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INSIDE

Exploiting IT in education: The NUS Science Foundation Module

Professor Chong Chi Tat • Deputy Vice-Chancellor

It has been said that while the world has seen many great changes over the past two thousand years, the method of teaching and learning has been left largely intact since the time of Plato. Teaching is still very much lecture based, with the copying of notes by students signifying the first stage of learning. There are variations here and there, with occasional experiments attempted by the more adventurous. Most would prefer the more cautious and tested path.

It then leads to the question of whether we as teachers have indeed found the truth (i.e., the best way of educating the young) or are we simply ignorant of, or resistant to, change? I will leave the deliberations of this question to the experts. Instead, I would like to cite one example, the Science Foundation Module, which is perhaps the latest venture into a non-traditional way of teaching on a fairly large scale.

The Science Foundation Module, a joint effort of the Faculty of Science and the Department of Philosophy in the Faculty of Arts and Social Sciences, was introduced with several objectives in mind. First, the syllabus should be set at the foundational level and the prerequisite should be minimal. Second, it must cover the major disciplines in science, from biology to physics, chemistry to computer science, complemented with the philosophy and methodology of science. Third, it should make full use of information technology for both teaching and learning. And, most important of all, the module must demand more of the student's own initiative, creativity and ability to learn independently.

Twentieth century science has developed into very specialized and diversified areas. At the forefront of research, and in many industrial applications, the approach and emphasis are multidisciplinary. Yet at many universities, the teaching and learning of science remain compartmentalized and narrowly focused. It is not unusual, for example, to see a biology student ignorant of mathematics beyond basic calculus, or a mathematics student not able to explain the difference between DNA and RNA. Similarly, computer science students wonder why they should ever study physics, while a physics student is likely to doubt the relevance of the subject of polymers in chemistry, despite its importance in materials science.

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Curriculum review

The Faculty of Dentistry's experience

This article was contributed by **Dr Grace Ong**, a senior lecturer in the Department of Preventive Dentistry and chair of the Faculty of Dentistry's curriculum review committee.

Fighting middle age spread is always a problem. Through the years, the curriculum has grown through the expansion of our course content and the addition of new courses. This "bloating" of the curriculum was due to an explosion of knowledge (to keep pace with fast changing technological advances and its impact on treatment modalities) and to individuals' pet interests. This expansion has occurred over the years without a comprehensive review of the degree to which the current curriculum meets the faculty's mission and goals. Consequently, despite the bloat in curriculum content, questions have been raised about inadequate coverage of certain topics, topics taught out of sequence and the heavy clinical and laboratory workload in the dental course.

In 1995, the curriculum review committee was given the task of reviewing the current curriculum and making recommendations for a new curriculum to be implemented in 1997. The curriculum review committee consists of academics from the faculty, a general practitioner and a representative from the Ministry of Health.

New directions

Starting from scratch, planning a zero-based curriculum would be ideal. However, in an established dental school, there are limitations in organisational structure, human resources and central administrative policies. These constraints were considered when formulating our recommendations.

The committee first reviewed the faculty's existing educational goals and objectives to ensure that they are in line with the needs of the profession and society. Disease patterns, health care and social needs were taken into consideration.

When our goals and objectives were translated into an educational programme, it was evident that the new curriculum must be both patient and student-centred, rather than the current discipline-based curriculum. Comprehensive and preventive patient care must be emphasised. Students have to become critical thinkers rather than consumers of information[1]. The knowledge we impart to students has to be more integrated and multidisciplinary in nature, rather than isolated bits of information, which is the product of traditional discipline-based teaching. We felt that a competency-based didactic and clinical curriculum would decrease the problem of "knowledge overload" and facilitate the student's progress in his/her clinical work.

In the course of two years, the committee met with deans from various dental schools from Australia, the United Kingdom and the United States. We also visited four dental schools in the United States and one in Canada to study their curriculum as well as their research activities and use of information technology. These visits confirmed the new directions recommended by the committee.

Competency-based curriculum

Competencies are the basic skills essential to the practice of dentistry. They combine the appropriate supporting knowledge and professional attitudes for clinical procedures to be performed reliably, without assistance[2,3].

Our current discipline-based curriculum has bloated the dental curriculum and predisposed students to a mechanistic approach to learning. This curriculum offered no help in drawing the line between what is necessary to know and what is merely "nice" to know[4]. Education is a path, not a destination and not the accumulation of nuggets of knowledge or the repertoire of skills. Competency represents the point along this path where the learner understands the foundations of his/her skills, has internalised appropriate professional values to work independently in normal settings and manages his/her own continued growth[5].

Our challenge was to develop a competency statement that would define the knowledge, skills and attitudes new dental graduates

should possess. This statement became our standard for defining the core curriculum and allowed us to assess outcomes and audit the curriculum content. Course coordinators then drew up their syllabi listing the supporting competencies, foundation knowledge and skills required to reinforce the main competencies.

Requirements for clinical and technical training have always been based on the number of units or pieces of work completed. Students chased their schedule of requirements and patients became a unit of work. This was undesirable but inevitable with traditional training. Another problem with the system is that it did not assess competency. Therefore, the faculty will radically change the traditional schedule of requirements to one of acquiring specific clinical competencies. Students will be required to take competency tests for various procedures, rather than just complete a predetermined number of procedures. The burden of completing a clinical schedule is removed and the amount of work individualised, allowing better students to progress at a faster rate and weaker students to be identified and given remedial help if necessary.

Problem-based learning

One of our faculty's objectives is to provide students with skills to continue learning beyond dental school; that is, to be lifelong learners. The problem-based learning (PBL) concept was designed to encourage students to assume personal responsibility for their learning and to emphasise learning in the context of real situations rather than organised bodies of knowledge[1]. Once the student has mastered the learning process, he or she is equipped to be a lifelong learner. This teaching method shifts from the traditional teacher-centred approach to one that is student-centred. The teacher's role changes to that of a facilitator who stimulates interest in the learning process[6]. With PBL, students are forced to take a proactive role in the educational process.

True PBL courses, however, require far more time and resources, both in terms of manpower and physical resources, than currently practicable. Instead, the faculty decided to modify this teaching concept to one of "case-based learning". Case-based tutorials are meant to integrate knowledge obtained from various disciplines and to reinforce the basic science behind clinical problems. This approach has the added advantage of reinforcing the basic sciences throughout the course.

The concept of integrating various subjects is important. Students tended to compartmentalise their learning because the subjects were taught independently. In addition to integrating subjects through clinical cases, the new curriculum contains more integrated courses like oral biology, radiology, cardiology and behavioural sciences. Multidisciplinary seminars will also be implemented. Other teaching methodologies designed to improve independent learning will be introduced, including self-paced learning packages and interactive multimedia computer-based teaching.

Effecting change

Traditional dental education has had its success and this makes it even more difficult to change old notions. Faculty members may want to justify the past, a source of their pride and self-esteem[7]. Some believe "if it ain't broke, don't disturb it".

