CHAPTER TWELVE

TECHNOLOGY IN EDUCATION AND RESEARCH

"Someday, in the distant future,
our grandchildren's grandchildren will develop
a new equivalent of our classrooms.
They will spend many hours in front of boxes
with fires glowing within.
May they have the wisdom to know
the difference between light and knowledge"

Plato:
(427-347 B.C.)

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There are numerous possibilities for the application of modern Information and Communication Technologies (ICT) in the environment of the IITs. One straightforward application is to enable the IIT faculty, staff and students to access information available in the cyber space. The MHRD has generously supported these institutes, through an allocation of Rs. 90 crore in the Ninth Plan, to install facilities like the personal computers and communication infrastructure. Consequently, IITs and the various sections of their community today command a comfortable internet connectivity. In recent years, MHRD has incurred expenditure to subscribe to about six thousand technical journals and has enabled the IITs to access them through the INDEST Consortium. MHRD has also aided the programme on digital libraries. By and large, IITs can be regarded as the best endowed academic institutions, alongside the Indian Institute of Science, in regard to the basic ICT infrastructure.

We shall be concerned with two other areas of application of modern communication technology in education. The first relates to IITs helping the vast network of engineering colleges, their teachers and students by creating course material and making it available through an existing technology channel. This is a mammoth programme that has been entrusted to the IITs. It is also possible to install the means to transmit live lectures delivered at IITs directly to remote centers in the country. A good example of this practice is what is being done at IIT Bombay. The second is for the IIT students and teachers to collaboratively work with distinguished overseas institutions through the medium of modern communication. We shall briefly discuss these developments.

12.1 e-LEARNING PLATFORMS

Many institutions in the world have recently initiated programs for dissemination of their curricula through the web. A number of commercial e-learning platforms have been used by them. Notable among these are WebCT, Blackboard, Lotus Learning Space, Top Class (all commercially available software products) and Acado (an Indian product developed by IIT students who have formed a company in Thiruvananthapuram, Kerala known as Transversal E-Networks). These e-learning platforms commonly support the following objectives:

- Design course materials using text, animation, movies, interactive templates, quizzes and assignments along with voice help etc., using simple web tools or sophisticated multimedia editing software;
- Provide learning space through interaction, hyperlinks, searchable databases and other web resources;
- Conduct examinations and online course grading for classes with large numbers of students;
- Provide opportunities for chat/discussion among students and enable them to communicate their ideas effectively around themes specific to a given course and
- Set up virtual universities for distance learning.

12.2 e-LEARNING IN IITs

Courses with large enrolment (about 500 students) traditionally taught by several faculty simultaneously to small batches of students have proved ideal courses for the web-based approach in the IITs since the syllabus, examinations and assignments are all common for all the batches. The challenge has been to ensure that all students have electronic access to course notes, assignments and previous examinations. Typically, in IIT Madras, the experiment has been extended to cover approximately 200 courses and about 50 of them are currently accessed by students. The web contents are diverse: power point presentations of lectures, html, Java, Text content, animations etc.

12.3 THE NATIONAL PROGRAMME FOR TECHNOLOGY ENHANCED LEARNING

A Virtual Centre for Technology Enhanced Learning (VCTEL) has been formed with the seven IITs, six IIMs and Carnegie Mellon University, USA as Partner Institutions. VCTEL submitted a proposal to MHRD involving four topics: distance learning, core course development, digital library and collaboration in Ph.D programmes. MHRD has funded the digital library activity separately and has approved a modification of the VCTEL proposal. The focus of the National Programme for Technology Enhanced Learning (NPTEL) is on course development in video format (for the Technology Channel, "Ekalavya") as well as multicast, CD and web-based formats.

Offering multimedia courses in technology assisted modes has not only become invaluable for the learner, but is also an attractive and a creative option for faculty. Such courses have the potential to enhance the learning experience for students on and off campus in a distance learning mode. In India, where a large number of private institutions have entered the field of engineering education with inadequate faculty support and training, the project is aimed at providing a standard for academic content for both the teacher and the student.

Seven IITs and IISc will work together to develop web and video based material for basic undergraduate science and engineering courses in order to enhance the reach and quality of technical education in the country. In order to facilitate the distribution of course material, two modes of operation have been suggested, namely, digital video lectures of courses and web-based courses. Approximately 100 core courses in each of these modes are expected to be made available by December 2005. The target group for this project consists of students and faculty in institutions offering undergraduate engineering programmes in India. The course development teams in IITs/IISc will interact closely with the teachers in the target institutions to ensure the usefulness of the courses for their students.

