, multimedia courseware or even National Science & Technology Board's National Undergraduate Research Programme), the only guideline issued to the students is that the activities they propose must be related to engineering. Each activity will be awarded a certain number of points (commensurate with the level of difficulty and achievement), and the students have to collect a

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minimum of 25 such points before they are deemed to have passed EE1000. This flexibility allows the student to select for himself what and how he wishes to learn. Consider, by way of example, the 100 teams which chose to participate in the student-robotics competition organised by NUS Innovators Club during the May-July 1999 vacation: each team (comprising 3-5 students) was given the liberty to define its own design specifications and had thus to struggle with implementation problems that were different from those encountered by the other teams during the fabrication and testing of the robots.

Another exciting avenue recently made possible by multimedia technology provides students with the opportunity to gain additional access to those experiments that are of interest to them. Using a web-based package developed by a team of EE researchers, any student can now remotely switch on the instruments stationed in the laboratory and collect additional experimental data in the comfort of his home. The Dept has included such extensions of experiments in the list of recognised independent-study activities that the student may embark on under EE1000.

B Interactive Tutorials

Also initiated in January 1998 are the interactive tutorials that all EE1-2 students have to attend—at least twice for each of the modules taken in a particular semester. The main features of these interactive tutorial sessions (as opposed to the other tutorials which continue to deal with problem-solving) are that the questions set by the course lecturers must be of the design or open-ended types and that the students are allowed to steer these brainstorming discussions to any other engineering-related topic (since the tutor is to assume the role of a facilitator instead of a teacher). Marks, accounting for 5-10% of the total grade for the associated module, are awarded for the contributions made by students during these tutorials.

One of the surprising findings from the teaching feedback collected since the introduction of interactive tutorials is that the EE1-2 students are more comfortable with graduate tutors (who are drawn from the top 10-20% of recent graduates). In view of this, EE Dept has recruited 28 graduate tutors for the 1999-2000 academic year to augment the pool of tutors who can be assigned to EE1-2 tutorial classes.

C Examination Format

It is noted that Singaporean students respond primarily to examination requirements. Unless structural changes are made to the format of examination papers, the majority of students will still adhere to their traditional mindset and not stray from the tried-and-tested methods that have seen them through their O- and A-level years. The only way to compel students to view engineering problems from a holistic perspective is to require them (where possible) to attempt at least one design-type or open-ended question for each examination paper. The following format has thus been recommended for course lecturers when setting their examination papers: Section A containing one compulsory question with several unrelated sub-parts to test the students' breadth of coverage, Section B containing standard problem-solving questions to test the students' depth of understanding on particular topics, and Section C containing design-type or open-ended questions to test the students' capacity for critical thinking.

In addition, more examination papers should be of the open-book type. For too long has the examination system been rewarding those who are able to flawlessly reproduce from memory a plethora of facts and formulas during each two-hour examination session. However, there may be attendant logistical problems for open-book examinations if each cohort of 500 EE students hogged library books at the beginning of the semester only to return them after having sat for their papers. A simpler solution is to allow each student to bring in one A4 sheet on which he can write whatever he chooses so as to free him from the need to commit such data to memory.

Trying to propel students towards creativity and independent learning is not easy. All ancillary measures that can help to accelerate the process are certainly welcome and should be incorporated where possible. EE Dept's experience has shown that the efforts put in by individual staff members have to be reinforced by reforms of the curriculum structure for such a campaign to bear fruit. ■

Teaching Pharmacy Practice

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In 1995, to make sure that pharmacy practice meets the changing health needs of Singaporeans, Associate Professor Ngiam Tong Lan, then Head of the Pharmacy Department, decided to revamp the teaching of pharmacy practice. I was among the staff put in charge of this overhaul in the curriculum and teaching methods used. Since then, several new modules in pharmacotherapy and pharmacy practice have been introduced. The teaching of medical subjects to pharmacy students by the Medical Faculty was also streamlined to cater to the needs of the pharmacy profession.

Possessing the requisite management and clinical experience, our team comprising of Dr Low Chai Luan, Dr Li Shu Chuen, Dr Grant Sklar and I, together with our experienced teachers, namely Dr Paul Ho Chi Lui, Assoc Prof Kurup, Assoc Prof Eli Chan, and Dr Lim Lee Yong, have sought to relate practitioners' experience to students via formal and informal sessions. Students have found the real-life examples interesting and enlightening. We have also been able to call upon past work contacts, pharmacists and doctors, for resources and support when needed in the planning and teaching of pharmacy practice modules.

The first completely open-book examination in the department was introduced in 1995 for the Pharmaceutical Marketing module. Project work (e.g. developing marketing/business plans, case analyses of the marketing of pharmaceutical products/services and creation/presentation of advertisements) provided the continual assessment component of this module. The objectives of these exercises were to build up the

The Pharmacy Department is responsible for educating and training a health care professional who is ultimately licensed to practice and provide pharmaceutical care to the citizens of Singapore. Thus, the nature of the education provided is comparable to that of physicians and dentists: many science courses must be integrated and applied to the solution of clinical problems; specific courses must inculcate students with the values, skills and knowledge unique to pharmacy; and the teaching methods must encourage students to identify and solve therapeutic problems encountered in practice... The staff has aimed to modernize their curriculum through the addition of relevant coursework... that incorporates progressive objectives and modern teaching methods, including problem-based learning.