This reminds me of the book *The Saber-Tooth Curriculum* by J. A. Peddiwell[8]. In the early Palaeolithic Age, an ingenious man named New Fist devised a system of education to teach children to find food, clothe themselves and find security. The New Fist curriculum included three subjects: fish grabbing, horse clubbing and tiger scaring. Over the years, the school became very efficient at teaching these relevant subjects. The children were trained and the tribe prospered. After many years, the Ice Age approached and environmental changes occurred. The waters became muddy and people could no longer see the fish to grab them. The forests became too wet; the horses went east and fast antelopes came instead. The air became damp and the saber-tooth tigers died of pneumonia; they were replaced by black bears that were not afraid of fire. There was no fish for food, no hide for clothing and no security from hairy death. A few practical men of the "New Fist breed" soon learnt to adapt. They made nets for fishing, snares for antelopes and pits for bears. But the schools continued to teach fish grabbing, horse clubbing and tiger scaring. "Why aren't the new skills we need taught in our schools?" the radicals asked. The wise educators replied, "If you had any education yourself, you would know that the true essence of education is timeless. It is something that endures like a rock through changing conditions and the saber-tooth curriculum is one of them." As time went on, instructional material became less and less relevant and the tribe was beset with many problems and, eventually, they were overrun by the adjoining tribe whose outlook was more pragmatic.

One of the most important factors in our review process was strong leadership. The leadership directed change and, more importantly, supported it. In our faculty's experience, which will probably be similar in other faculties, there are always those resistant to change. Strong leadership is required to break the tyranny of the old culture, the frame of dysfunctional assumptions[7]. A supportive "working group" ready for change became invaluable in convincing the faculty that the committee's recommendations for change are essential.

Outside counsel can also be invited to present new concepts to the faculty. Those who are not ready for change were still invited to contribute as resource persons for their specialist knowledge. Of course, it is

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LEARNING and LABOUR through PROJECT WORK

On 22 February, CDTL organised a seminar entitled *Using Project Work to Enhance Learning* with speakers from the Architecture and Building, Engineering and Science faculties. Following the programme, a number of participants expressed interest in learning about project work in the humanities and social sciences. The following is a collection of project work perspectives from the faculties of Arts and Social Sciences, Business Administration and Law.

Mr Parthiphan s/o Krishnan • Department of Geography, Faculty of Arts and Social Sciences

Geography courses on climatology and geographical information systems (GIS) are ideal settings for projects. However, structuring projects that challenge yet stimulate students are formidable tasks in themselves. My first set of resources in designing projects for my students were handouts and booklets prepared by CDTL. Also, participating in seminars and talks about project work and other teaching issues broadened my options for designing projects.

I learnt several lessons along the way. Firstly, projects mean exactly that. While references can help by raising points of interests, the design and structure of projects are still very much hands-on. Secondly, as with other assignments, projects must have definite objectives and scopes. Boundaries, especially in terms of time and topic domains, must be set. Too often, students pursue peripheral issues that interest them. While this is laudable, they must be guided back to the project's focus. This requires regular feedback sessions. The pitfall to avoid is not letting these sessions turn into mini lectures. Thirdly, projects must stimulate the student's thinking process. One method is to deliberately keep certain issues vague. For example, in my GIS course, I ask students to perform a simple project on spatial analysis. One condition of the analysis is to locate school sites that are more than 1 km from industrial areas. Most students accepted the condition at face value. Few students queried the rationale of the condition and the precise definition of an industrial site, crucial issues in spatial analysis. Another method is to introduce some difficulty into the project that is not evident on first inspection. In the same project, I introduced two other conditions that were mutually exclusive of one another. Most students did not notice the contradiction. A few noticed, but took the easy option of referring the problem back to me. The rare student attempted to solve the problem. Although some might consider these methods deceptive, my aim is to simulate reality, where crucial pieces of data and information are often lacking. By forcing students to cope with these problems, critical thinking is encouraged. Lastly, projects are not only for students. They are learning experiences for us as well, for students have a way of forcing us to rethink the answers. n

Dr Kalyani K. Mehta • Department of Social Work and Psychology, Faculty of Arts and Social Sciences

The professional component of the social work programme demands rigorous practical training. From the first to fourth year, projects are intertwined with teaching practical social intervention skills. Projects are also designed to further research in specialized areas.

First-year students are actively involved in two main projects: the community laboratory project and social service visits to human service agencies. In the former, groups of students are immersed in a geographical community for three days (they do go home at night). The tutor/staff member acts as a facilitator cum catalyst, enabling students to meet grassroots leaders and arranging maximum exposure to community life. Regular discussions draw out the students' reactions, assumptions as well as internal prejudices. The culmination of the community laboratory project is a creative item that each group presents to the class on the last day. The second project demands greater student initiative, resourcefulness and independence. Although staff members arrange the agency visits, students are expected to organise themselves before the visits and assign roles for themselves (e.g., coordinator, reporter, leader). This cultivates teamwork and involvement.

During the mid-year break of the second year and the following long vacation, students are given attachments or placements that commonly require research, group work and community work. Before their placement, students undergo micro skills training to prepare them for the experiential learning they will gain during their placement. Under the supervision of a field teacher and a department tutor, the student practices assessment and intervention skills while simultaneously increasing his/her self-awareness. Written reports are required at the end of each placement.

In their third and fourth years, students carry out action research projects, which may be qualitative, quantitative or a mix of both methodologies. Scientific objectivity, rigorous validity and reliability tests and mastery of instruments used are emphasized.

Human professions demand comprehensive knowledge, appropriate skills and right morals/ethics. Lectures and tutorials provide the theoretical dimension while projects and practice grill students in the practical aspects. The integration of both is the key to mature learning; it is also the area that students tend to be weak in. To strengthen students' abilities in this area and motivate them to continue the process in their careers is one of our most critical challenges. n

Dr N. Sriram • Department of Social Work and Psychology,
Faculty of Arts and Social Sciences

From 1989–90 to 1995–96, all third-year psychology undergraduates had to conduct a research project, which accounted for fifteen percent of their third-year grade. Each student was assigned a faculty member as his/her project supervisor. With over one hundred students in a typical third-year cohort, this translated into about ten students per faculty member. To conduct a piece of empirical research, students identified a broad area of interest and addressed specific issues using a variety of techniques. A list of the topics covered is available on the Internet at http://www1.swk.nus.edu.sg/1990-96.html.

It is evident that students tended to work in the supervisor's area of expertise. Some projects were based on experimental designs while others were survey based; some used university students as experimental participants while others relied on school students, disabled children and other special populations. Some students undertook research to test hypotheses derived from existing theories; others undertook simple fact-finding surveys. After completing their projects, students submitted written reports for evaluation. The quality of the reports varied considerably; a few have been published in international journals.