The specific educational goals of NPTEL are the following:

- Make video lectures in a format appropriate for broadcasting that would provide quality content through the technology channel named the Ekalavya channel in recognition of the first student of distance education named in the Mahabharatha.

- Create web-based (e-learning) material and make it available in the form of a portal/CDs that would be tailored to meet the needs of engineering students across the country.
- Create a website for NPTEL activity.
- Make e-learning material available on the web for the video lectures to supplement class room teaching.
- Advise target institutions with regard to the software/hardware requirements for benefiting from the national project.
- Conduct workshops for teachers from other institutions who would like to use the contents.

Under NPTEL, IITs and IISc have set up or have augmented their facilities. They now have one or more full fledged studies staffed with project associates who are qualified graduates and post-graduates in engineering/science and well acquainted with the software. The Programme is expected to deliver the learning material in stages and complete its tasks by March 2006.

There is an international dimension, too, to e-learning, which IITs should not lose sight of. For instance, MIT in USA has encouraged their staff to provide their course material worldwide *via* the web. Thus, MIT OCW (open course ware) has made an international impact in academic circles. Is there a challenge and an opportunity here?

It is widely known that Indian institutions nurture good teachers. In some of the reputed universities and academic institutions, it is fairly common to come across outstanding teachers who would be prepared to dedicate all their working life to teaching. Scholars devoting themselves to teaching is, it would not be an exaggeration to state, an Indian tradition from eons. There is here immense potential waiting to be tapped.

IITs can and should very well be in the same arena as MIT, what with the talent and experience in teaching that their teachers possess which has made their B.Tech.s so greatly sought-after. The Committee would enthusiastically encourage IIT teachers to consider the possibility of their teaching materials, too, becoming internationally competitive. IITs can lead and also motivate teachers in sister institutions to join them in this activity. **In order for this to happen, effective technical support and the necessary funds would be paramount, so also a reward system that would be attractive to the teachers.**

12.4 THE DISTANCE EDUCATION PROGRAM AT IIT BOMBAY

The Distance Education Program (DEP) is an activity of the Kanwal Rekhi School of Information Technology (KReSIT). The DEP was set up in early 2002 with the specific mission of reaching IIT courses to teachers, working professionals, and students of other institutes and organizations across India. The program started out with modest four Remote Centers (RCs), including one at IITB. The program had eleven centers, as of March 2003, with several centers being commissioned to join shortly thereafter.

The goal of DEP is to offer courses taught by expert teachers to a large number of participants across the country. Objectives of the program can be summarized as:

- Creating a quality learning environment at a remote location, with facility for live interaction between participants and faculty
- Providing a cost effective and scalable solution for the participating centers and participants in the program, using technology to ensure that the dynamics of content delivery matches the learning needs.

The model provides the benefit of live interaction between the participants and faculty. The mechanism to provide interaction is briefly outlined below:

- Lectures from the central site are synchronously transmitted, *via* satellite based communication system, to the various RCs.
- A typical classroom at each RC has thirty to forty students viewing the lectures, which are projected onto a large screen. This classroom environment provides the opportunity for the participants to interact with each other.
- Any participant from any of the RCs has the freedom to ask a question during the lecture. The desire to ask a question is communicated to the faculty through video-conferencing software.
- The faculty may grant the floor to the RC, in which case the question being asked is heard by the faculty as well as the participants at all the other RCs. Subsequently, the floor is taken back by the faculty, the question is answered and the lecture continues.

To-date, the program has registered over 1000 participants for its semester long PG level courses and over 500 participants in the short-term courses run through the Continuing Education Programme (CEP) in a pilot mode. Around 1200 participants have benefited from the broadcast of lectures by eminent speakers to the participating RCs.

The program is now poised to leverage the available bandwidth during the day by transmitting recorded lectures in popular subject areas such as Linux, and Embedded Systems, free of cost, for the benefit of teachers and students in the partnering educational institutions. In the Autumn 2004 semester, several UG courses will be transmitted, as the courses are being conducted at IITB.

12.5 CYBER UNIVERSITY PROGRAMME AT IISc

The idea of an Indo-French Cyber University came up during a meeting between Indian and French Government officials in November 1999. In the beginning of 2000, applied mathematics was chosen as the first discipline to test the concept. The Toulouse University (TUN) was appointed as the coordinator on the French side and Indian Institute of Science as the coordinator on the Indian side.

