A Case Study of a First-of-Its-Kind Remote Course among Premier Institutions in India

Smruti R. Sarangi
Computer Science and Engineering
Indian Institute of Technology
New Delhi, India 110016
Email: srsarangi@cse.iitd.ac.in

***Abstract*—This paper describes one of the first experiences of an e-learning based remote course taught between two premier institutes in India namely IIT Delhi and IIT Ropar. By using state of the art infrastructure, and by adopting an approach that advocates continuous monitoring of the quality of the learning experience, it was possible for the instructor to seamlessly conduct remote courses over a span of two years. The performance of students in the remote course was similar to that of students who had a conventional education. Lastly, this paper reports subjective feedback of students that indicate that the degree of learning is very heavily influenced by the nature of the network, jitter in the audio-video streams, and the timely availability of study material.**

I. Introduction

This paper describes the results of one of the earliest experiments in distance education using novel e-technologies in India. Efforts such as NPTEL [6], and the PGDIIT [3] programme mostly focused on disseminating videos of lectures, and using local facilitators for clearing doubts. In comparison, this paper describes the experience of teaching a full second year undergraduate course in computer architecture across two different institutions (IIT Delhi and IIT Ropar) for a period of two years. To the best of our knowledge this is the first effort to document a successful e-learning based course across two prestigious tier-I institutions in India.

Let us give a brief background. IITs (Indian Institute of Technology) are premier technological universities in India. They run both undergraduate and postgraduate programs that are highly selective. Originally, there were five IITs in five different Indian cities – Kharagpur, Madras, Bombay, Kanpur, and Delhi. Note that each IIT is academically and administratively independent of other IITs. However, they have a common exam to select students. This is known as the Joint Entrance Examination (JEE). In 2005, the government decided to increase the number of IITs to 15, and by an act of parliament, the new IITs were allowed to confer degrees in 2011. One such IIT was IIT Ropar (Rupnagar) in the northern Indian state of Punjab. It was set up in 2008, and the first batch of undergraduate students passed out in 2012.

To bootstrap these new institutions, existing IITs were assigned the role of mentoring the new IITs. In specific, IIT Delhi was assigned the role of mentoring IIT Ropar. These new institutes gradually started hiring world class faculty, and as of 2013 have mostly become fully functioning institutions. Nevertheless, there was a paucity of faculty in the early years, and some faculty from existing IITs volunteered to teach in these new universities.

Initially, the teaching was regular contact-based teaching that entailed an instructor to physically travel from Delhi to Ropar. The distance from Delhi to Ropar is 287 kms by road, and it takes more than 5 hours to reach there by car. Hence, most of the time instructors preferred to go to the nearest city, Chandigarh, from which Ropar is a one and half hour drive. The classes were held mostly on weekends. As a part of a novel experiment, the authorities of both the institutes decided to have remote classes that were primarily taught through a high speed video link. Students could interact with the teacher over video, and both the sides had high fidelity audio-visual equipment. The instructor on his side used a tablet PC to teach. One of the earliest courses to be taught in this mode was the undergraduate computer architecture course, CSL211. It was taught across both the institutions, and the course content, and the exams were similar in nature. The performance of students across both the institutions was found to be roughly similar, and we can thus arrive at a preliminary conclusion that students who are taught remotely using novel technologies, are not particularly disadvantaged.

Note that culturally, classes in premier institutions in India have never been taught remotely. Remote teaching was mainly used for extension and outreach programs of premier universities, or was used for very small modules. To the best of our knowledge, this paper is the first to chronicle such an effort. We believe that the methodology, and conclusions drawn from this paper, are relevant to other developing countries also. In specific, a lot of universities that want to setup a remote course might find some of the methods described in this paper very useful. Secondly, we also would like to emphasize that e-learning has its share of pros and cons. It can prove to be extremely effective as we have learnt from our experience; however, if not managed properly it can fail to provide effective results. Hence, it is necessary to design a distance education program very carefully, and continuously monitor it, and change its direction if necessary.