In the early years, each project was assessed by the student's supervisor and another staff member and it was not uncommon for disagreements to emerge. For the last three years, all projects were marked by two designated staff to ensure objectivity and consistency in the evaluation process. In 1996–97, project work was incorporated into an elective third-year research methods course spread throughout the year, with the theoretical aspects preceding, and being somewhat independent of, the project component. The elective was also made a prerequisite for the honours degree. These changes reduced the number of students doing projects by about half and enabled supervisors to spend more time with supervisees who, on average, are more capable and motivated than earlier cohorts. In 1997–98, the research methods course will be offered in both semesters to enable the project work and coursework to be completed within the same semester. n

Dr Rachel Davis • Department of Business Policy,
Faculty of Business Administration

I have identified four areas of learning that take place through project work. First, projects require students to develop something on their own, to express something of themselves. For many students, this is daunting, as they are overly concerned with fulfilling expectations, especially those relating to content. Students often fail to appreciate that there is no right answer, that it is the process of doing the project, conducting research, organizing material, choosing an analytical framework, etc., that defines the success of project work. Thus, it is critical that the instructor emphasize the importance of "process" as well as "content" in project work. My personal experience has been that when the process is followed, the content-based outcomes are also realized.

The degree of structure and direction provided by the instructor is an important consideration. My preference is to provide only enough structure to clearly define the project's pedagogical objectives. In the Asia-Pacific Business course, students must choose a multinational corporation (from a list of over 600 companies) and assess its activities in Southeast Asia and the role, if any, that the Singaporean operations play in the company's regional strategy. In choosing a company, students have to balance their interest in a particular company or product with other considerations like the availability of information and the company's popularity among fellow students. The choice is clearly a process-based component of the project and, more than any other factor, it defines the project's direction and domain, hence the instructor has to ensure that students appreciate this point. The objective is for students to develop the ability to make informed and well-thought-out decisions, a critical factor in business.

Next, projects are meant to develop conceptual and analytical skills while enhancing information gathering and library research skills. Knowing how information is organized and accessed creates confidence in students that they will be able to meet the challenges of a dynamic business environment. The ultimate pedagogical objective is to get students beyond factual information so they can develop the analytical skills to understand more fundamental phenomena.

Thirdly, projects help develop both presentation and report-based communication skills. Students need multiple opportunities during the course of their studies to develop such skills.

Finally, group projects are opportunities for learning the pros and cons of group dynamics. Students learn how to work together, deal with personal agendas within the group and negotiate outcomes for themselves and the group. n

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Ms Lim Lei Theng • Faculty of Law

Introduction to Dispute Resolution (IDR) is a compulsory course for all undergraduates in their second year at the Faculty of Law. The course aims to teach basic civil and criminal procedure and lawyering techniques through experiential learning.

IDR is taught in two sections, the first on criminal and the second on civil procedure. In both sections, students work in pairs as "lawyers" representing a "client", a first-year student volunteer. Confidential instructions are given to the clients to paint the scenario of a legal dispute. In the criminal case, the scenario is of a murder that has taken place. Volunteers play the parts of the accused and of a key witness to the crime. The lawyers interview the clients to gather information and construct their legal case in preparation for a mock criminal trial. In the civil case, the scenario is often of a contractual dispute. In this section of the course, student lawyers are given opportunities to represent their clients in a negotiation before the matter is brought to a mock civil trial.

The philosophy of the course is to teach procedure by contextualising it into simulated case scenarios. While learning rules of procedure, students put them into practice in the "case" they are handling. At the same time, students learn the important legal skills of interviewing their clients and preparing them for trial. Through lectures and workshops, students share their experiences and draw important lessons in communication, ethics and client relations. Advocacy skills are tested through the mock trials.

A great deal of independent learning takes place in the course. It is up to students to determine the amount of effort they put into each case. Assessment is made on the basis of the mock trials, periodic written assignments and an open book examination at the end of each semester to test the basic knowledge learnt by each individual student. The workload for the course is heavy and, in view of that, the amount of reading in the course is minimised.

The course has run for two years. While many students have complained of the workload, many have also accepted it as a valuable learning experience quite different from other legal courses. n

SCIENCE FOUNDATION MODULE *...continued from front page*

It is often argued that time is limited, and not every topic deemed important can be accommodated into the university curriculum. But we live in a fast-changing world, where all too often, new developments in science and technology take place linking fields previously thought to be unrelated. This makes it imperative to re-examine the prevalent notion of early specialization.

Many universities, notably those in the United States, subscribe to the philosophy that specialist training should be preceded by a grounding in general education. The core curriculum at Harvard is but one example. The NUS Science Foundation Module aims to address this issue, at least for education in science.

The Science Foundation Module has two distinctive features that make it different from traditional coursework. It is not tutorial- and project-biased; only introductory lectures are given. The student must do a lot of reading, be it books, articles or web pages. With some guidance, each student undertakes a mini-project, searches for materials in the library, on the web or elsewhere, and analyzes the information gathered. A paper is submitted for assessment, and an oral presentation is given in a tutorial session for discussion.

The module is intended to be very much information technology driven. The course materials are on the NUS web server. Because of this, it is possible to provide the user with links to other sites containing computer simulations of certain experiments or information on current research in a particular topic. The entire resource in cyberspace is made instantly available to the student. On top of all this, updating information on the web is straightforward so course materials can be updated regularly.

By surfing the Internet, the student will also appreciate how the powers of information technology can be harnessed and how resources available on the web can be integrated into the curriculum. He will discover what leading research laboratories and institutions are currently interested in, and what potential impacts these developments may have on society. The underlying thesis is that there is a lively way of learning science, and that information technology can be exploited to make this a reality.

The Science Foundation Module is likely to be superceded by other modules, perhaps on different subjects, that look at teaching and learning in non-traditional ways. Until then, the module is expected to evolve and improve in due course. This is as it should be, for in the world of teaching and learning, just like in science, there is no last stop. n

Open Book Examinations

A report and a response to some recurrent concerns

Last semester, CDTL organised a seminar on conducting open book examinations (OBEs) with presentations by four panelists from the faculties of Arts and Social Sciences, Engineering, Law and Science. The following article was contributed by panel member **Associate Professor K. P. Mohanan**, from the Department of English Language and Literature.

A REPORT ON CDTL'S OBE SEMINAR

There was consensus among the panel members that open book examinations are generally more suitable than closed book examinations for testing the application of knowledge to novel situations, as well as for testing higher order thinking abilities.

Associate Professor Walter Woon [Faculty of Law] emphasized that what students learn in a course would ultimately be determined by the goals implicit in the system of assessment. We are at liberty to set these target "hoops" where we want them: rote memorization, exposition of knowledge content, mechanical application, critical thinking or creative thinking, at easy, medium or difficult levels. Our students are intelligent and efficient: they will jump through whatever hoops we set.

I outlined a set of possible educational goals for university courses in the sciences and humanities, and illustrated different types of examination questions appropriate for each of these goals. I also demonstrated that open book examination questions, which demand the processing of novel information, are particularly suitable for questions that simultaneously test mastery of knowledge and thinking abilities.

