

Engineering Education for Everyone

A Distance Education Experiment at IIT Bombay

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Abstract - Distance education at IIT Bombay is carried out through live and free transmission of its own courses, through satellite, video conference and webcast. Distance education is a partial solution to improve the dismal state of engineering education in India. Optionally, the transmission is also available under value added modes, using powerful features, such as, video course on demand and the learning management system, moodle. A brief description of the nonthesis master's degree, known as postgraduate diploma of IIT Bombay, PGDIIT, available through the distance mode, is given. The article concludes with a summary of the national programme on technology enhanced learning, NPTEL, a joint effort of all IITs and IISc. The students, staff and faculty of IIT Bombay enthusiastically support distance education.

Index Terms – free courses, satellite transmission, webcast, video conferencing, LMS, moodle, PGDIIT, NPTEL

I. ABBREVIATIONS

B.Tech	Bachelor of Technology
CA	Course associate
CDEEP	Centre for distance engineering education programme
COEP	College of engineering, Pune
EDUSAT	Educational satellite, launched by ISRO
IISc	Indian institute of science
IIT	Indian institute of technology
ISRO	Indian space research organisation
JEE	Joint entrance examination for admission to the undergraduate programmes of IIT
LMS	Learning management system
M.Tech	Master of Technology
PGDIIT	Postgraduate diploma of IIT
TA	Teaching assistant
VOD	Video course on demand

II. INTRODUCTION

In this report, we summarise the distance education efforts undertaken at IIT Bombay. We believe that transmission of our regular courses and also making available a live video

recording of the courses is the most easily scalable proposition.

This report is organised as follows. First, we point out how our concept of distance education can help improve the overall level of engineering education in India. We explain the technologies that we have used and also the different modes of accessing our courses. We explain the process model that we have identified to make the system work. We briefly describe a nonthesis master's degree, postgraduate diploma of IIT Bombay, PGDIIT, available through distance education. We conclude with a discussion on a national programme on technology enhanced learning. It is our firm belief that participation in distance education will help IIT Bombay, as much as it helps others.

III. STATE OF ENGINEERING EDUCATION IN INDIA

About 500,000 students enroll in engineering studies in India every year at the undergraduate level. The total number of children who are of this age group is 20 million. This is obtained by dividing the population of 1.2 billion by the average life expectancy of 60 years.

Dividing 500,000 by 20 million, we obtain 0.025. Thus, we see that only 2.5% of the age group studies engineering every year. Despite this being a select group, according to McKinsey studies, only 25% of the engineering graduates of India are employable [1]. This happens even after paying substantial amount of tuition.

The main reason for this state of affairs is the lack of college teachers in most colleges. The high paying IT and related sectors have sucked out the best people from all other areas. The low pay of college teachers aggravates this situation. Because of shortage of teachers, students end up studying most of the subjects by themselves. Indeed, the students take the help of private tuition to clear their college exams.

Because of this dismal state, not many students with a Bachelor's degree in engineering are ready to go for higher studies. Moreover, less than 1% of them can hope to enroll in Master's programmes, as there are only about 5,000 seats in India. Naturally, there is a big shortage of Masters and Ph.D graduates.

IV. IITS ARE AN ISLAND OF EXCELLENCE

During the past fifty years, IITs have established themselves as one of the premier institutions around the world in providing engineering education. Just about 1% of the aspirants get admitted to the IITs, through an entrance exam called JEE. Only once during these fifty years, the question papers of JEE leaked, and of course, the exams were promptly cancelled and re-examinations conducted.

The IIT courses are at a level suitable for the aspirations of the bright students who get through the JEE. The senate of each IIT has given guidelines to ensure good quality: syllabus for each course, number of contact hours, continuous evaluation methodology and examination procedures. Through this process, IITs have developed excellent instructional material. IIT Bombay offers a total of over 1,000 semester long courses in sciences and different branches of engineering. These are at the bachelor, master and Ph.D levels in most branches of engineering and at Masters and Ph.D level in sciences.