—Professors Mary Anne Koda-Kimble
(University of California at San Francisco),
Vincent H. L. Lee (University of Southern California), and
Ho-Leung Fung (University at Buffalo,
State University of New York),
Report by visiting committee appointed to review the academic
activities of NUS' Department of Pharmacy, July 1999

students' oral and written presentation skills, as well as challenge their creativity and analytical thinking. This approach was new to the students as it was not traditional classroom teaching.

In 1996, the equipment for teaching and seminar presentation in the department was 'modernised' to support portable multimedia presentations with computer notebooks cum LCD panels, white-light overhead projectors and a scanner. We also purchased video cameras and a videocassette player/recorder for recording students role-

playing as patients or pharmacists in 'mock' medication counselling sessions and for group projects in which students produced educational videos on health- and medication-related topics for the layman.

Practitioners from the pharmaceutical industry, community and hospital pharmacies now serve as part-time teachers by either giving lectures on the marketing of pharmaceuticals, seminars on drug development and clinical research or conduct problem-based learning in small groups on medication management and counselling.

In May 1999, the vacation attachment scheme for students at hospital and community pharmacies gave way to a formal preceptorship programme. Students are required to complete the 12-week programme in two parts over two vacations after Level 2000 and 3000 examinations. This programme aims to fulfil the following objectives:

1. Gain an understanding of the practice of pharmacy and learn more about career opportunities available to pharmacy practitioners;

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2. Acquire and apply some knowledge, experience and skills to achieve professional competency in pharmacy practice;
3. Begin to develop high standards of ethical, legal and professional conduct in pharmacy practice; and
4. Begin to develop the commitment to keep abreast with developments and maintain professional competency in the pharmacy profession.

The Singapore Pharmacy Board has agreed in principle that this programme will fulfil in part the statutory pre-registration training requirement for admittance to the Pharmacists' Register in Singapore.

The department has also implemented a part-time Master of Pharmacy (Clinical Pharmacy) programme

by coursework for the working pharmacist in July 1999. It is a two-year programme that includes didactics, clerkship rotations at hospitals and a clinical research project.

Another development is the increasing collaboration with practitioners (namely physicians, pharmacists and other healthcare professionals) in the final year projects on various aspects of pharmacy practice research. In research terms, pharmacy is one of the most complex, but perhaps the least described, and analysed, health care profession. The generation of a research base that is sufficiently robust to support the ongoing changes in practice is an enormous challenge. ■

The Importance of Teaching Technology Subjects to Today's Architecture Students

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Architecture: A Multi-disciplinary Career

Early architects were able to design and run building construction projects with little or no support from other professionals. But buildings have, in recent years, become much more complicated and contain more sophisticated systems and employ ever-increasing levels of technology and engineering. This has resulted in 'division of labour' where specialists are required to be involved in handling different aspects of building construction projects.

Today for an architect to be able to co-ordinate and ensure a high standard of construction projects, he/she must have knowledge of the general principles of technology and engineering. An understanding of the implications and opportunities which technology and engineering offer can help the designer to 'shape' a building at an early stage in the design process. This is an essential skill, which comes from familiarity with physical constraints and technical possibilities.

Teaching Architecture Students

More than ever before, architecture students need to experience this multi-disciplinary nature of the construction industry in a realistic manner throughout their university education by working with multi-disciplinary staff, including in-house technology specialists. The aim of these technology¹ teachers include:

- Encouraging students to explore and understand technological and engineering possibilities and limitations;

¹ In this paper, 'technology' is used to refer to the key subjects of Building Structures, Building Services and Environmental Control (e.g. acoustic, lighting, thermal environment) and not to Building Construction.

- Imparting techniques of operation and practice in system and building design and construction; and
- Fostering the practice of interacting productively with other professions.

Design is indisputably regarded as the most significant subject of an architectural course. Although both design tutors and technology teachers agree on the importance of incorporating technology subjects as part of the core curricula, they debate on how much relevant technology/engineering knowledge and how such knowledge should be imparted to the architectural students.

For instance, considering the nature and expectations of the architectural profession, the traditional approach of focusing on formal scientific knowledge and mathematical techniques in technology and engineering teaching can be counterproductive for architectural students. Consequently, the mathematical content of subject lectures has been reduced in recent years; instead pragmatic issues are emphasised and students are encouraged to form alternative designs and prototyping.

To address the concern about the difference between technological teaching and design, there has been a valuable trend towards teaching technology and engineering inputs in an 'integrative' manner both in lectures as well as in the studio. For truly 'integrative' teaching, and higher valuations by students, it is necessary for technological issues to become intrinsic requirements of current design or assignment projects; hence the timing and concurrency of inputs with design challenges becomes very important.