Associate Professor Winston Seah [Faculty of Engineering] showed how one can test both knowledge and thinking abilities through a type of question that requires students to attempt a real life task of the kind that professional engineers are typically faced with. By changing the variables of this question each year, the examiner can generate novel questions without the danger of recycling, and hence this pattern is not too taxing for the examiner.

Professor S. M. Tang [Faculty of Science] brought in a cautionary note by pointing out that while open book examinations are particularly suitable for testing the student's ability to apply knowledge to novel situations, one must not over-emphasize this aspect at the cost of knowledge content and depth of understanding.

Another warning bell was that many lecturers and students that Associate Professor Seah talked to were not in favour of open book examinations, on the grounds that they are likely to be difficult for the examiners to set, and for the students to answer.

A number of recurrent issues emerged in both the speakers' presentations and the discussion session that followed. What follows is my response to some issues that appear to reflect the major concerns of the teaching community.

A RESPONSE TO SOME RECURRENT CONCERNS

WHAT KINDS OF SUBJECTS ARE SUITABLE FOR OBEs?

The suitability of open book exams depends not on the subject matter of a course, but on the kinds of questions we want students to answer, which in turn depends upon what is being tested in an exam. Ultimately, it boils down to what we want them to attain at the end of the course. If a course expects students to memorize the information given to them, and reproduce it in the exam, an open book examination is unsuitable. On the other hand, if a course expects students to be able to *process new information*, an open book examination is more appropriate. If a course aims to test understanding through exposition, open book examinations are not suitable; if it aims to test understanding through application to novel situations, then open book examinations are suitable.

Suppose we want to find out if students have understood the so-called nature–nurture debate on the roles of genetic predisposition and environmental factors on human behavior. We could design an exam question like: "Critically evaluate the debate between nature and nurture in human behavior."

This question is definitely not suitable for an open book exam, because, to answer this question, all students have to do is copy material from a textbook or a prepared model answer they have brought to the examination hall.

In an open book exam, we would ask a different kind of question. For instance, we could construct a question that tests the student's understanding of the debate on the basis of information they have not come across in their textbooks or lectures. We might, for instance, begin the question by pointing out that children who are born blind still smile when they are happy. We would then ask students to discuss the nature–nurture controversy on the basis of this information. Does it provide evidence in support of one of the competing hypotheses? How can we formulate the argument?

To answer this question successfully, students should be familiar with the nature–nurture controversy, and understand it in a deep sense. They should also be able to think through the new evidence. They cannot answer the question by lifting material from a textbook or lecture, or reproducing ready-made answers. The crucial concept here is that of processing new information in the context of what is already learnt.

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WELCOME ABOARD

Induction programme kicks off new year for new lecturers

The cries were deafening. The floats magnificent. Programmes like the Freshman Welcome Convention and Rag and Flag Day build school spirit and help freshmen become part of the NUS family. CDTL's induction programme for new teaching staff serves a similar function, albeit in a less frenetic, more dignified fashion.

Over fifty new academic staff participated in the Welcome and Induction Programme on 4 July at the Shaw Foundation Building. Deputy Vice-Chancellor Professor Chong Chi Tat gave the opening address and Deputy Vice-Chancellor Professor Hang Chang Chieh spoke on "Education for Life: IQ and EQ." Other presentations afforded new faculty a profile of NUS students and overviews of library resources, the use of information technology in teaching and learning and doing research at the university. Workshop topics included assessment and large and small group teaching.

It was a full day, packed with information and ideas. Here's what some participants liked about the programme.

"Understanding the Singapore student."

"Informative, informal, interactive."

"Good exposure to NUS culture."

"Excellent value."

"Covers the basic queries of a new academic."

"Provides motivation for my research and teaching career here."

And, in case you're wondering, we didn't ask any participants to sing songs or build floats. Maybe next year.

Lights... Camera... SURGERY!

No, we're not referring to the filming of *ER* or *Chicago Hope*. Who needs cheap imitations when you can have the real thing, right next door at NUH. Since 1990, NUS medical students have been watching surgical procedures the high-tech way—through live interactive video. Gone are the days when students had to stand on a balcony above the operating room, craning and straining to get a better view of the operation. With CDTL's expertise and sophisticated closed-circuit television (CCTV) facilities, voice and video are piped from the operating theatre to the training room, and vice versa. It's a win-win situation: more hygienic for the patient, less distractions for the surgeon and vastly improved audio and visuals for the students. The facilities are also used to conduct workshops for professionals from around the region. CDTL is currently helping the medical faculty set up interactive video facilities in the hospital's new wing.

SURF'S UP AT CDTL

If you haven't swung by our homepage lately (or ever), there has never been a better time to pay us a visit. We have a new look and new features like our Online Courses where you can learn how to create a web page or make your course materials available on the Internet. Are you planning to incorporate video conferencing into your teaching and research? Now you can book our facilities online or download an application form for funding. Just go to the "Job Requests" or "Video Teleconferencing" sections of our site. Or maybe you missed our seminar on creative thinking and want to get an idea of what was presented. Click on Seminar Notes under "Publications". You'll find hand-outs from past seminars on topics like creative thinking, curriculum review and producing high value-added students. So do come by! We'd love to have you visit. You can find us at **http://cdtl.nus.sg** or just click on our link under the "Major Resources" section of the university's homepage.

NUS research saves lives, with venom and toxins!

Information kiosk tells the story

Scorpions. King Cobras. Malaysian pit vipers. Dangerous animals that strike fear into the hearts of children and adults alike. But in the near future, an interactive information kiosk will help people understand that venoms and toxins from dangerous animals, plants and insects can be used, not to harm, but to save lives. A multidisciplinary team of researchers at NUS' Venom and Toxin Research Group (VTRG), led by Associate Professor P. Gopalakrishnakone from the Department of Anatomy, has made significant contributions to basic and applied research in this field. In collaboration with INTRO (Industry and Technology Relations Office), CDTL staff are developing a multimedia package for the kiosk that will help share this information with the general public.

COMING UP NEXT IN OUR SCV SERIES...

If you are all cabled up at home, be sure to catch our programme featuring the Faculty of Science, with a special look into the world of orchids and DNA Polymerase research. It's the next exciting instalment in our series with Singapore CableVision showcasing NUS. The programme will air on Thursday, 7 August at 8.30 PM on the Eureka Channel.

IT VIDEO GOES ONLINE

To serve you better, we've put key information from our video, *Using Information Technology to Enhance Teaching and Learning*, on our web site. This new option enables you to work on your computer at your own pace, with clearer images and the latest, most up-to-date information. Just go to our homepage, click on Online Courses and select Using Information Technology to Enhance Teaching and Learning. From there, you can learn how to find information about publishing on the web, how to load course materials onto the web server and how to convert existing documents into PDF files.

Learning, epistemology and the use of technology

Dr Chee Yam San • Department of Information Systems and Computer Science, Faculty of Science

As educators in a university context, a substantial amount of our time is taken up with the activity of teaching. We know how the teaching activity varies with factors such as class size (e.g., 20 versus 400 students), instruction type (e.g., lectures, tutorials, laboratory supervision), the nature of the subject (e.g., conceptual, problem solving, design oriented) and so on, and we discharge our teaching responsibility as best we can in whatever teaching situation we find ourselves.