II. Distance Education in India

Let us quickly provide an overview the state of higher education in India. India has 20 central universities, and 217 provincial universities other than the premier institutes, which mainly comprise of 15 IITs, and 30 NITs (National

Institutes of Technology). As of 2013, India produces around 1.5 million engineers, of which around 10,000 engineers graduate from premier institutions, or in Indian terminology – institutes of national importance. We can clearly see that there is a vast disparity between the number of institutes that can attract world class faculty, and are thus termed premier institutes, and the number of institutes in the rest of the country. Hence, there is an ample demand for remote education and e-learning especially for highly specialized post graduate courses.

Since the sixties, correspondence courses have been very popular in India. It was common to pursue a Master's degree with a university that is geographically far off. In this mode of education, students used to get study materials by post, and they used to mail their assignments, and even ask queries by post. This method of education still exists. However, it is quickly being phased out by e-learning based remote education. Some of the important initiatives that have been taken in this regard are the NIIT Netvarsity (established 1996), and Indira Gandhi National Open University Virtual Campus Initiative (established 1999). These universities offer remote classes based on recorded lectures, and online course materials.

In the late nineties, faculty from the IITs also joined this initiative and started to release videos of their lectures. One of the most successful programs is the NPTEL [6] program that has 1260 courses (Phase I and II), and all of these courses are available free of cost. Most of these courses are also available on youtube. This started the era of diversifying Indian education, and it became suddenly possible for students in remote areas to access courses taught by outstanding faculty in IITs. It is noteworthy, that MIT Open courseware [1] was never very popular in India. This primarily stems from cultural differences. There is a difference between the pedagogic style of American and Indian instructors. Secondly, students find it difficult to understand American accents. However, students did not have these difficulties with NPTEL lectures.

The role of NPTEL and similar programs such as the PGDIIT [3] program run by IIT Kharagpur, or ELNET [3] have been praised in prior literature [12], [13], [8], [10]. All the authors have rightly observed that remote education increases the span and outreach of quality education. In a developing country such as India with limitations in terms of physical access to quality education, e-learning is a potent tool [9], [4], [5].

There are two points to be noted about the Indian experiment with distance education. The first is that it is limited to premier institutes offering courses to other institutes. However, there are no documented cases, of premier institutes being recipients of remote courses. Secondly, most of these courses, were not of an interactive nature. They were limited to distributing online videos of lectures. There was minimal participation with the instructor. India's e-learning efforts are much smaller in scale than those of other developing countries, notably, China. Long and Haklev [7] describe China's ambitious nation wide course plan that includes 12,000 courses from 700 universities.

Our study is unique because IIT Ropar uses the same student pool as IIT Delhi. Both the institutes have a common admission test known as IIT-JEE. The computer science department of IIT Delhi gets students with higher ranks, typically in the range of 1-300. In comparison, the students in IIT Ropar, typically have ranks between 1500-2500 in computer science, and the students in electrical engineering have ranks between 2900-3700. Given the fact that roughly 500,000 students take the JEE exam, and most of the students are very bright and well prepared, we believe that both the institutions have students with roughly similar intellectual abilities. Since there are no references that objectively quantify the aptitude of students vis-a-vis their JEE rank, we rely on subjective experience of instructors, and disregard any biases towards the quality of students in both the institutions.

The main challenge for the instructors in remote courses across IIT Delhi and IIT Ropar was to ensure that there is a consistent quality of lecture delivery at both the locations, and students do not perceive an adverse experience. Let us review some general observations with regards to e-learning in literature.

III. General Tenets of E-Learning based Distance Education

Romiszowski [11] summarizes the main reasons for the failure of e-learning based projects. The most important aspect is the technical proficiency of the adopters of e-learning. This includes the students, the instructor, and the facility managers. It is possible to have a very adverse experience if there are problems with the video links, or internet connectivity. Even small disruptions in the video quality tend to have a big effect on the learning experience, and can distract students. Once students lose their concentration in a remote class, it becomes hard for them to regain it back.

The second important factor is getting appropriate bureaucratic approval and support from the university administration. We need to note that novel teaching methods using e-learning are still not very popular, and it is often difficult to convince administrators about the need and efficacy of such mechanisms.

