Free and synchronous course delivery at IIT Bombay

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Abstract

IIT Bombay used to transmit its regular courses at a cost to cover bandwidth charges and other operating expenses. After switching over to EDUSAT with free bandwidth, the courses have been transmitted live and free. To make them accessible to people who do not have access to EDUSAT, the courses are also transmitted through webcast, at 100 kbps.

This article explains the social issues in popularising distance education amongst the faculty and students of IIT Bombay and the motivational techniques employed to switch over to the required technologies.

These activities are now funded by the national mission on education through ICT. IIT Bombay is in the process of releasing one hundred courses to the public free of cost.

Abbreviations

CDEEP	Centre for distance engineering education programme
COEP	College of engineering, Pune
EDUSAT	Educational satellite, launched by ISRO
IIT	Indian institute of technology
ISRO	Indian space research organisation
JEE	Joint entrance examination for admission to the undergraduate programmes of IIT
NKN	National knowledge network
NPTEL	National programme on technology enhanced learning
RA	Research Assistant
TA	Teaching assistant
VOD	Video course on demand

1 Introduction

Engineering education is in a shambles in India [1]. Although only about 3% of the population enters engineering, more than 75% of these graduates do not find appropriate jobs [2]. One of the main reasons is that we do not have good teachers in colleges. This neglect, combined with an expansion of colleges to meet the aspirations of the youth, have worsened the situation. Deregulating engineering education offers good potential to solve this problem [1].

In contrast, IITs have remained as centres of excellence. Distance education is a powerful tool through which IITs can help in this effort. The freely available NPTEL video and web courses is a good example of this. An Alternate approach has been demonstrated by IIT Bombay that has been transmitting live, through EDUSAT and webcast, about 1,000 hours of its own classroom teaching, absolutely free of cost, every semester.

The centre for distance engineering education programme (CDEEP) makes available IIT Bombay's courses and educational methodologies to the outside world. A detailed account of the activities carried out by CDEEP in the past two years is presented in [3]. An account of the earlier activities has been documented in [4].

The fact that the ministry of human resources development (MHRD) has created a Joint Secretary level position and appointed an outstanding administrator Mr. N. K. Sinha to this post indicates that the Government is seized of the potential offered by distance education. To improve the levels of education, MHRD has also launched the National Mission on Education through ICT [5], with Mr. Sinha as its mission director. The funding available through this mission is about USD 1 billion for the current plan period, that ends in 2012. The national knowledge network (NKN) [6] also is working in sync to provide high bandwidth connectivity to a large number of institutions.

This article is arranged as follows. We first explain the transmission and supporting technologies. The effort to make distance education socially acceptable to a large number of faculty members and students of IIT Bombay is explained next. The live distance education is contrasted with studio recorded courses of NPTEL. We conclude this paper with a discussion of difficulties we experienced and possible future work.

2   Transmission technologies

Distance education at IIT Bombay started with satellite transmission. Until December 2007, bandwidth was purchased for this purpose [3].

In January 2008, we switched our transmission over to EDUSAT [7], operated by the Indian space research organisation (ISRO). ISRO posed the following conditions for providing free bandwidth: (1) the courses should be freely transmitted and (2) there would be no encryption. IIT Bombay agreed to these under the condition there could be charges in case anyone wanted additional recognition, such as, certification, although the basic transmission would be free. Although we were worried about the misuse of transmission by unscrupulous operators, we went ahead with this plan as possible misuse by a few should not deprive other institutions.

When we switched over to EDUSAT, there were about 40 remote centres that could receive our transmission - all of them had been given the equipment free of cost by ISRO. Now, including those in the pipeline, there are about 90 remote centres. All the new remote centres have paid a one time charge of about Rs. 450,000 to establish this infrastructure. The new remote centres have shown a lot more interest in participating in our programmes. The growing numbers also show that our EDUSAT programme is popular.

The main reason for going with the satellite based transmission in the early years was that it was much more reliable than the internet. In addition to the reliability, the guaranteed bandwidth of 1 Mbps from our side and 0.5 Mbps from each of the RCs for asking questions, both absolutely free of cost, makes transmission through EDUSAT an extremely popular option even today.