V. DISTANCE EDUCATION: A PARTIAL SOLUTION

Major structural changes are required if we want to solve the crisis facing engineering education in India. The only fool-proof solution seems to be the deregulation of education, simultaneously with the establishment of impartial regulatory mechanisms. Even if this were to happen, the role of IITs in this solution process cannot be understated. As the publicly funded IITs have an excellent educational system, they will be called upon to play a leadership role in this revamp. What better tool other than distance education do the IITs have in effecting this transformation? The distance education at IIT Bombay is coordinated by the Centre for Distance Engineering Education Programme [2].

An obvious first cut solution seems to be the live transmission of IIT's regular courses to the target audience. Because these are regular courses of IITs, they will be of the same high standard, maintained at IITs. Every course will have about 40 hours of contact time in a semester. They also start on a fixed date and end also on a fixed date. Because these are live, interaction with students will ensure that the classes happen at a right pace. Because the students at IITs and elsewhere will ask questions on unclear topics, the lectures will become clearer, compared to studio recorded offline courses. If these lectures are recorded and made available for the public, they would become a valuable educational asset as well.

VI. DISTANCE EDUCATION TECHNOLOGIES AT IIT BOMBAY

In this section, we briefly present the methods used for live transmission and interactive learning at IIT Bombay.

A. Commercial Satellite Service

IIT Bombay has been active in distance education for the past seven years with the satellite transmission as the work

horse. Until the current semester, we used to transmit our courses through the satellite INSAT 3A on a commercial basis. Fifteen colleges and companies from five states used to receive our transmission. IIT Bombay paid the bandwidth charges for everyone. We paid for 512 Kbps on a demand based multiple access, half duplex, mode. In this mode of transmission, only one party could speak at any time. During the past six years, we transmitted about 70 semester long courses with over 7,000 students in attendance at remote locations.

The original plan was to expand this network heavily and to distribute the expenses. Unfortunately, however, our senate could not be convinced about the dilution of standards in parting with diploma/degree of IIT through distance education. The senate of IIT Bombay fixed the admission norms so high that only a small number of students could be admitted into the diploma programme, PGDIIT, through the distance education mode. Because of this reason, the network of institutions enrolled with us did not expand.

Given the small network, the maintenance costs became high. Often maintenance did not take place in time, resulting in poor audio-video connectivity. Because of this, the enrollment declined further at the remote centres, further reducing the subscription. We ended up raising amounts just sufficient for bandwidth charges only.

B. Videoconferencing

As an alternative to transmission through satellite, we explored the option of videoconferencing, starting in January 2007. The impetus came from the college of engineering (COEP), in the nearby city of Pune. COEP lent us videoconferencing equipments and also paid for some of our bandwidth charges, so that we could use this mode in parallel to satellite transmission. A leading IT major of India, WIPRO, also received some courses transmitted through this mode. One of the problems with this mode of transmission has been the unreliability in the available bandwidth. Although we had paid for 512 Kbps, the available bandwidth dropped to as low as 64 Kbps at times. After this experience, we have increased the bandwidth to 2 Mbps. We have not gone for guaranteed bandwidth option, because of the exorbitant costs. Videoconferencing continues to be a good alternative to satellite based transmission.

C. Free Satellite Service

In January 2008, IIT Bombay signed up with the Indian Space Research Organisation ISRO [3] to transmit through the satellite EDUSAT, its courses free and unencrypted. In return, ISRO has agreed to provide free bandwidth. In return for a transmission of a fixed number of courses, we have been allowed to charge for the courses.

ISRO has given us 1 Mbps for the transmission mode and 512 Kbps in the answer back mode, both being guaranteed quantities. More than fifty colleges all across India already have interactive terminals. Another fifty are in the pipeline to buy these terminals. During the current semester, we are transmitting 13 courses. We have made all of them free as a goodwill gesture.

D. Webcasting

We have also begun live webcasting of five semester long courses, starting January 2008. About 700 students, mostly from the neighbouring state of Gujarat, have enrolled in this programme. We introduced this mode to help some institutions come on board immediately - it takes quite a bit of time to install satellite receiving terminals. We introduced this mode, also because we wanted to explore this important technology.