All too often, however, the teaching responsibility so swamps us that we forget to think *beyond* teaching. In this article, I direct attention to the flip side of our teaching activity—to focus attention on students' learning instead—and to share some viewpoints concerning learning and epistemology. I shall also describe two computer-based learning environments that we have been developing in the Department of Information Systems and Computer Science as part of our efforts to devise useful tools to support students' learning.

Consider the typical lecture session that occurs in the university. The lecturer arrives. He delivers his lecture using transparencies or presentation slides. He leaves. The amount of interaction that occurs between lecturer and students is usually minimal, especially when the student enrolment in a course is high. As educators, it behoves us to consider this question: how much does a typical student learn from attending a lecture? My experience tells me that the answer is "not a lot."

Learning, especially learning with understanding, can only be attained at a much higher cost in terms of a student's time and effort. Lectures provide an effective means for disseminating domain information, but listening to a lecture goes but a short distance along the road to learning with understanding. Why is this so?

Intensional vs. extensional meaning

To better appreciate what it takes to learn meaningfully, we need to turn to epistemology and consider the epistemic dimension of learning. We need to have some appreciation of what it means to know and how we come to know. Hayakawa and Hayakawa (1990), in their book *Language in Thought and Action*, draw an important distinction between intensional and extensional meaning. Briefly, the intensional meaning of a word or expression is that which is connoted in a person's head whenever the meaning is expressed using *other* words; it is based on natural language.

On the other hand, the extensional meaning of an utterance is that to which the utterance points (or refers to) in the physical world; it is based on our experience in the real world. Seen in this light, the quest for meaning and meaningfulness in human learning can never be attained if we operate entirely at the level of intensional meaning. Thus, I would never succeed in learning German (or any other natural language) if all I have to learn the language from is a German–German dictionary. There is no way to bootstrap the semantics of the words used in such a situation. Indeed, one might go further and assert that dictionaries don't contain meaning. They can't. At a literal level, all that dictionaries contain is carbon on paper. Meaning making through interpretation of the symbolic forms perceived in a dictionary is an entirely human cognitive activity. Words don't have meaning of themselves; rather, we *give* them meaning.

Following from the above, it should be evident that experiential grounding is a prerequisite for meaningful learning. Experience provides the extensional grounding for words and concepts, thus imbuing them with rich semantics. Once a core set of concepts is grounded, learning and reasoning can begin to operate on the intensional plane. The weakness of the lecture instructional method arises out of the teaching context (typically, a lecture theatre) that provides little support for experiential grounding. Hence, students find that new terms and concepts introduced during a lecture have, at best, a fuzzy meaning, until such time that they begin to engage in active forms of learning (e.g., attempting tutorial questions, running a lab experiment or writing a computer program).

The viewpoint propounded above is consonant with what is known from the field of neurobiology (see, for

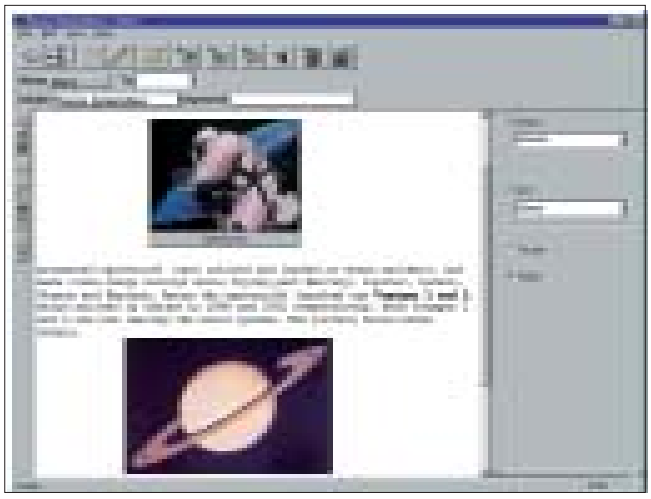
example, Gerald Edelman's book *Bright Air, Brilliant Fire: On the Matter of the Mind*). Changes to human memory that arise out of learning experiences are realized neurally by synaptic modifications in the cerebellum, basal ganglia and hippocampus. These modifications occur over longer time scales and are related directly to human experience. Furthermore, it is expedient to recognize that the brain stem and limbic system also play an important role in learning. They manifest themselves in the affective and emotive dimensions of learning and impact upon the memorableness of the things we learn. It is refreshing, therefore, to see increasing importance being placed on project-based learning within the university because project-based learning provides a more conducive context for meaningful and experientially grounded learning. There is ample evidence for this claim. In a third-year project that I recently evaluated, the students wrote: "This project has given us a golden opportunity to put what [we] were taught in NUS to good practice and experience the gap between theoretical knowledge and practical application in the actual execution of building a system."

The social construction of knowledge

Assuming the grounding of extensional meaning through experience, meaning construction can be facilitated further through language-based discourse. From a social constructivist viewpoint, the main task of intelligent human effort is to make stability of meaning prevail over the instability of unfolding real-world events. Knowledge and knowing result from processes of social interchange and interaction with the environment. Knowledge acquisition does not entail absorbing truth, as defined by some outside criteria, into one's mind. Rather, it is the direct consequence of social interaction.

The goal of instruction, then, is to nurture the ongoing processes by which learners ordinarily come to understand the world in which they live. The role of teaching shifts from seeking to maximize the communication of fixed content or skills to one in which students are led to construct interpretations, appreciate multiple perspectives, develop and defend their own positions while recognizing the views of others, and to become aware of and be able to manipulate the social process of knowledge construction itself. These processes of human learning inherently entail social couplings based in language. Human learning is, in a very real sense, human languaging: the exchange of conversation and dialog. Individuals come to see the world by representing it socially through conventional means such as language.

The social constructivist perspective on knowledge construction accords well with our understanding of how human knowledge is created. Scientific knowledge production, made evident in conference presentations, panel discussions, journal publications and scholarly critique and rebuttal, effectively encapsulates the process of socially grounded knowledge construction. We need to engage students in a similar learning process. As part of this process, students are naturally encouraged



Mind Bridges/Web: An web-based platform for student dialog and multisensory learning.

to seek out information, filter and evaluate it, apply information to support a stance and critique, defend and rebut points of view. These activities foster the development of critical and independent thinking skills. They also help to inculcate an attitude of lifelong learning.

Again, it is refreshing to note that the university now de-emphasizes rote learning and emphasizes critical and independent thinking. How can we help facilitate learning of the kind espoused here with the aid of computer-based technologies?

Using technology to support learning

In this section of the article, I outline two computer-based learning environments that we have developed in the Learning Environments and Learning Science Laboratory in the Department of Information Systems and Computer Science. The design of both learning environments is driven by the viewpoints expounded above.