When IIT Bombay signed up with ISRO, the national dailies covered the event well, for example, front page stories in Times of India, etc. [8]. This increased the visibility of our satellite transmission many fold. Students from around the India, hungry for good education, wrote mails wondering when a remote centre would be established in their town. Given that India has of the order of more than 5,000 towns, these demands cannot be fulfilled by satellite transmission alone. Moreover, ISRO has given us only one channel on EDUSAT and we have been using it fully: we have been transmitting courses from 8:30am to 8:00pm, five days a week, during every one of the past three semesters, since we inked the agreement with ISRO.

In January 2008, we explored the possibility of delivering courses through live webcast by running a pilot with five courses. Most Indian students did not have access to high bandwidth. To cater to them, we used a compression format that enabled us to transmit at 100 Kbps. We strongly believe that if we had required a larger bandwidth, we would have catered to only western and affluent audience. This requirement of high compression resulted in some changes in teaching methodology, as explained below.

Webcast involves one way transmission only. We have found the learning management system Moodle [9] to be a good medium for two way interaction. We are now exploring the possibility of using Amrita's A-VIEW for low cost two way interactivity, through internet [10]. Any student who has access to about 150 Kbps of bandwidth has the potential to join us with two way, audio-video interaction, using this technology. Students who do not even have this bandwidth could, instead, go for two way audio and chat based interactions.
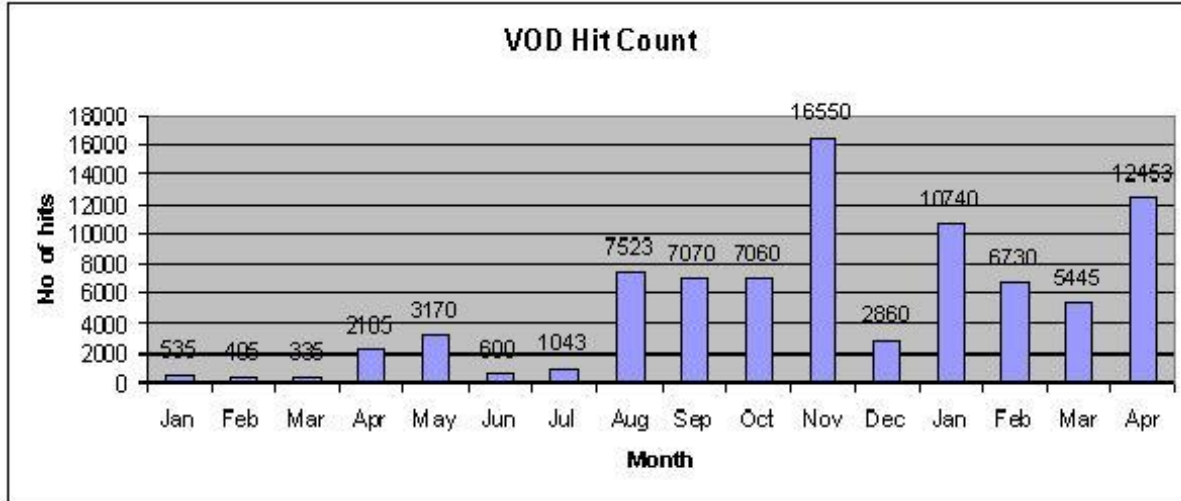
Figure 1: Number of monthly hits for video on demand service at IIT Bombay intranet during Jan. 2008 - April 2009. There were 35 courses in autumn 2008 and 27 courses in spring 2009. Exams are conducted in November and April.

3   Supporting technologies

To project a friendly face to the IIT students, we edited the live lectures and released them on an intranet server within about 24 hours of delivery. The local participants benefit immensely by this VOD service: (1) Those who miss a class can go through the recorded lecture (2) Weak students can go through the lectures more than once at their leisure (3) It is useful to all students to go through difficult topics more than once (4) It is useful for teaching assistants to conduct tutorial sessions (5) It is useful during exams. This also promotes group study, as the students listen to the lecture through a speaker in the privacy of their rooms.