E. Learning Management System

One of the important aspects of any education is the classroom interaction and group learning through discussions. In distance education, this important component gets missed out and as a result, the distant mode participant loses out.

Live interaction takes care of the classroom participation to a huge extent. More important than asking a question is the satisfaction that one can ask if required.

While answering all questions may not be possible in a class consisting of a large number of students, often answering a few may be sufficient. The doubts are often a result of how a certain topic is explained. In view of this, several students may have similar doubts and the instructor needs to discuss just one to satisfy many. If there are a lot of doubts in a lecture, the instructor may repeat the topic with better examples and explanations.

Group learning is possible through the learning management system (LMS) moodle [4] that is in use at IIT Bombay. The LMS allows the instructor to post the instructional material consisting of slides, notes, hand written material, as well as related documents. In addition, one may post the assignments, exam question papers as well as their solutions. Thus, the students at IIT and at remote locations have similar access to all material associated with the course. Thus, it is possible to use the LMS in an equitable way for all students, irrespective of where they are.

Another important capability of an LMS, such as moodle, is the discussion forum. The instructor can create different threads of discussion and let all students participate in it. Some of the possible threads are, doubts on lectures, doubts on a specific assignment and project related questions. It is possible for a student to answer some other's question. This could be challenged or improved by another student. The Teaching Assistants (TAs) could also post some answers. When the discussion goes in the wrong direction, the teacher may interrupt and guide it back on track.

One of the problems in disseminating live classes to a large number of locations is the scalability. The above explained procedure to handle the offline doubts through moodle is scalable because most doubts are answered by students themselves and the TAs. I already explained that real time answering also is scalable because one explanation will settle similar doubts from many students.

While large class sizes lower the efficacy of face to face interactions, they could actually enhance offline interactions, through an LMS, such as, moodle. A topic could be analysed from different angles by the large number of

participants. The heterogeneity of the population could actually be beneficial, provided the participants are serious.

Because the access to moodle is through the web, the students could be from anywhere in the world. In view of this, even the students from remote locations can get the benefit of group learning.

For the LMS based learning to work, the teacher has to promote its use. I take the following steps to make effective use of LMS. I mainly use moodle to interact with students: if a question addressed to my personal email is of generic nature, I ask the student to post it on the LMS. I also assign a fraction of marks (typically 10%) for class room discussions and moodle participation. In order to prevent the last minute deluge of postings, I also insist on postings throughout the semester. It is easy to get summary reports of postings of every student to find out the extent of participation.

VII. MODES OF PARTICIPATION

As explained earlier, IIT Bombay has started transmitting its courses free of cost. In addition to this, we are offering these courses under different value added modes. In this section, we explain these.

TABLE I
PARTICIPATION MODES, A COMPARISON

	Live	Extended live	Offline	Solo
Live reception	x	x		
Live Q&A	x	x	1hr/week	
Recording at RC or VOD		x		x
CDs - free set		x	x	
LMS		x	x	x
Certificate	One per remote centre	One per remote centre		One per student

A. Live Classroom

This service is the most important part of the joint project between IIT Bombay and ISRO: the latter has given the bandwidth free and IIT would give its content free. The result is the product *live classroom*.

The students can receive live our courses through EDUSAT. They can also interact with our faculty live, if they have access to the student interactive terminals of ISRO.

The participants of this mode, however, may not record the courses. It is a copyright violation to do so. Table I compares the different modes of participation.

B. Extended Live Classroom

This package extends the live class room. It has the following features.

1. Reception of live lectures.

2. Ability to interact with IIT faculty during the lectures.
3. Video course on demand (VOD) facility, through which previously delivered lectures are made available from our server, whenever required. Alternatively, we allow the recipients to record the lectures and re-use them for internal purposes.
4. Access to the course pages in the LMS, moodle.
5. A certificate to the remote center that it participated in the extended live classroom.

C. Offline Classroom

This package makes use of pre-recorded courses. It has the following features.