As Romiszowski notes, there is typically an inevitable rise and fall of e-learning based schemes (e.g., ETV based scheme in Latin America). After an initial gust of enthusiasm, there is a marked decrease in the efforts spent on keeping the e-learning mechanism running. This is because it takes a sizeable amount of effort on the part of the university administration, especially in developing countries, to keep the infrastructure up and running. In comparison, all that is required for running a regular class is a marker and a whiteboard. Infrastructural challenges are probably the biggest limiter to e-learning in developing countries as we have gathered from personal conversations with many instructors in different colleges in India.

Nonetheless, once a country such as India or China wake up to the prospects of e-learning, the momentum typically continues. Currently, in both India and China [7], efforts are underway to create a national web that integrates all forms of non-conventional modes of education. This includes video courses, online courses, interactive sessions, and

instructional videos. China has already integrated thousands of courses into their national knowledge network. Indian has also created its national knowledge network (NKN) that connects many universities together. We are thus seeing an agglomeration of different e-learning based systems in developing countries. A similar effort is also underway in Brazil as pointed out by Belderrain [2].

However, in almost all the countries for which literature is available, e-learning is mostly a one-way process, where the recipients have been in one of these categories:

1) General Public: This category consists of people who want to get a knowledge about the subject without registering in a formal school.
2) Students in less privileged institutions: There is typically a wide disparity in the quality of education provided across different institutions in a developing country. Hence, students in institutions where the quality of education is not up to the mark, prefer to take courses by accomplished professors online.
3) Extension/outreach activity: Sometimes major universities or even major corporations perform social outreach activities as a part of their overall social agenda. This includes e-learning.

The scenario described in this book does not quite fall in any of these categories. This is because IIT Ropar is a very well reputed institute albeit being new, and secondly the students in that university have superlative academic abilities. At the time of teaching the course, the faculty in IIT Ropar were competent enough to teach the course, and were excelling in other areas of teaching and research. Note that the main need for the remote course was that the number of faculty members in IIT Ropar was small, and thus they found it difficult to create the bandwidth to teach an additional course. The bureaucratic and administrative challenges mentioned by Romiszowski were also not present in this effort, because the administration in both the universities (IIT Delhi and Ropar) was extremely supportive of the effort. The main challenge was to develop a paradigm of education that ensures that the performance of the students in IIT Ropar is comparable to that of IIT Delhi.

IV. Nature of the Classes

A. Class Structure

We describe the experience of teaching the basic undergraduate computer architecture course (CSL 211) in two subsequent years (Fall of 2011, and 2012). The number of participants in both IIT Delhi and Ropar are given in Table I.

Term	IIT Delhi	IIT Ropar
Fall 2011	118	63
Fall 2012	123	60

TABLE I: Number of students in the computer architecture class

There were two one hour 15 minute lectures in a week, and the duration of the course was 14 weeks. Note that IIT Delhi and Ropar were taught separately. The classes for IIT Delhi were taught in a regular classroom setting with all the students seated in the same room. However, the classes for IIT Ropar were taught remotely, with the instructor using a tablet to write notes. The students were able to see the notes, or slides shown by the instructor, the video of the instructor explaining concepts, and get a direct audio feed in Ropar. The instructor used a dedicated AV conference room in IIT Delhi for teaching IIT Ropar.

The course contents were exactly the same, and there was no difference in any respect. However, the nature of evaluation was slightly different between the courses, primarily because both the universities follow a different pattern of evaluation. IIT Delhi has two minor exams, and one major exam, whereas IIT Ropar has one midterm and one endterm. The major exam of IIT Delhi and the endterm of IIT Ropar were the same. However, the mid semester exams were different. There was also a lab component in this course. Traditionally, the labs in the computer architecture course are converted to take home assignments. This is because, each assignment is fairly long and elaborate, and it is not possible to complete it in a limited amount of time, as demanded from a lab setting. There were 4 assignments in the course for the first year, and 3 assignments in the second year. The assignments were same across IIT Delhi and Ropar. The main change from 2011 to 2012 was the change in the weightage of the different components of the course. The weightage of the different exams and assignments in shown in Table II.