Our VOD service is extremely popular amongst IIT Bombay students, as can be seen from Fig. 1. Assuming an average strength of 50 students per class, the number of hits per student in the exam months of November 2008 (for 35 courses) and April 2009 (for 27 courses) is about 9. We are trying to extend the VOD service for also students outside the IIT system.

One of the problems with the video recording is that it takes real time to understand what the instructor says. That is, a student requires one hour to understand one hour of lecture. To overcome this difficulty, we supplemented the video lectures with slides. Many instructors used power point or LaTeX slides. We uploaded them on Moodle. The students could go through the slides and decide on what slides they needed help. They could then listen to only that part of the lecture. For a more detailed discussion on how we use Moodle, the reader is referred to [4].

How did we handle the lectures that did not use computer slides? What about those who were accustomed to writing on the blackboard? We ran into problems while transmitting blackboard instruction through webcast. As mentioned earlier, we were forced to use a low bandwidth for transmission, to cater to our students in remote areas. Unfortunately, what is written on the blackboard does not come out clearly. In view of this, we explored the alternatives and found the document projection camera to be a good alternative. This solution involves writing on a paper with a bright pen and projecting it on the screen through an LCD projector.

We preferred the document projection camera over other technologies for the following reasons: (1) Document projection camera requires that one needs to write with a normal pen, *i.e.*, it involves no high-tech, which makes it easy to switch from blackboard, which is also a low-tech writing method (2) As we captured the faculty member as well, we needed to use good lighting - electronic boards reflected the light (3) There were alignment related difficulties while going back to electronically stored data.

We found several benefits in using the document projection camera, as opposed to a blackboard. The foremost of them is that the former allows the instructor to face the students while writing. This allows them to get an immediate feedback on whatever they write. While writing on a blackboard, however,

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the instructor does not face the students. Blackboard writing results in the back of the instructor getting captured in the video camera, while a frontal view is possible if a document projection camera is used.

Some of the other benefits of a document projection camera are now listed: (1) Pre-written material can be accommodated in the flow (2) It is seamless to switch between the slides and writing (3) It is easy to recall previously covered topics - locate the previous sheet and place it on the screen (4) It is possible to scan the sheets into a .pdf file and put it on moodle, thereby making the lecture notes available to students (5) At the end of the semester, the instructor will have a complete set of notes (6) These notes will also be in a form, suitable for conversion to ppt, etc. - one sheet's content can go into one slide. A secretary can convert them into power point. In other words, the difficult task of deciding how much to write in one slide is taken care of automatically. (7) Finally, the quality of video recording of this approach will come out to be a lot better than writing on the board.

A bottleneck in releasing the courses within one day of delivery is editing, further explained in Sec. 6. To tackle this problem, we explored the possibility of doing away with the tapes. We transmitted the .avi files from classrooms to a central storage server. The plan was that the lectures would be beamed from the server to editing stations. The .avi files were of the order of about 15 Gb and an attempt to upload from five classrooms that hosted thirty five courses, choked up the fibre backbone at IIT Bombay. After some failed experiments, we reconciled to work with compressed files. We transferred from five classrooms lectures, compressed in Mpeg2 format. These files were transmitted from the hard disk of the computer systems in the classrooms. We found that the lectures did not get stored properly in the hard disk, resulting in problems, such as, frame dropping. There were problems in transmitting the Mpeg2 files also to the central server - these files were also very large. At present we record the courses on removable hard disks, physically take them to the editing room and download the files into editing stations through an intranet. We also go back to the tapes whenever there are problems. Unfortunately, however, the proposed efficiencies were compromised by this requirement to use the tapes.

4   Promotion of distance education within IIT Bombay

Promotion of live transmission within the campus involved quite a bit of work, targeted at the students, instructors and administrators. For example, IIT's faculty members are busy with research. How to make them contribute in the area of education? If the courses are not delivered properly, the students could dissent them and demand that they go back to conventional classrooms with neither recording nor transmission. They could argue that only they are eligible to receive the IIT courses by virtue of having cleared the joint entrance exam conducted by all IITs together for admitting students.