1. At the beginning of the semester, a complete set of CDs for the course will be sent from IIT free of charge.
2. The college is expected to screen three hours of the course, every week, to be attended by the students.
3. The instructor will be available for one hour of live interaction to answer the doubts arising out of the three hours of lecture seen in that week.
4. All students enrolled for this course at our remote centers will be eligible to participate in the LMS for this course.
5. The remote center will get a certificate that it participated in the offline classroom.

D. Solo Classroom

We get queries from many students who are far away from our remote centres. It is frustrating to turn them away. We reach out to them through webcast and VOD. Cable TV may also effectively be used for this purpose.

The solo classroom package enables students to participate in our courses as individuals. The students are expected to access the lectures through webcast, VOD or cable TV. It has the following features.

1. The student gets access to moodle.
2. The student gets an individual letter that they registered for the solo classroom.

VIII. PROCESS MODEL

Given that there is a large number of recipients for our courses, we need to establish well defined procedures for interaction. These are important also because of the long delays associated with the procedures. For example, the time table of a value added course has to be finalised well in advance for a college to schedule its own courses. In this section, we describe the process model used by CDEEP and summarise it in Fig. 1.

We publish a list of courses expected to be taught at IIT Bombay in every semester, along with the course content. The colleges at remote locations (referred to as colleges I from now on) go through the list and identify the courses suitable for (1) free mode and (2) value added mode. Free courses are useful courses that may not have exact overlap with the courses studied at the college. These are taken to augment the instruction, not as a substitute. The value added mode is to be preferred, on the other hand, for the courses that have a good overlap.

Colleges convey this requirement to IIT Bombay. We, in turn, get in touch with the faculty members and ascertain their willingness to make available their course under the distance education mode. With further discussion, courses that may be offered live free and under value added mode and also the courses based on past recordings are to be decided.

A time table for the transmission of these courses should also be decided. It is not possible to meet the convenience of every participant in arriving at the time table. As a first cut solution, timings suitable for the faculty instructors at IIT Bombay are to be used. This information has to be conveyed to the colleges well in advance so that they can adjust their other course timings suitably.

For every course taken under the value added mode, the college should identify a course associate. It is usually a person who has in theory the required background to teach the course, but without much experience in teaching the said course. The responsibilities of the course associate are the following:

1. Provide the infrastructure support required at the college.
2. Conduct extra classes to teach background material the students at the college may not be familiar with.
3. Help conduct tutorials.
4. Using the question papers to be made available by the instructor at IIT Bombay, conduct exams. In the same way, using the help from IIT Bombay, evaluate the answer sheets and do the grading.
5. If the instructor at IIT Bombay is willing to conduct labs for the students at the colleges, help in the organisation.
6. Take care of other administrative activities, such as, enforcing attendance or other rules prevalent in the college and facilitate communication between students and the instructor at IIT Bombay through LMS and other means.

In short, the course associate helps in orderly conduct of the course at the college and in the process gets the required educational material to teach the course in future semesters. IIT Bombay allows them to use our study material free of cost in the future.

The teaching load for a course associate should be considered as equivalent to that of teaching a full course at the college. The reason is that the courses of IIT Bombay are demanding and hence being a course associate of such a course is definitely equivalent to that of teaching a full course at the college, if not more.

The college could certify the participation of their students in the value added programme of IIT Bombay.

The college and the course associate should take the value added courses seriously. Using the educational support material made available by IIT, they should be able to offer them in future by themselves. That is, a college should not keep taking the same course under value added mode.

In addition to sharing the course material and training the course associate at the colleges, one important objective of this exercise is to introduce the IIT system to faculty and students of colleges. As a matter of fact, COEP wanted the *IIT experience* when they started receiving our courses through the videoconferencing mode. They believed that it is possible only through live reception of courses and not

through recorded courses. They were particularly interested in the following:

1. In case the IIT instructor made mistakes, they wanted their students to see them: they wanted to convey the message that it is alright to make mistakes.
2. In case the IIT instructor cracked jokes, they wanted their students to see them: it is not necessary to be serious all the time.
3. By the same token, they wanted their students to see how ALL lectures, numbering about 40, are actually delivered in a semester; that every lecture starts on time, etc. They wanted their students to demand similar kind of course delivery from other course instructors in their college.
4. They also wanted to convey to their students the amount of work done by the IIT students in a typical course.