The primary aim of the project is to create a cyber-platform devoted to information exchange between India and France within the fields of research, development, education and dissemination of knowledge on a long term non-commercial basis. In the first phase, the project is concentrating on developing and delivering a set of post-graduate level courses in applied mathematics. It is envisaged that this will progressively develop into an Indo-French consortium encompassing a wide range of disciplines and courses at different levels. The programme at IISc is generously supported by the Ministry of Human Resources Development, Government of India.

In February 2003, a Cyber workshop in Applied Mathematics was held at the Digital Information Services Centre (DISC) using temporary two-way satellite communication between IISc and France through the EuropeStar satellite. Six lecturers from India and six from France gave lectures during the course of the workshop. Based on the success of this workshop, IISc and TUN approved the offering of 2 courses to their students under this project for the academic year 2003-2004.

In order to facilitate the offering of the above courses, a permanent satellite transmit-and-receive earth station was set up at the Digital Information Services Centre (DISC), IISc, in an existing room seating 20 students. The present transmit-and-receive earth station set up is an integrated system and configured as per the digital video broadcasting standards. The complete set-up is made of two parts. One part is the set of equipment used for encoding and modulation of the video signal depending on the bandwidth allotted by the satellite service provider. Then the signal is amplified and transmitted using a transmit antenna. On the other hand, while receiving, the signals from the satellite are received by a receive antenna and decoded back to original video signal. The system is able to achieve a dedicated 2 Mbps data communication rate.

The first course (Control and Homogenization) was successfully started on October 1, 2003 and ended in January 2004. The second course (Combustion and Shock Waves) started on January 22, 2004 and ended in April 2004. A crucial aspect of this joint endeavour is that the course content is developed jointly by the Indian and the French tutors. When the French tutor lectures in TUN and the lecture is transmitted to IISc, the Indian tutor is present at IISc along with his students. The counterpart operates when the Indian tutor lectures at IISc. Any discussion that takes place in the class in France is witnessed and heard by the IISc students and vice-versa. Based on the feedback received from these courses, additional equipment (DVD recorders, cameras etc.) has been purchased to record the lectures live and store them on a server for the benefit of students.

In the academic year 2004-2005, it is proposed to offer four courses: Control and Homogenization, Combustion and Shock Waves, Cryptography, and Variational Methods. A learning management system is proposed to be developed so that registration, announcement of grades etc. for all these cyber courses can be done online. The lecturers will also be broadcast live over the local area network. Finally, research seminars and workshops between IISc and TUN are proposed to be conducted using the above set-up.

12.6 SUMMARY OF ISSUES AND RECOMMENDATIONS

The issues regarding the use of technology for educational purposes can be cast in the form of five core elements, namely (1) Technology (2) Content Generation and Delivery (3) Training of Mentors and Other Professionals (4) Cost-effectiveness and (5) Research Collaboration.

Since a couple of years have gone by since the launch of these programmes with substantial support from MHRD, this Committee recommends that a review be carried out by a small expert group drawn from IISc and the IITs. It is likely that this expert group will easily be able to clarify the key-issues related to the five aspects mentioned above. The major points concerning these programmes will be constant upgradation of technology infrastructure, regular updating of teaching material and sustainability in terms of the needed expenditure and possible recovery through revenues. More importantly, one has to resolve how best the cyber links can be advantageously utilized to embark upon and promote joint research endeavours between the IITs and eminent University groups overseas.

We now raise a few issues with respect to each of the five core elements mentioned above which can be considered by the expert group.

(1) Technology

There are 3 currently available technologies which can be used for distance education: ISDN (video conferencing), Internet and Satellite Communication. We analyze below the pros and cons of these three technologies.

(i) **ISDN** is used by many companies for video-conferencing and this technology can be adapted to give lectures.

Pros: The cost of the set-up is minimal.

Cons: The recurring costs are high. It is quite unreliable unless one uses dedicated lines between two points like many companies do. Many smaller towns may not have ISDN facilities.

(ii) **Internet** has been widely used for distance education by many Universities.

Pros: It has a wide reach. The costs of the set-up are minimal. Ideally suited for delivering lecture notes, web-based courses (for delivering video, see below) to a large audience. Can be used as a supplement to other technologies like satellite communication.

Cons: For delivering video lectures, even the receiving institutions need to have about 2 Mbps bandwidth. This makes it unaffordable for most institutions since they have to pay for the leased line costs irrespective of whether they are receiving the video lectures or not.