Mind Bridges/Web is a learning environment designed to support media-rich student co-articulations as part of a collaborative knowledge building process. The environment allows students to express their thoughts on any subject matter in a threaded form of discussion. Students can import text, pictures, sounds and digital movies in the creation of their messages. They can also directly record sounds and digital movies into their messages. The multimedia elements enhance the representational power of the ideas that can be expressed. All multimedia elements play back *in situ*.

Mind Bridges/Web runs as a web-based application. Communication between students takes place in an asynchronous fashion. In addition to browsing and responding to threaded discussions, students can also perform keyword-based search to find relevant messages. The Mind Bridges/Web snapshot (shown above) illustrates what it is like to read a multimedia message incorporating

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From the faculties...
TEACHING AND LEARNING HIGHLIGHTS

Faculty of Architecture and Building:
A design workshop on tropical architecture

When it comes to teaching through the medium of project work, the School of Architecture has long experience with its value, as the greater part of the students' work is in the form of design drawings, models and design-related assignments. Since students are expected to have individual portfolios of their work, projects are usually done on an individual basis but last semester's design workshop on tropical architecture was an exception to the rule.

From 6 to 11 January 1997, over ninety students were engaged in creative group work under the guidance of Malaysian architect Jimmy Lim of CSL Associates. The underlying theme of the workshop—and Jimmy Lim's area of expertise—was tropical architecture. The challenge was how to make a building comfortable and efficient in the heat, glare and tropical rainfall that Singapore experiences year round.

Students were given an intriguing and thought provoking range of design topics, including a Japanese-style "Love Hotel" and "Centres for Stressed Executives". These themes were further varied by designating a range of locations, such as a green-field site, downtown plot and even the penthouse of an existing building, so that each group was able to exploit the differences of their allocated building type and its unique location. Groups had to examine environmental strategies, appropriate building forms and detailed methods to provide shade and shelter. Simple modelling tools were widely used (e.g., using the Heliodon to simulate the sun's impact on a window). Analysis, by brainstorming and collective discussion, was a vital part of their work. Final designs were presented to a panel of tutors and visitors for the "Crit", which is the established method of feedback and assessment in most schools of architecture.

Our students proved very effective in group work. The way they organised the exploratory as well as the production side of their projects is something that merits further analysis. All too often, the need for individual assessment denies students the chance to work in groups to a common end; but, in the real world, it is the individual's ability to work effectively within a larger team or organisation that is often the most critical. n

Faculty of Arts and Social Sciences:
The Teaching and Learning Resource Unit

The Faculty of Arts and Social Sciences is the only faculty on campus with its own Teaching and Learning Resource Unit (TLRU). Established in 1991 with Dr Daphne Pan as the first coordinator of the unit, the mission of TLRU is to develop and maintain standards of excellence in teaching and learning in the faculty. Associate Professor Augustine Tan is the current coordinator. He is deputised by Dr Tan Ngoh Tiong who is also Sub-Dean.

Located at AS7 Level 2, the unit complements CDTL's work by offering a variety of faculty-based services and activities including organising seminars and workshops, setting up a resource center with selected materials on teaching and learning for easy access by FASS staff; spearheading research and facilitating matters pertaining to teaching and learning such as reviewing skills in leading group discussions, use of audiovisual aids, continuous assessment, self-appraisal and evaluation.

Recent TLRU workshops topics have included student-centred teaching and learning, public speaking and using web pages for teaching (academic staff actually posted their course material on the web at this hands-on workshop). Panel discussions have covered topics like small group teaching, open book exams, student feedback and the use of computer technology. TLRU also plans to hold induction courses for new faculty members.

FASS' new Multimedia Laboratory comes under TLRU and the Foundation Course Unit of the Dean's Office. Services provided by the Multimedia Laboratory include: multimedia applications development using Macromedia Director, scanning of photos, notes and pictures, digitising videos tapes to compact discs (CDs) and writing files and programs to CDs. Although the laboratory was opened only recently to staff and students, the response has been good with many people requesting services. n

Faculty of Dentistry:
Project work presentations

Recently, much attention has been directed towards the quality of teaching in the university. As part of the Faculty's academic audit and quality assessment, the project work format was revamped this year. This was to address the need to move from a superficial approach to learning where students act in passive roles, to a more thought provoking and exploratory approach that motivates students to be involved.

Instead of conducting the "traditional literature review" as project work, research was emphasized. This research option was taken up by sixty percent of the final dental year students. To facilitate these projects, students were divided into small groups of four or five and assigned to selected staff of various specialities at the beginning of their third year. This gave the students twelve months to complete their projects. The research projects undertaken were specially designed to be applied to clinical dentistry. In this way, students were able to relate their research to the daily practice of dentistry, thus creating a new and innovative learning environment. Students were also given the opportunity to develop a range of interpersonal skills that they will need in postgraduate work and in the professional field that they will eventually enter. Such skills include leadership, teamwork, communication, planning, time management, literature searching, economic and logistic awareness, problem solving and analysis.

We held our first faculty-based final-year project work presentations at the NUH Kent Ridge Wing Auditorium on 18 January 1997. The event drew about one hundred participants, ranging from staff members and students to private practitioners. Students presented their project work to the entire dental faculty; they were given fifteen minutes for their presentations and five minutes for the question and answer session. A panel of independent assessors was selected to evaluate the quality of the projects and presentations. The results of this assessment will be factored into the progressive assessment scores for the final profession examinations. Two of the research projects were selected to represent Singapore at the 23rd Asia Pacific Dental Students Association Congress (APDSA) and the faculty is proud to have clinched the top two prizes at APDSA's scientific competition. n

Faculty of Engineering: Highlights from Civil and Electrical Engineering

The university has encouraged the concept of virtual classroom teaching using the Internet for some time. In the **Department of Civil Engineering**, Dr Ang Kok Keng took the challenge by introducing a virtual computing class in EG1101 Computing. Students needing additional lessons on the subject can surf the class web page at any time of day. The site includes colourful graphics, which can enhance the student's understanding of difficult topics. Students can also download FORTRAN source codes and evaluate the efficiency and robustness of their own programs against the code provided when both are run on the computer. Students can also email their queries or comments to the lecturer using the class web page. Since the "opening" of the virtual computing class on 21 August 1996, there have been over 2,500 visits to this page or about 3–4 visits per student. To experience virtual classroom teaching first hand, visit the virtual computing class website at http://www.eng.nus.sg/civil/Class/EG1101.