From the beginning of distance education activity that started about a decade ago, IIT Bombay went for transmitting live courses as they were delivered in a classroom. This only requires the faculty member to make his instruction also to the outside world. We believe that this is the only scalable way to make available our courses to the outside world.

The next question is what extra effort is required on the part of the faculty member. We request the instructors to give a schedule of what they will teach for the entire semester. This requires some planning. Since it is transmitted live and also recorded, instructors come better prepared. Both of these help improve the quality of courses. Good teachers normally attend to these requirements anyway. Transmission through CDEEP only formalises this activity. As a result, the extra effort required is minimal.

In order that the faculty members come forward on their own, technology has to be made transparent. Changes required should be minimal and also *appear* to be minimal. Support staff, trained to be competent and also friendly, is one of the most important requirements.

In order that it is useful and also catches attention, it is important to transmit a number of related courses. Until autumn 2006, five to seven courses were transmitted live every semester. A conscious effort was made to increase the number of courses. Fig. 2 shows the number of courses transmitted semester-wise. Technology, combined with marketing helped achieve this, as explained below.

To make the delivery of courses through CDEEP attractive to students, we came up with several initiatives. We implemented the delivery of lectures on VOD within 24 hours of the actual lecture. We also made available the lecture slides on Moodle. As mentioned earlier, the students equally appreciated these two resources. We also created active Moodle support and organised tutorial sessions on the use of Moodle for instructors, teaching assistants and students. We organised competitions for student feedback
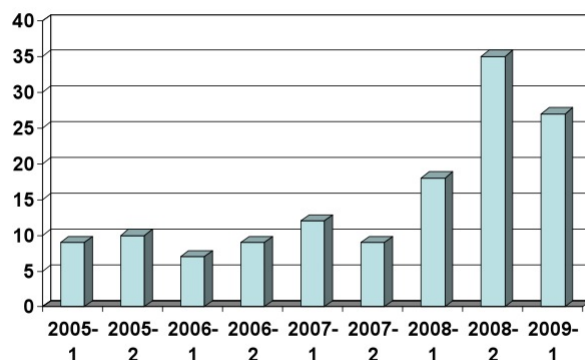
No. of courses transmitted

Figure 2: Course transmission statistics, semester-wise, during the period Jan. 2005 to Apr. 2009

on our courses and gave away prizes. Finally, as mentioned earlier, the courses delivered through IIT are well planned and delivered better.

We possibly overdid the promotional effort. In autumn 2008, fifty faculty members came forward to teach the courses through CDEEP with simultaneous live transmission. From Fig. 2, we see that this is a big jump. The studio environment and the support structure that we provide makes it a comfortable place for course delivery. Another important reason is that the students started requesting the instructors to deliver their courses through CDEEP. Just as in any good academic institution, student inputs are extremely valued at IIT Bombay as well. The instructors obliged the students.

The support services provided by CDEEP is appreciated by the faculty members as well. By word of mouth, the faculty members came to know about our services. The effect of this is that 35 of the 50 instructors who offered to deliver their courses in CDEEP in autumn 2008 were first timers.

If we do not nurture the new instructors, the quality of instruction, recording and transmission could falter, resulting in discontent. We came up with detailed set of guidelines for the instructors to follow. Unfortunately, very few read the long set of instructions. To help overcome this, we came up with a honorarium formula that listed all the activities with associated rewards. Separate honoraria were given to the following different activities: basic course delivery, slide preparation, quality verification and correction, creating additional instructional material and using open source software.

This honorarium formula has resulted in good response. We believe that this response is not entirely due to the financial incentives, although, they are important. While the faculty members did not necessarily read the brochures, bulleted points and associating them with honoraria made them aware what steps were important in the course creation. As most instructors consider us as their friends, they also wanted to help us by addressing these points.

5   Quality of education

An important byproduct of transmitting courses live is recording and distribution of the lectures. An immediate question comes to one's mind: Are these inferior to studio recorded courses, such as, NPTEL? The answer is that these can be as good as any other course, if properly created.