(iii) Satellite communication has been another popular tool used for distance education.

Pros: It has a wide reach. Receiving institutions incur no recurring costs for receiving the lectures. The equipment for receiving the satellite signals is the same one used by cable TV companies. So it is cheaply available throughout the country. Ideal for delivering live video lectures. The transmitting institution needs to pay transponder costs only for the duration of the lecture. With the launch of EDUSAT, even this may become simpler and cheaper.

Cons: The costs of the set-up for the transmitting institution is very high. One needs to reach out to a wide audience to make it cost effective.

Another issue which has to be addressed (in collaboration with ISRO) is how best to use the recently launched EDUSAT satellite for meeting many of the goals outlined above. Therefore, it may be useful to include a representative from ISRO in the expert group suggested above.

(2) Content Generation and Delivery

Web-based delivery of courses: It is easy to host course content on the web. The most difficult part is creating the content in the first place. NPTEL programme would go a long way in addressing this aspect. The second most difficult part is keeping the content current. This can pose serious problems. The advantage of web-based delivery of courses is that it can scale to any number of students.

Satellite-based live delivery of lectures: The main advantage is that the give and take that is always present in live delivery of lectures is faithfully captured. To ensure this, the lectures should not be given in a studio but in front of students which greatly increases its pedagogical effectiveness. The presence of students would be assured if the courses being offered are integrated into the existing curriculum of the Institute which is delivering the courses. This also has the advantage that the instructors would not feel any extra burden being imposed on them. No special effort needs to be taken and, therefore, more instructors would be willing to participate. Further, every time the course is repeated, the content gets automatically updated since the instructors keep modifying the contents based on current trends. Moreover, corrections made based on student feedback also get incorporated. Regarding scalability, the satellite based delivery scales to any number of students one way (i.e from instructor to students). However, the other way (student to instructor) does not scale up so easily. Therefore, for ensuring student feedback, it is necessary to supplement satellite communication with low bandwidth tools, e-mail or chat facility. One can also explore the recently released tool, Skype, which allows free voice communication over low bandwidth.

To combine the advantages of the above two systems of delivery, one can consider the following solution. The target institutions can be divided into Tier I and Tier II institutions. Tier I institutions can receive the live lectures with possibility of feedback in some form. Tier II institutions can rely fully on web-based material.

(3) Training of Mentors and Other Professionals

For long distance education to be effective, it is essential to have a mentor in each of the receiving institutions who can clarify doubts, conduct exams, award grades etc. This implies that the level of instructors in these participating institutions has to be raised. One possibility is that they can be brought to the institution delivering the course to attend that course one year before it is transmitted. To mitigate the load on the instructor, the following phased delivery schedule can be arranged. In the first year, mentors from 50 other institutions attend the live course. In the second year, this course is transmitted to the above 50 institutions which carry out their own evaluation and grading. Simultaneously, mentors from 50 additional institutions attend the live course. In the third year, the lectures are transmitted to a total of 100 institutions whose mentors have undergone the course. 50 additional mentors are brought in. This process continues.

For purely web-based courses, the content should be delivered to the mentors at least a year in advance so that they can go through it and get familiarized with the content. Some feedback mechanism between the mentors and the instructor is essential in this phase.

(4) Cost-effectiveness

From the viewpoint of funding agencies, the question of cost-effectiveness of any solution that is proposed assumes great importance. When performing a cost-benefit analysis, the cost of deploying a technological solution should be supplemented with the recurring costs which can be substantial. On the positive side, these costs should be balanced with savings resulting from the fact that a single instructor now reaches out to a much wider audience. Further, the result of having better-trained manpower can confer enormous benefits to India and will have a positive cascading effect throughout the Indian economy. This would be more difficult to quantify but has to be a crucial input in any analysis of the viability of the projects. Finally, since better-trained manpower would obviously reduce the retraining costs of companies (which many companies are forced to undertake, given the poor input quality), a public-private partnership to bring down costs could be considered.

(5) Research Collaboration

The final aspect to be considered is the use of technology to enhance research collaboration. For example, internet is an ideal medium for developing research collaborations between two high level Institutes (say, between an IIT and MIT) both of which have good bandwidth. If there is extensive collaboration between two institutes, it may even be worthwhile funding a dedicated internet link between the two. Using tools like Netmeeting, Skype etc. effective collaboration can take place. Another recent trend worldwide is to enable operation of specialized research instruments through the web. This would expand the user base of specialized facilities in a cost effective manner.