In the **Department of Electrical Engineering**, the Faculty Teaching Methodology Committee has organised ten in-house seminars to promote informal discussion and the exchange of ideas among staff on matters related to effective teaching and learning. Senior staff were appointed as facilitators and 3–4 staff members were assigned to participate in each of the seminars. Also, in line with the Deputy Vice-Chancellor's directive on small group teaching and developing our student's creative thinking potential, the department undertook a pilot program, implemented during the 1996–97 academic year. Seven elective modules were selected for this project, based on the staff strength and student enrolment. The aim of the project was to encourage active participation by all students and to promote the culture of independent learning. Assignments consisted of one or more of the following categories: topics requiring independent literature search and the ability to extract the salient features, challenging questions, questions requiring critical appraisal and creative thinking, open-ended questions and group assignments requiring teamwork in presenting a collective report and short presentation to the class, followed by a question and answer session. n

Faculty of Science: Cultivating leaders with the Special Programme in Science (SPS)

The Special Programme in Science (SPS) was launched in July 1996 for a selected cohort of bright and talented undergraduates. The objectives of this programme are to foster small group learning and enhance student–mentor interaction. The programme also enables students to participate in creative interdisciplinary projects, learn science in an interactive environment, develop interpersonal and communication skills, attain a broad perspective in science and cultivate leadership qualities. The programme's philosophy and teaching style are reflected in the following activities.

Science update. SPS students are required to read up on current developments in science which interest them. They then present at a seminar the type of work done in a particular field of science, its current status, advancement and impact. They also answer questions from their mentors and peers after their presentations. The students are self-motivated and self-directed. They set the tone and level of discussion and, through these sessions, students (and mentors) acquire and are stimulated by new knowledge. The topics are usually multidisciplinary in nature to show the many facets of the problem and different approaches that can be taken. Updates have included teletransporting, AIDS cure, cell ageing and cryonics.

Essay writing and critique. Each student must also write a research essay with critical input. Selecting topics approved by the mentors, they must present their arguments and discussions in a logical and critical fashion. The essays usually require some in-depth understanding of the topic and references are needed to support each case. Topics have included life on Mars, continental drift, animal communication and artificial intelligence.

The science update is a group effort. Team members (usually three) have different backgrounds in their major disciplines and they must integrate their expertise for the task. The essay requires individual effort and in-depth understanding. The update is similar to a bulletin report while the essay requires more language and organisation skills. Both activities, however, train students in effective communication skills and the ability to ask and answer questions. The activities also require students to exercise their investigative and analytical skills. In addition, they learn from each other as they explore new knowledge. All SPS students are trained to make professional multimedia presentations. n

The Centre for English Language Communication: Meeting communication needs today and tomorrow

November 30, 1996 was a red-letter day for the Centre for English Language Communication (CELC). On that day, CELC Director Dr Wong Lian Aik announced the official change in the name of the centre from the English Language Proficiency Unit (ELPU). The change reflects a new and more dynamic role which the centre performs within the university and society at large. When the centre was formed as ELPU in 1979, its main goal was to offer proficiency courses for undergraduates who were weak in English. Today, it caters to the needrøf a wider population, including those highly proficient in English. The centre aims to increase students' English proficiency, develop students' communication skills for academic and professional purposes and conduct research on issues related to language teaching and learning.

One of the greatest challenges for the centre has been the increasing number of postgraduate students from ASEAN countries and beyond. To better meet their needs, the centre offers courses that cater to the diverse proficiency levels and enable students to conduct research and write academic papers in English. The increased demand for tertiary graduates with strong communication skills has prompted the centre to conduct communication courses to prepare students for the workplace. In addition, CELC continues to run, in conjunction with the Ministry of Education, intensive English courses for pre-matriculation students from Indonesia and the People's Republic of China.

In the 1996–97 academic year, over forty full-time teaching staff and many regular part-time teachers conducted twenty courses for almost seven thousand students campuswide. Despite their full-time commitment to teaching, the staff have undertaken research in relevant areas. Research findings are disseminated through the centre's *Working Papers*, as well as in regional and international journals. As part of its staff development programme, the centre runs regular in-house seminars, which have included guest speakers from other institutions. n

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If the ultimate aim of a course is understanding and thinking, then open book exams are very useful, but if the goal is rote learning and regurgitation, then closed book exams are clearly better.

How are open book exams different from closed book exams?

Intelligently designed closed book exams can be used to test thinking, but they are typically used as tests of memory. Open book exams cannot be used as plain tests of memory. If we want to ask questions like: "Describe the Rutherford model of the atom." or "Give the structural formula for methane." or "Critically evaluate the biological account of aging." then we cannot use open book exams because students could copy the answers from prepared answers. Such questions prompt students to regurgitate the information given to them in their lectures and readings. Flags like "critically evaluate" are only cosmetic, since what students are going to do is repeat the lecturer's critical views.

Students prepare for traditional examinations by: looking at previous question papers, spotting probable questions, constructing/finding model answers to these questions and memorizing these answers.

Constructing a model answer on one's own deserves credit. However, given that model answers are easily available, usually from senior students, all that students need to do to prepare for an exam is to memorize such answers.

If students can spot the likely questions and come ready with prepared answers for an open book exam, the exam does not test even memory. Hence, open book examinations cannot allow questions whose answers students can prepare in anticipation. One consequence of this is that open book examinations cannot afford to recycle questions.

What kinds of abilities are tested in OBEs?

A closed book exam typically tests (in practice) the ability to memorize and reproduce. An open book exam lends itself to a wide range of higher order abilities. Suppose we design a question that contains a two page passage on evidence of life in Mars, with a set of questions to test the students' ability to understand a piece of academic prose, evaluate the arguments and claims, consider alternative interpretations of the same facts and so on. Such a question would be ideal for testing the students' critical reading ability. If the processing of the passage crucially requires the knowledge content of the course, the tasks can also test how well the students have mastered this content, and how well they can acquire new knowledge on the basis of what they already know.

Suppose we design a question that contains a brief case study of a company that is currently running at a loss, with a set of questions to test the student's ability to analyze the probable causes of the problem, come up with a proposal to solve the problem, consider alternative proposals, and decide on the best solution. Such a question simultaneously tests the students' understanding of the concepts taught in a course, their creative faculty and decision-making abilities.

Undergraduate students in chemistry are generally told that the combination of atoms in a molecule may involve different kinds of bonds: single bonds, double bonds, triple bonds and so on. An ethene molecule, for instance, is believed to have a double bond between the two carbon atoms it contains, while an acetylene molecule is believed to contain a triple bond. If an examination question requires students to write down the structural formulae of these two compounds, they can regurgitate the correct answer without a shred of understanding.

The first step towards building a generation of thinking students is to sensitize them to issues of evidence and alternatives. One of the reasons for assuming double bonds and triple bonds in ethene and acetylene is the valency theory. Hydrogen is assumed to have a valency of one, while carbon is assumed to have a valency of four. Ethene and acetylene have two carbon atoms each, so we would expect these molecules to have eight hydrogen atoms. Contrary to the expectation, there is evidence to believe that ethene has four hydrogen atoms, and acetylene has two. This puzzle is explained by the double bond and triple bond hypotheses. Suppose an examination question proposes that we explain the number of hydrogen atoms in ethene and acetylene by assuming that carbon has a variable valency of four, two and one. This variable valency hypothesis would allow each carbon atom to combine with two oxygen atoms (as in carbon dioxide), two hydrogen atoms (as in ethene) or a single hydrogen atom (as in acetylene). We can now ask students to choose between the two explanations in terms of available evidence. The answer to this question cannot be found in any of the standard textbooks. To answer this question, students will need not only a considerable knowledge of the facts of chemistry, but also the ability to think critically by pulling these facts together.