Interaction with students helps arrive at a suitable delivery of course material. The difficulty faced by the students helps the instructor arrive at better instructional techniques, examples, extra lectures, etc. In other words, the feedback from the students could actually help improve the quality of the live lectures enormously.

College of engineering, Pune (COEP), has been an important partner of IIT Bombay in distance education. COEP is one of the best engineering colleges in India. The administrators of COEP wanted to get live courses of IIT, in preference to recorded courses. They attributed this preference to the desire to get IIT *experience*. What is this experience?

(1) When an IIT instructor makes a mistake, the students at COEP should see it and understand that it is acceptable to make mistakes (2) When the IIT instructor cracks a joke, COEP students should see it and realise that it is not required to be serious all the time (3) The students should also see that all lectures are delivered and also on time - COEP students could demand a similar service from their faculty. (4) COEP faculty could demand from the students to work as seriously as the IIT students. In other words, through live transmission, we also impart education *methodologies*.

A related question is whether the quality of the lectures can go down for IIT Bombay students because of the participation of the students at remote locations. The answer once again is that it can actually go up if properly done, as explained next.

We require a detailed schedule of lectures for every course. Ideally, what topic will be covered on a given day. To make it acceptable to the faculty members, we relax it: they can give lecture-wise schedule (no dates) or weekly breakup. Naturally, these schedules are not hard and fast. Depending on the difficulty level experienced by the students, there could be some changes to the schedule. The benefit of this exercise is that it forces the instructor to decide how much importance they should give for each topic. This planning helps improve the courses for the local participants. It also helps the distant learners to decide whether they should attend the lecture on a given day.

The instructors come better prepared for the lectures, as they do not want to get their mistakes transmitted and recorded. They also realise that the effort involved in correcting a mistake in the recorded media is much more than the extra work required to prepare the course material.

It is natural that mainly good instructors and those who are aspiring to become better teachers come forward to share their lectures with the outside world. As a result, the recording mechanism has a natural tendency to select better courses. Our process serves another important contribution to the society: it archives the courses of good faculty members before they retire.

The incentive scheme for participation in the live transmission, outlined in Sec. 4 is expected to make this scheme popular with more faculty members. It also sends a clear message that teaching *also* is important. It is fair to say that the distance education methodology, as implemented at IIT Bombay, has a good potential to greatly improve our own education.

The role of technology is substantial in live transmission and in web based support services. For example, the compression technologies that we developed for transmission to the outside world is useful for enabling the video on demand (VOD) service to the IIT students, as explained in Sec. 3. The offline answering system of Moodle that we use for interaction with the outside world helps improve interaction with our own students. Technologies that are required for handling large numbers of students have the potential to help manage our own growing numbers better.

6 Effort in studio vs. live recorded courses

The work required for live courses is more than that required for studio recorded courses in some sense and less in another sense. Because of simultaneous live transmission, all equipment should be in working condition. As all classes have to take place as per strict schedule, there is not much time in between lectures to correct mistakes, if any occur. Any disruption could drive away both instructors and students. Finally, the studio should be large enough to accommodate all students.

Scheduling of live courses require a lot less work as compared to studio recorded courses. The live courses should be scheduled only once, at the beginning of the semester. One can be rest assured that all the lectures will happen at the appointed time, without any additional work. Every studio lecture, however, has to be scheduled individually, with possible last minute cancellations.

In live classes, one can optimise the use of studio time. It is possible to pack classes one after another, without any gap. The studio recorded courses do not have this benefit. Accommodating instructor's other commitments and last minute cancellations could result in studio idling for a reasonable amount of time. Live classes begin on the first day of classes and end on the last day. Studio recorded offline courses, on the other hand, may extend for more than one semester. Moreover, except on special occasions, there is no need to schedule the live lectures on weekends and holidays.

In summary, live recording is associated with concentrated, high pressure work. The work done per course, however, is less than that for studio recorded offline courses.

