Teaching Experiences at IIT Bombay

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A typical faculty member has three primary responsibilities at IIT Bombay: teaching courses, conducting research (including guiding bachelors, masters and doctoral theses or supervising post-doctoral scholars) and administrative service to their home department and the institute. I have always viewed teaching as a highly enjoyable experience, and a form of learning as well. This article briefly describes some of my experiences while teaching at IIT Bombay, and some practices that I followed.

1. **The importance of rehearsals:** There exists a large gap between knowing a subject really well and presenting it lucidly to a large, potentially heterogeneous audience. Practicing a presentation or a lecture aloud a day before the actual lecture really, really helped me, especially during my initial years at IITB. This was literally like a dress rehearsal for a drama. It helped me unearth any potential gaps in communicating material from my side. It helped me figure out where I needed to cite that extra example or prepare that additional diagram, or where a particular bullet point required clearer explanation. This practice also helped me anticipate several questions that a reasonably attentive student would want to pose. Every subject has a set of topics that are considered difficult to learn and difficult to teach. These rehearsals were of great benefit especially for such topics. An example from my own field of image processing is Fourier transforms, which requires a diversity of teaching material: mathematical rigor and derivations, intuition, visual examples and animations, intricate algorithms and numerical examples.

2. **The importance of good lecture material:** We live in the world of information overdose on the internet and also the world of large language models (LLMs). There of course exist course textbooks, but I do not think that a large number of students really take efforts in reading any textbook. All these factors make it all the more important for teachers to prepare a comprehensive and detailed set of lecture slides, notes or videos. These serve both as an aid/guide to teaching, and as a useful resource for students to study. This material evolves over a period of time, and improves with each iteration of the course you teach. While a good set of lecture slides should be detailed and explain all aspects of a concept really well, I also feel that it should deliberately contain some brain teasers and leave a few things open as exercises or 'food for thought' for the students.

3. **Questions and more questions:** One of the best experiences while teaching at IIT Bombay is the kind of questions that students ask in literally every class. These questions are different from year to year (but they are exciting every year!), even for the same subject and the same topic or sub-topic. Students will ask you questions that you would have never thought of while preparing the course material. In fact, some of these questions will cover nuances that

are not sufficiently well explained in most textbooks or lecture notes. It is a real marvel that some of our students have this wonderful ability to ask such questions on the fly. I have two contrasting (and yet, similar!) experiences to share here: There have been times, I was able to give convincing and correct answers to such questions while thinking on the fly, and there have been times when I didn't know the answer or couldn't figure it out, and had to say 'I don't know'. The first one felt like a moment of epiphany, and the second moment was a gentle reminder that 'we are all students of the subject' and I have always felt motivated to think about or find out the answer and convey it to the class in the next lecture or over moodle. In both cases, my knowledge and understanding of the subject improved (The rehearsals in point #1 above have helped me a great deal, but of course, we can never anticipate each and every question!) and so did my rapport with the class. I am very happy to observe that the best questions come from not only the class toppers, but from even those who are not at the 'top of the class' in conventional terms. To give a taste, I will cite one example of a great question from an introductory image processing lecture where I was talking about methods to represent image pixel intensity. The question the student asked me in class was: "Is the intensity value stored at an image pixel always directly proportional to what the brain perceives it to be?" The answer is in general 'yes', but not *always* a 'yes'. The answer is closely related with color perception and color optical illusions – see `https://en.wikipedia.org/wiki/Checker_shadow_illusion` for example. The student's question inspired me to study something about color perception in the brain and the cause of some well known visual illusions. I am so happy that the student asked me such a question on the fly! Coming back to the main point, this spontaneity has been the most exciting part of my teaching experiences at IITB, and it is something that only a live lecture can provide! Furthermore, my attempts to answer some of these interesting questions posed by students have on some occasions led to the creation of new research problems. In this way, these experiences helped me realize that teaching is a huge inspiration for research.

4. **Class heterogeneity:** Heterogeneity is part and parcel of India. And it is part and parcel of IITB. This heterogeneity manifests itself in the following ways:

   (a) Linguistic: The level of comfort with the English language (it is useful to speak to some students one-on-one in Hindi or Marathi or any common language.)

   (b) Academic backgrounds: In elective courses, there is a wide variation in the backgrounds of students. It is a challenge to teach a topic XYZ to (say) group A of students who have no introduction to it, while holding the attention and interest of students in (say) group B who have seen most of the topic before. This is where visual aids, animation and intuition behind the math play a major role. Also in some of these topics, extra lectures or tutorials are useful (though they may not always have the same level of attendance and will invariably consume a bit of the instructor's time, they definitely help the students who really, really want to learn.)

   (c) Financial backgrounds: It was in courses like CS 101 (an introductory programming course for first year UGs, with an enrollment of nearly 750 students each semester), where I got to see this first hand. I had students who owned Macbooks and had already had the chance to study much of the course material even before joining IITB, and I had students who had never used email before and were struggling to lay their hands on even a second-hand laptop. Here's where I found out some softwares and applications that ran on a mobile phone, so that the students could get at least some practice if they

were motivated. Here's where we see how useful a 24 by 7 computer lab for the institute would be.

IMHO, it is the instructor's responsibility to cater to this diversity. It is challenging, but brings about a great deal of sensitivity to problems that students face. All efforts in these directions helps cultivate a better rapport between the teacher and the students, and it is very rewarding.

5. **Challenges posed by LLMs:** Homework assignments and projects are a great way for students to learn the material, in a manner that is not constrained by time-limits enforced during exams and quizzes. If these are to be done in a group, it also fosters collaborative spirit. However in the LLM world that we live in, it is becoming extremely challenging to design questions that LLMs will not be able to crack, without making the questions so challenging that they become burdensome and defeat the purpose. (As such, it is okay with me if students use LLMs as a tool for better understanding or for getting some hints. But there is a serious problem if they are off-loading the entirety of the assignment questions to the LLM.) In these situations, it is still important to foster collaborative spirit and give homeworks and take-home projects for credit, but it is equally important to put up an in-class quiz or a viva for every homework. These quizzes/vivas should contain questions that adequately or conclusively test whether each student really put in the required effort to crack those homeworks. The questions can in fact be centered around the difficulties/challenges a typical student will face while attempting those assignments.

6. **The importance of enthusiasm and approachability:** Ultimately, the most impactful lectures are those where the instructor is not just thoroughly prepared, but carries in him/her a certain form of excitement about the topic being taught. It catches student attention, encourages questions and makes it a very enjoyable experience for everyone. Equally important is the approachability of the instructor and receptiveness to questions of all shades and hues. A good instructor should be willing to sit down with a student or a group of students after class, and trace through a derivation or a program for a longish period at least once in a while. I have always enjoyed this, each time this has happened.

7. **Challenges faced while grading exam papers:** Exams involving subjective questions occasionally pose some sort of a challenge while grading. Students may interpret the question in a somewhat different (but nonetheless sensible and acceptable) manner than what the instructor had in mind while setting the question and preparing the answer key and grading rubrics. This may not be totally apparent while grading, but may show up during discussions in a regrading session (sometimes called a 'crib session' in IITB lingo). This may require significant amount of regrading if the instructor realizes that the student's interpretation was sensible after all! One tip to control this situation is for the instructor to put up detailed solutions and grading rubrics well in advance (even before the actual grading begins), and invite students to alert the instructor/TAs regarding alternative interpretations.

These are just some experiences I thought I'd share with everyone. There are likely a few other experiences that I am not immediately able to recall at this point. But I hope people will find some of these useful.
Best wishes and happy teaching to all!
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