Is knowledge content ignored in OBEs?

Thinking does not take place in a vacuum. Solving problems, inventing explanations, evaluating alternatives, testing theories and so on require close familiarity with and understanding of a large body of available facts, theories, analyses, and explanations. An open book examination can test the students' mastery of content indirectly by testing how well the student is able to apply this knowledge to new information. In fact, such application-oriented questions are a superior means of testing the mastery of content.

Even memorization is tested through such applications, provided that what is memorized has a crucial role in the processing of new information. We do expect chemistry students to know that carbon has a valency of four, and physics students to know the equation that expresses Newton's law of gravitation. We do not treat such knowledge as meaningless memorization because without this knowledge further thinking in the subject will be impossible. What open book examinations will eliminate is rote memorization with the goal of simply reproducing what is memorized, not memorization that enhances the efficiency and speed of thinking in a given domain.

How do OBEs affect the learning process?

The traditional learning strategy of spotting, preparing and memorizing answers will not work for open book exams. Instead, students will have to practice activities that develop abilities tested by open book exams. If we have to take a test in swimming or piano playing, we don't try to memorize a set of ready-made answers. Rather, we engage ourselves in activities that enhance our ability to swim or play the piano. The same holds for open book exams.

Students who are used to traditional examinations take a long time to figure out how to study for an open book exam.

It is therefore necessary to help the students change their study habits by giving them quizzes and mock examinations. One of the speakers remarked that in his courses, more than fifty percent of the students simply flunk in the first open book quiz, because they come in with memorized answers without any practice in thinking that calls for processing novel information in terms of what they have learnt. The post-mortem of the quizzes helps students see why they did badly, how they can study to do better and so on. By the time they come to the third quiz, most students have a reasonable idea of what open book examinations call for. They stop looking for ready-made answers to questions. After the third quiz, they are ready for the final examination.

How will OBEs affect the teaching process?

If we are going to use open book examinations, it may be necessary to replace the lecture mode of teaching with an interactive mode. In a traditional lecture in a university, the lecturer delivers a fifty-minute lecture, and the students listen passively and take down notes. In the student's mind, each lecture is converted into a possible answer for a potential examination question. They write down the points made by the lecturer on each topic, including the lecturer's criticisms, and reproduce the points in the final examination. The lecture method is ideally suited for regurgitation in closed book exams.

In an open book examination, the focus shifts from the *reproduction* of information to the *processing* of information. What this means is that the focus shifts to the testing of certain abilities closely tied up with the knowledge content presented in the course: the ability to apply a theory, test a theory, propose an explanation, interpret the meaning, infer predictions, design an experiment, find logical inconsistencies and so on. We cannot help students develop these abilities by lecturing to them. The crucial concept here is *active interaction*: students actively interact with the teacher, instead of listening passively to the teacher.

One may think of a teacher as a master craftsman, and students are apprentices. One of the speakers said that he thought of himself as an experienced potter. His classroom is not a lecture hall, but a pottery workshop. Students make clay objects in the workshop, individually and collectively, and receive feedback from both the teacher and other students. The basic idea is that students construct and critically evaluate a large part of the knowledge that we expect them to acquire in a course. By doing this, they develop their creative and critical faculties while acquiring a body of knowledge, and are able to extend the knowledge beyond the classroom and examinations. The teacher, like a master craftsman, helps students construct and evaluate the knowledge.

In the lecture method, the teacher is at the center of the picture. In the interactive workshop method, the focus shifts from *what the teacher does* to *what students do* in the classroom. If we use open book exams, the lecture method must be replaced by the workshop method, or some other student-centered interactive method to trigger learning in students.

Needless to say, not all lectures are necessarily geared towards regurgitation. In a graduate course in MIT, Caltech or Stanford, we find some of the top people in the field communicating their recent ideas to students in the form of lectures. But these are contexts in which students are already well trained in their thinking abilities, and are not afraid of challenging the lecturer and converting the lecture into a discussion. In a context where students are not trained in the active mode of learning, however, the lecture mode is perhaps not the best.

To conclude, open book exams trigger a transformation of the modes of teaching and learning which enhance the students' creative, critical and decision-making faculties. The overall result can be summed up in two words: enhanced intelligence. n

CURRICULUM REVIEW *...continued from page 3*

always great to have unanimous agreement, but real life is never ideal. We just have to move on.

Training may be necessary to make change effective (e.g., staff may need training in new teaching methodologies or techniques) and this must be supported by the administration. At our faculty, eight staff were trained in conducting PBL tutorials by an instructor from the United States. Finally, it may be necessary to change the faculty's physical structure (e.g., to make more rooms for small group teaching sessions) and even its organisational structure.

As educators it is our responsibility to not only impart knowledge, but also to respond to change as the profession evolves and to recognise changing trends, envision the future and prepare our students to meet tomorrow's challenges. I have shared our faculty's review process and some changes that we are going to effect. The acid test is in implementing the new curriculum! n

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VROOM: Using computers to enhance opportunities for collaboration.

a digital movie, text and a picture using the MIND BRIDGES/WEB client.

The second project, VROOM, is a learning environment for highly socialized meaning construction and knowledge building. Unlike MIND BRIDGES/WEB, VROOM is a real-time,synchronous system where students navigate in a virtual world, meet other people and discuss ideas with them. VROOM, an acronym for Virtual Reality Object-Oriented MUD, is a system that integrates virtual reality technology with object-oriented MUDs (also known as MOOs). Unlike traditional text-based MOOs, however, world building is not an important element in VROOM. Rather, the aim is to support a highly socialized form of learning interaction between participants in the virtual world.

The VROOM snapshot (shown above) shows how participants in the virtual world, represented by avatars, can roam the virtual world and engage in learning conversations with other participants. The virtual world is full of life. In the background is a digital movie on a wall that can be played, observed and commented upon by the two human-like avatars shown. In addition, the virtual world supports animation (the rotating zebra in the cage) as well as sound (when approached and clicked, the monkey will animate and speak at the same time).

CONCLUSION

It is hoped that readers will be able to appreciate how systems like MIND BRIDGES/WEB can be deployed to support media-rich knowledge construction and, in the process, develop students' critical and independent thinking skills. Learning environments like VROOM, on the other hand, can lead to deeply engaging forms of (physically) remote yet highly productive collaborative learning. In the not-too-distant future, we hope to deploy these systems for student use within the university.

I have attempted, in this article, to share certain epistemologically grounded viewpoints concerning learning and to illustrate how, based on these viewpoints, we have developed learning environments to support students' learning. It should be noted that these systems are oriented toward knowledge construction and to acquiring conceptual understanding. They do not, for example, foster skill acquisition. Experiential grounding, through the pursuance of projects, for example, must still take place *outside* of these systems as a complement to intensional knowledge building. n

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The Centre for Development of Teaching and Learning (CDTL) provides a range of facilities and services to support the teaching and research programmes of the university.

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