Component	Weightage(%)		Weightage(%)	
	Delhi		Ropar	
	2011	2012	2011	2012
Minor 1	15	20	-	-
Minor 2	15	20	-	-
Midterm	-	-	20	30
Major	20	30	30	40
Assignment 1	10	9	10	9
Assignment 2	10	9	10	9
Assignment 3	20	12	20	12
Assignment 4	10	-	10	-

TABLE II: Weightage of different components in the class

There was also a tutorial component in this course. The tutorial hours were 1 hour a week for both the classes. It was possible to conduct the tutorials in Delhi in contact mode. However, for conducting tutorials, it was necessary for a TA or the instructor to travel from Delhi to Ropar, and conduct the tutorials on weekends. The ratio of the number of TAs (teaching assistants) to the number of students was a constant for both the courses – 3:1. The TAs were either Master's students, or Ph.D students. They were well versed in computer architecture, and proved to extremely proficient during the course.

In the 14 week course, there were 12 tutorial weeks. The first week did not have any tutorials, and one week was full of exams. The instructor visited Ropar thrice to conduct

tutorials, and the rest of the 9 tutorials were handled by TAs. The structure of each tutorial was the same across both Delhi and Ropar. In each tutorial session, the instructor or the TA, handed out a tutorial sheet that contains 5-10 problems of varying degrees of complexity. The students attempt to solve them. If there is any difficulty, then they come and discuss with the instructor/TA. There was no attempt to conduct the tutorials in a remote mode, primarily because it was logistically possible to send a TA to Ropar every week. The TA could also assess the quality of the learning experience from Ropar, and comment on the audio-video facilities. A lot of this feedback was continuously incorporated to improve the course.

Assignment 1	Annotate an ARM assembly program
Assignment 2	Reduce the number of instructions in an assembly program/ Implement the Karatsuba multiplication algorithm in ARM assembly
Assignment 3	Write a processor simulator and model a 5 stage pipeline and the memory system
Assignment 4	Implement a processor pipeline in Logisim

TABLE III: Details of the assignments

Assignments 1 and 2 were evaluated automatically using a set of shell scripts. The details of all the assignments are shown in Table III. Assignment 4 in the first year was a Logisim based assignment to design the pipeline of a processor. This assignment included a demo and viva, and thus required a set of TAs to physically take demos. In the case of Ropar, the TA that visited Ropar that week conducted the vivas for the assignments. Assignment 3 involved designing a full scale architecture simulator with branch prediction. This also involved a demo and a viva. The instructor evaluated these assignments in Ropar.

V. Infrastructure

The most important factor in a distance education based setup is the network. We used a fast 1 Gbps connection between Delhi and Ropar that is part of the national knowledge network (NKN) (see www.nkn.in). It connects 1045 institutions using a fast 30 Gbps backbone. Each participating institution has a dedicated 1 Gbps connection. The NKN network is a highly reliable network that connects educational institutions in India, and is primarily meant for e-learning. We used the virtual classroom software to connect IIT Delhi to Ropar.

The instructor sat in a dedicated room with a Tandberg 1700 6000MXP machine with an associated HD camera as shown in Figure 2. The Tandberg machine was responsible for communicating with another Tandberg system with the same specifications in Ropar. It transferred data from the instructor's laptop to IIT Ropar, and orchestrated a 2-way video conferencing. The instructor primarily wrote notes using a HP Touchsmart TM2 tablet, and the notes were displayed on a large screen in Ropar. In Ropar, the Tandberg based gateway sent the video output of the instructors laptop to a projector (SHARP CXGC 455W) that projected the notes on a regular conference sized screen. There were two large 55 inch TVs on both sides of the screen that displayed the video of the instructor teaching as shown in Figure 1.

In a remote class, audio quality is an important issue. The students reported a very adverse quality of experience with even a slight amount of jitter in the audio stream. At Delhi we used the built in microphone and speakers of the Tandberg system. At Ropar, we had Bosch microphones hanging from the roof. Each microphone covered an area of 9 m^2. We used 6 high fidelity Ahuja speakers, with a VIAMP multichannel mixer at Ropar.