It is pertinent to point out the effort involved in ramping up our operations, as mentioned earlier. Fifty faculty members came forward to offer their courses for live transmission in autumn 2008. Fifty

courses correspond to 150 hours of instruction every week. This translates to 30 lectures every day. The average time it takes to edit a one hour lecture is two to three hours, include the time it takes to capture a tape on the hard disk. Thus, we required a minimum of 60 hours of editing every day. We organised a team of about ten people for full time editing, becoming a production house!

7   Difficulties

Some of the difficulties in carrying out distance education from IIT Bombay have already been explained. We point out some more issues that we need to address.

The first and foremost difficulty is in improving the interaction with students. With large class sizes, this is becoming a problem for our own education. The problems can get compounded with additional distance participants. We are exploring the possibilities of using Moodle and clickers to overcome some of the difficulties.

Copyright is a serious difficulty that we face in distance education. In Sec. 4, we referred to fifty courses, but Fig. 2 shows only 35 courses being actually delivered. This is precisely because of copyright issues. What is considered a fair use within four walls of a conventional classroom may not be fair use under distance education, even if it is offered free of cost. Most people confuse acknowledging the source with getting explicit permission for a work. The instructors also worry whether the problems in the textbook in use carry copyright and whether they can state these problems verbatim or solve them in the class or both. We need to do a lot more work in this area: creating an awareness, establishing a copyright clearance office, etc.

Bandwidth remains a concern. Because of the non-availability of it at reasonable prices, many services, such as, transmission through a video conferencing facility or video on demand for remote participants, are not possible. This is expected to ease substantially when the 1 GBPS connectivity is established for all 20,000 colleges, university departments and research centres, as proposed in [5, 6].

We have a reasonably complicated transmission configuration in our studios. For example, from one of our studios, we transmit courses through three channels: EDUSAT, webcast and video conferencing. It is difficult to come up with a configuration that is acceptable to the live students, while simultaneously being optimal to all remote students. It takes a long time to tune and to debug and correct, in case of problems.

Getting a feedback on our performance remains as another difficult problem. Most donors want to know the efficacy of our programmes. They would at the least want user feedback. We have been successful in getting feedback from the students of IIT Bombay. Unfortunately, it is a lot more difficult to get the feedback from remote participants. Initially, we gave the links for the webcast facility without any strings, without even registration. We explored the possibility of requiring registrations, but abandoned it in autumn 2008, for the fear of losing the audience. As a result, we do not have a clear idea of the people who watched our webcast. Once we became aware of the importance of these details, we made registrations and logins, available free of cost, mandatory, after one month of free access. Our reasoning is that if a student finds it useful, she will register and continue to listen to the courses.

Registration is the first step in getting the feedback from remote participants. In general they are reluctant to give adverse comments, possibly because they feel guilty as they get the courses for free. The other reason is that we have been slow in attending to the user complaints, because of the complex nature of the problem. The fact that we did not have funding for a long time has compounded the problems. Now that we have received a grant from [5], we hope to be in a better position to address at least some of the problems.

8   Future work

In this section, we give a brief summary of the work that CDEEP has proposed to the national mission on education through ICT.

At present the video course on demand facility is available only to the students who stay within the IIT campus. Such a facility to the outside participants is indispensable, if a college wants to use a live course of ours as a substitute for theirs. This VOD facility, however, can be made available only after

we create adequate bandwidth and establish streaming services. We plan to use the bandwidth offered by NKN [6] and establish this facility soon.

Providing the capability of asking questions to the remote students may be considered as the ultimate frontier of sharing live courses. While this facility can make the students at remote locations feel empowered, it is not without its own problems. The major difficulty is that this is not scalable. For example, if there are too many questions, it could interrupt the course delivery. It is proposed to create online chat facility to the remote students for asking questions. The questions that come through the chat can be monitored by a teaching assistant and good questions can be brought to the notice of the instructor.

In popular courses, the method proposed above also could get out of hand - the teaching assistant may be swamped with too many questions. It is proposed that the questions from *good* students of remote locations be preferentially answered to overcome this problem. How does one become a good student? It is proposed that the calibre of students be determined by the kind of *offline* posts that they make on Moodle. In other words, students who actively participate in offline discussions in an intelligent manner be empowered to also ask questions during live sessions. This should become the incentive for more students to participate in the course discussions on Moodle.