One of the important incentives for the live transmission programme to succeed is that there should be sufficient motivation for the instructors at IIT:

- 1: IIT publishes on the web all its available courses
- 2: College identifies desired courses
- 3: **for** every desired course **do**
- 4: College informs IIT
- 5: if IIT faculty agrees to offer their course in distance mode **then**
- 6: CDEEP finalises the time table in consultation with the IIT faculty and recipient colleges
- 7: College schedules its courses after IIT's course timings are finalised.
- 8: **if** IIT's course is close to that required at the college **then**
- 9: Pay and take the course under value added mode
- 10: Appoint Course Associate
- 11: Attend classes
- 12: Access LMS (moodle) and video on demand
- 13: Use IIT's assignments and exams
- 14: College certifies student participation in value added mode
- 15: **else**
- 16: Take the course in free mode
- 17: Attend classes
- 18: **end if**
- 19: **end if**
- 20: **end for**

Fig. 1. Process model used by CDEEP

1. They should be convinced that the distance education actually helps some people.
2. The technology should be easy to use. At the beginning we insisted on the use of slides only. Later we introduced document projection camera and allowed them to write on a paper. We have now further simplified and allowed the faculty to write on blackboards as well.
3. Office support to prepare the study material. If we can help them with the copyrighted material, more instructors will come forward
4. There should be a good support of teaching assistants.
5. There should be good financial incentives.

A summary of the process model is given in Fig. 1.

IX. DEGREES AND DIPLOMAS

The IITs have been extremely selective in degree granting. As mentioned earlier, the seven IITs put together grant their undergraduate degrees to only 0.025% of the population. A similar number of students only receive the postgraduate degrees as well. This exclusivity is a major reason for the brand name of the IITs.

IITs are reluctant to grant their degrees through distance mode, as this could involve a large number of recipients, resulting in brand dilution. In addition, grading and certification of a large number of external students could stretch IIT's resources to unacceptable levels.

The senate of IIT Bombay has approved the granting of postgraduate diploma of IIT Bombay (PGDIIT) through distance mode. PGDIIT requires completion of ten courses at the more popular postgraduate programme of M.Tech offered by the IITs. If taken in full time mode, it is possible to complete these courses in two semesters. This requirement is identical to the course part of the M.Tech. In view of this, the PGDIIT may be considered equivalent to the nonthesis Master's degree offered in several US universities.

The PGDIIT programme is aimed mainly at the working professionals. As most of them would participate on a parttime basis, a longer time period of three to four years is made available for the completion of this programme.

As the requirements of the PGDIIT is identical to the course component of the extremely popular M.Tech degrees, we expect a brand image for PGDIIT as well. Any shortcoming is expected to be more than compensated by the work experience, as the PGDIIT is targetted mainly at the working professionals.

In addition to meeting an important requirement of social obligation, the PGDIIT is expected to bring in the much needed revenues - the distance education programmes explained until the previous section mainly aim at capacity building and are not expected to generate much income.

The electrical engineering department at IIT Bombay has recently decided to offer PGDIIT in its five areas of specialisation:

1. Communication and Signal processing
2. Control and Computing
3. Power Electronics and Power Systems
4. Microelectronics and VLSI
5. Electronic Systems.

We expect to roll out the PGDIIT in these areas in the near future. Simultaneously, we are making efforts to popularise this programme. We expect the PGDIIT to be a huge success with several other departments at IIT Bombay also participating.

X. NPTEL

No report on distance education at any IIT will be complete if no mention is made of the National Programme on Technology Enhanced Learning (NPTEL) [5], partnered by all seven IITs and the Indian Institute of Science, and

coordinated by IIT Madras. This programme is funded by the ministry of human resources development.