VI. Results

A. Student Scores

Figures 3 and 4 show the distribution of total marks for 2011. The average scores for Delhi and Ropar were 62.32 and 60.58 respectively, and the standard deviations were 14.77 and 16.31 respectively. These are roughly similar scores, and IIT Delhi students did slightly better.

Similarly, Figures 5 and 6 show the distribution of scores for 2012. In 2012, the average score in Delhi was 52.67, and in Ropar was 67.02. The standard deviations were 21.94 and 11.30 respectively. The discrepancy in the scores can be explained by the fact that there were many students in the course who were doing a minor in computer science. IIT Delhi offers a *minor* degree in an area of a student's choice. For example, it is possible that a student enrolled in the undergraduate program in mechanical engineering might decide to pursue a minor degree in computer science, in addition to his major program. He or she is required to complete a minimum number of credits to be considered for the minor degree. However, the issue that the instructor faced is that a lot of students who were in the minor program changed their mind midway in the course, and their commitment levels came down. These students either failed the course, or got a low grade. If we discard the students who lost interest in the computer science program midway, then the average shoots up to 59.32. Secondly, students at IIT Delhi were taking two more highly demanding courses at the same time. Thus, they did not have a lot of time to devote to the computer architecture course. Whereas, the semester for IIT Ropar was comparatively lightly loaded, and students were able to devote more time to the computer architecture course. Given these subjective observations, and the feedback from the TAs, the instructor concluded that for the year 2012 also, the performance across both the institutes was roughly similar, and it is not possible to conclusively say that one institute did significantly better than the other.

B. Student Feedback

Students in IIT Ropar were overall satisfied with the course. Only 1 class out of 46 had to be missed because of problems in the video connection. The students were asked to score the quality of the video, audio, and lecture. The