In other words, by integrating the teaching of technology subjects to architecture students within the studio using technology staff well-versed and sympathetic to architectural design/philosophy and real-life considerations, there results in greater success in bridging the gap between the fundamentals learned in lectures and the application and integration of them into projects. Students also gain crucial realistic exposure to working with construction professionals other than architects, an experience that will stand them in good stead when they have to work closely with many other professions in their future careers. ■

Wither Cross-Disciplinary Classes?

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In December 1998, I visited Philips' design lab in Eindhoven, and came away dazzled by its Vision of the Future project. Already one of the world's biggest electronics companies and Europe's largest, with sales of US\$ 33.9 billion in 1998, Philips wants to take a crack at the world's corporate summit by looking to beyond-the-horizon ideas that will shift contemporary paradigms. The project aims at forward research into possible future technologies for future lifestyles and workplace. Its talented cross-disciplinary teams—work groups that comprise varied departmental experts with different but complementary skills and various job functions—lighted up a firestorm of mind-thrilling concepts.

Cross-disciplinary teams are put together for swift complex problem-solving or integrating new products with a sharp customer focus. Companies use cross-disciplinary teams for software development, human factors, technical documentation, and marketing. They have also been utilised for business mediation, complex

systems study, biocomputation, remote sensing and geriatric mental health care. Indeed, the integration of various functionalities has recently been emphasised as one of the most important success factors in Japanese product development (K. Kusunoki and T. Numagami. 1998. 'Interfunctional Transfers of Engineers in Japan: Empirical Findings and Implications for Cross-functional Integration'. *IEEE Transactions on Engineering Management* 45, no. 3:250)¹.

To prepare students cross-functionally for a technically driven knowledge-based business environment, engineering schools have expanded and enriched their curriculum by adding topics that were previously offered only in business and industrial design schools. Business schools have developed courses that attempt to expose

¹ The US Department of Defense's Test, Systems Engineering and Evaluation Office is another major user of cross-disciplinary teams, which they label integrated product teams.

business students to the practice of product design. Liberal arts schools have packaged social science and information technology programmes for greater employability of their graduates.

In NUS, students have a wide choice of cross-faculty modules. For some, they attend courses alongside students of the guest faculty. Certain programmes are 'exported' from one faculty to another. There are also courses jointly conducted by two or more departments, such as Negotiation and Conflict Resolution, which involve colleagues from business administration, arts and law. With the commencement of the Core Curriculum programme, arts and science students are able to encounter each other in the modules they select.

Unfortunately, the attainment of inter-functioning effectiveness through employees who had been job rotated or cross-functionally taught and trained may not, per se, be adequate. The attainment of cost and quality competitiveness will continuously rely on economies of scale and role specialisation. Manpower shortage in Singapore prevents job rotation of considerable duration. Acquiring many skills and multi-tasking may cause detriment to core competence in the long term.

We should facilitate the mix and interaction of students from diverse faculties through ownership of a common hands-on project as a prelude to cross-disciplinary teams in the workplace. This mirrors a firm's attempt to enhance its value chain through a greater integration of critical and secondary functions.

Shared class discussion or written assignment may be insufficient because students retain strong identification with their home faculty and the total duration of tutorials/workshops is short. There is consequently little satisfaction with or commitment to their cross-faculty groups. One solution to build habits for cross-disciplinary collaboration is the installation of a joint project or joint internship during the final year.

At the University of Houston, a Shell-sponsored programme, which draws on law, engineering, business and physics, looks at new technologies, analyses possible markets, researches law and prosecutes patents. The 'Building Virtual Worlds' class at Carnegie Mellon brought together 50 students from art, design, drama, and computer science.

Boeing and NASA funded a joint preliminary design of a hybrid rocket booster for future space efforts at the University of Alabama. Mechanical and electrical engineering students designed and prototyped the hybrid rocket; finance students estimated overall costs; whilst liberal arts counterparts contributed their skills in improving the quality of the written reports and presentations.

The intention of these programmes is to promote a migration from a parochial view of the world—in which one's own function, values, and goals are paramount—to a culture that says, "We're all in this together." Hopefully the approach will contribute towards reducing inter-departmental conflicts that are common in some workplaces.

However, the cross-disciplinary approach is not a matter of just putting together a class. The administration and students must be sold on the idea, and support it. Staffing, funding and facilities are key issues that must be resolved. The course must be properly structured and a mechanism is embedded to enable reflection of the teaming process. Conflicting guidance from a joint faculty team and overloading students with materials that exude expertise of a particular area are common, and should be addressed.

Some departments in NUS may have experimented with the described cross-disciplinary classes. Is it time to ponder and percolate the concept further? ■



The Centre for Development of Teaching and Learning (CDTL) provides a wide range of services and facilities to support the teaching, learning and research programmes of the National University of Singapore.

These include teaching and learning support, research on educational development issues, as well as instructional design and development.

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