The objective of this exercise is to create instructional material that accompany the excellent quality video courses mentioned above. We should have a mechanism to retain the original high quality of the courses and also to add explanatory parts that make the difficult parts easily understandable. We should have a mechanism for collaborative participation. Given that in a particular area we may have excellent breadth and depth of teaching material, we should be able to extract suitable portions and thus help create textbooks for different needs. Finally, we should have the means to let people create short clips of instructional material with audio support in different languages.

It is possible to tie up the different types of educational material for a course through a wiki. The different types of educational material are, Video course, slides or A4 size sheets used while presenting the course, spoken tutorials in English and possibly other Indian languages[11]. Links to web resources and a wiki can tie up all of these and also grow through collaboration.

The course instructor will create a skeleton wiki or the scaffolding around which the instructional material will grow. The base version will have things, such as, slides or handwritten notes and links to appropriate locations in the video lecture. There will be a wiki moderator, who may also be the video course instructor, who will help the wiki grow. They could also be industry experts or faculty members from colleges and universities. They will supervise the creation and growth of the wiki and help identify links on the web, such as, digital libraries, virtual labs, simulations and animations. They will review the postings to the wiki and decide whether to accept them.

It is proposed to create a facility to compile the writeup on select topics, so as to create an e-book. Thus, it is possible for a college teacher to create a textbook, suitable for the syllabus of their university. As mentioned earlier, deployment and use of phrases, such as, *index terms*, *prerequisites* and *difficulty level* will help in this regard. Usage of these terms may be extended to all types of content: write up, video lectures, spoken tutorials, examples, assignments, quizzes and question banks. It is proposed to create a facility to include the syllabi of different universities as well. Fig. 3 illustrates these activities.

Last, but not the least, is the transformation of CDEEP from a service centre to an academic unit. CDEEP has the potential to deliver academic programmes in the areas of pedagogy and technologies for distance education.

9 Conclusion

IIT Bombay has pioneered synchronous distance education. Although there were a lot of hurdles, we have been able to clear many of them successfully. We have also made reasonable progress in offering technology based solutions for distance education. In this process, we have also created more than one hundred full courses, each lasting about forty hours of instruction. Now that we have received funding from the national mission on education through ICT to release these courses to the public for free access, we expect to do a lot more.

The strength of the distance education programme at IIT Bombay comes from the all around support for it from the faculty, students and administration.
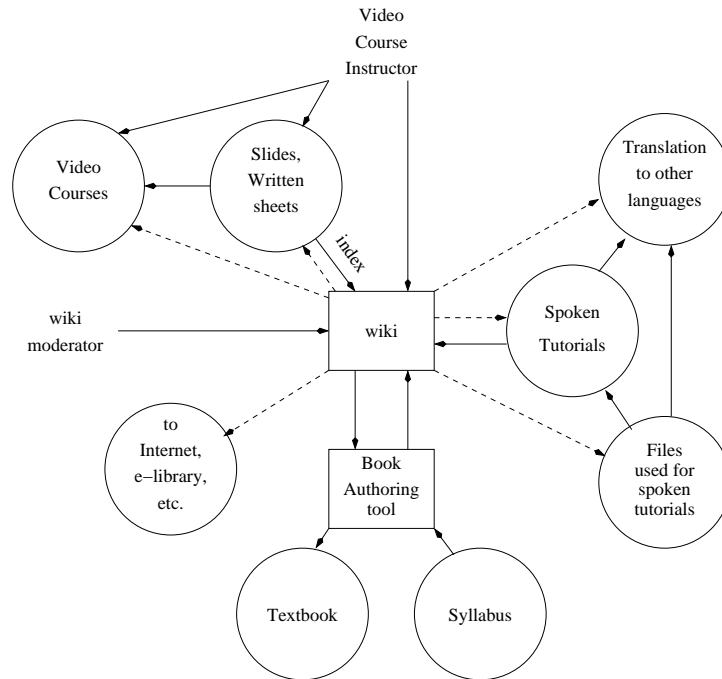
Figure 3: Wiki, leading to book writing

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