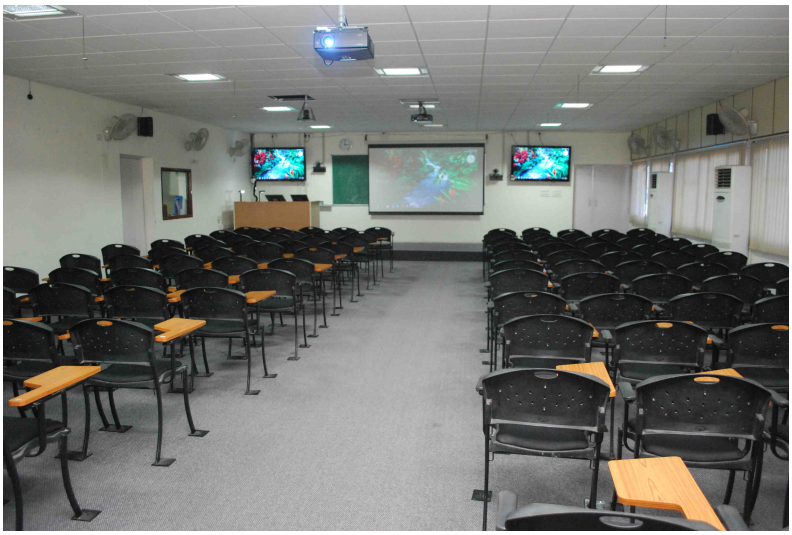

Fig. 1. Photograph of a classroom in Ropar

Fig. 2. Instructor's seating area in Delhi

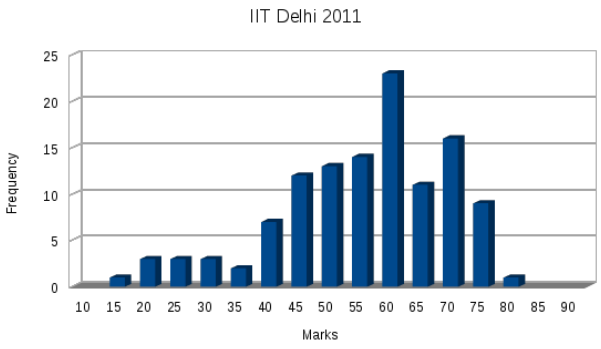

Fig. 3. IIT Delhi 2011 Scores

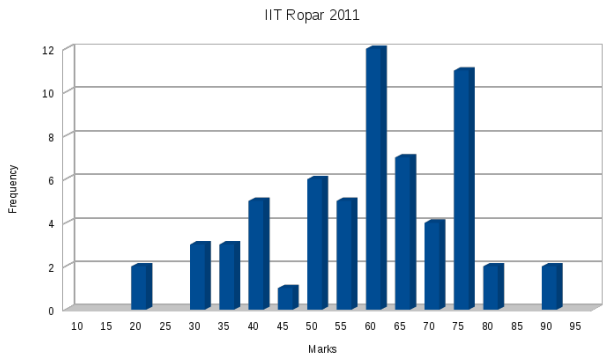

Fig. 4. IIT Ropar 2011 Scores

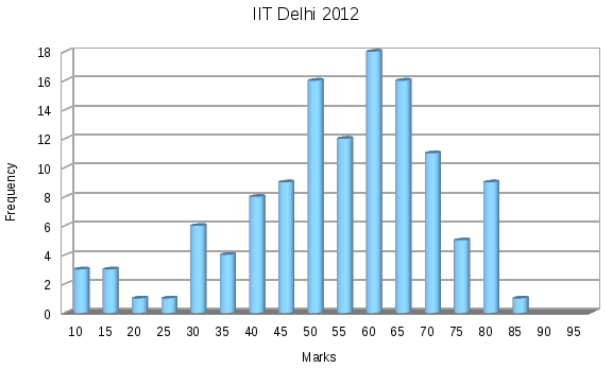

Fig. 5. IIT Delhi 2012 Scores

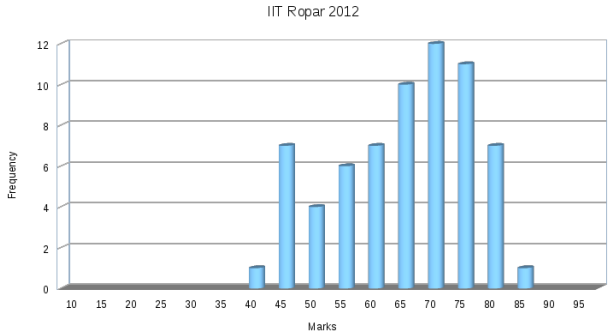

Fig. 6. IIT Ropar 2012 Scores

baseline for comparison was a conventional class where an instructor taught in the same room, and was clearly audible to the entire class. The students were asked to assign 100 points to this scenario.

The class representative collected opinions and gave 80 points each to the quality of video and audio. The students wanted a bigger display at their end, and a higher resolution. They also wanted the size of the screen that projected the instructor's writing to be larger, and complained about occasional jitter in the video stream. According to them occasional jitter events (as rare as 10 s in 15 mins) reduced the lecture quality by as much as 10%. Keeping these factors in mind, they assigned a subjective score of 88/100 to the lecture as a whole. The lecture as a whole got more points than the audio, and video quality metrics because the instructor took more care in ensuring that the class is able to follow the content by a combination of question-answer sessions, and repetition.

VII. Conclusions and Lessons Learned

1) In a remote course setting, especially with academically very bright students, it is necessary to use state of the art infrastructure to achieve a near perfect video transmission. Minor amounts of jitter and lag between the audio and video have a very adverse effect on the quality of the lecture. Students quickly get distracted, and lose track.
2) HD or preferably ultra-HD video is required to sustain an immersive e-learning experience. It is important to have the video as clear as possible. Secondly, there should be absolutely zero lag between the video and audio. Even a small amount of lag can distract the class.
3) The class does not want to see detailed views of the instructor teaching. They just want to see the face, and the expressions.
4) The class would rather look at a big screen that shows what the instructor is writing on his tablet, and the slides that he is showing. The class also suggested having two views. One view can show some amount of background, and the other can show the instructor's current workspace.
5) If the technological issues are properly addressed, along with a proper administrative framework that is co-operative, and responsive, then technology based remote education has the potential to deliver the same results as a conventional class room setting.
6) From the scores of the students, we can conclude that the performance of the conventional class and remote class were similar. The students studying remotely were not particularly disadvantaged. The success can be attributed to the extremely co-operative administration at both the institutes, the diligent staff, and the advanced technological infrastructure.

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