In the first phase of NPTEL, undergraduate level compulsory courses have been created in five engineering disciplines: civil, computer science, electrical, electronics and mechanical. There are a total of about 240 courses, half of them being video courses with the rest being web courses. Using this material, it is possible to design undergraduate programmes in all of the five disciplines mentioned above.

The process model of NPTEL is the following:

1. Identification of coordinators at every institute and also one per discipline at the all india level
2. Identification of courses to be created
3. Identification of creators of each course
4. Identification of syllabus for every course, so as to meet the requirements of important universities in India
5. Creation of courses
6. Review by another expert
7. Incorporation of referee's comments

The web courses are available for free download. The video courses are transmitted through the Eklavya TV channel, dedicated for the transmission of educational programmes. These courses are also available through YouTube [5].

The second phase of NPTEL involves the following:

1. Popularisation and dissemination of NPTEL courses
2. Extending the NPTEL programme to other engineering disciplines, such as, chemical and metallurgical engineering
3. Creation of elective and postgraduate level courses

The second phase of NPTEL is in the final stages of financial sanction.

XI. CONCLUSIONS

In this report, we have summarised the distance education activity of IIT Bombay. Widespread dissemination of knowledge has been the most important objective of distance education at IIT Bombay.

For a person whose mother tongue is not the same as the instructional language (in this case, English), it is always beneficial to listen to the lectures more than once. A recorded video course offers this benefit. Considering the fact that many languages are spoken in India and that only a small fraction of the population speaks English, video courses become extremely important for an average Indian. Indian students are basically shy and hence do not ask many questions in a class. While a large number of questions cannot be fielded during live lectures, exactly the opposite happens in the case of LMS: there is no limit on the number of questions that can be answered. In fact, a single issue can get analysed from different angles by people with different educational backgrounds and social upbringing.

Participation in distance education helps IIT Bombay in many ways. Because of video recording, the courses offered in this mode tend to be better organised and better delivered - instructors work hard to come out well in front of the

camera. Students who miss classes may go through the video recording. This is possible for difficult topics as well. In India, quite a bit of learning happens in groups. Video on demand service allows groups to go over lectures together, before the exams. As our class sizes are becoming larger, some of the distance education methodologies are useful for our own internal education. Students who have a backlog in a course will benefit, if a video recording of it is available.

We are now in the process of publicising our distance education activities, so as to increase the enrollment. We are also in the process of establishing one studio level room in every department to record their courses.

A recent pilot study [6,7] shows that our students do not mind the parallel transmission of the courses to the outside world. As a matter of fact, they want more courses to be offered through CDEEP: they like the value added services, such as, VOD and moodle. On the flip side, they are less enthusiastic in asking questions for the fear of being seen by out-siders. There has also been a tremendous support also from the faculty. From the time we started this programme, we have recorded a total of about 55 courses. We expect to record another 50 courses in the next semester itself!

While there is a reluctance to part with its degrees, it is fair to say that IIT Bombay has absolutely no reservation in parting with its curriculum, courses and teaching methodologies. The NPTEL programme demonstrates that the other IITs also have similar ethos.

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REFERENCES

- [1] D. Farrell, N. Kaka, and S. Sturze. Ensuring india's offshoring future. *McKinsey Quarterly*, pages 75–83, September 2005.
- [2] www.cdeep.iitb.ac.in, seen on 23 May 2008.
- [3] www.isro.org, seen on 23 May 2008.
- [4] M. Dougiamas and P. Taylor. Moodle: Using learning communities to create an open source course management system. In D. Lassner and C. McNaught, editors, *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2003*, pages 171–178, Chesapeake, VA, 2003. AACE.
- [5] www.nptel.iitb.ac.in, seen on 23 May 2008.
- [6] M. Goyal. A pilot study of efficacy of distance education at IIT Bombay. Technical report, CDEEP, IIT Bombay, May 2008. Available at www.cdeep.iitb.ac.in.
- [7] R. Deshmukh and M. Goyal. Live webcast courses on virtual sets. An experiment at IIT Bombay. Technical report, CDEEP, IIT Bombay, May 2008. Available at www.cdeep.iitb.ac.in.