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Biosciences & Bioengineering

When I started teaching at IIT Bombay, I had an existential crisis. I was teaching MSc students, and had no MSc degree myself! Because of this, I had to get back to basics: What do MSc students need that builds upon their undergraduate classes? Am I trying to impart more than factual knowledge? Should I include more activities to keep them engaged? Some of my teaching experiments in biology can be found on the IndiaBioscience website (1, 2). Here, I mention a few of the strategies that have worked well for a variety of UG and PG classes.

Clear learning objectives: Before starting a new course, it is helpful to state learning objectives. This may seem obvious to trained teachers, but it is not obvious to researchers like IIT Bombay faculty who are thrown into teaching. There are two benefits to this exercise. First, the objectives drive the course structure, lectures, assignments, and exams. For example, in my Molecular Biology course, my course objectives included “critical thinking”. Explicitly stating this objective ensured that some of the assignments included reading research papers, while the exams had minimal memorization and plenty of data analysis. The undergrads from engineering departments who took this class often remarked that they had begun to appreciate that biology is a science based on logical problem solving, rather than “mugging”.

Another benefit is the inclusion of objectives that are more universal and not specific to the discipline. When I taught a lab course, one of the objectives was “time management”. A biology lab course can stretch indefinitely, so when we actively incorporated time management, we planned our day for the first 15 minutes of the session and stuck to the agreed-upon timelines. We finished well in time and everyone involved had their evenings to themselves. Students found this difficult at first, but soon got used to the idea that time is also a resource.

Team learning: In almost every course I teach, there is an activity where students come together as a team and do a small project, which they present together. In the Molecular Biology course, teams worked on a “genetic switch” where they identified a real-world problem that could be addressed by designing a DNA switch that an organism can turn on to make a protein when required (for example, a protein made by bacteria that could clean up industrial waste when it is detected in the environment). In the Molecular Diagnostics course, teams chose a disease to which they would apply each of the diagnostics techniques we discussed in class. By the end of the course, the breadth of our understanding was expanded, due to the discoveries made by the teams during their research. The grand finale was when I invited doctors from the IITB hospital to evaluate their final presentations and give feedback.

Team activities require students to take ownership of their projects and therefore, their learning. This idea came to me while watching a TED talk by Sugata Mitra describing his “Hole in the Wall” experiment, where children learned how to use computers with unsupervised and team learning (3). It was clear to me that I had to design at least one activity, that would count for marks, where students would learn with each other in a format that was well outside the standard lecture.

This leads to an important question: how to evaluate students? As teachers, we have a bias towards exams with clear marking that will lead to a final grade. Over the years, I realized that my exam format of data analysis is difficult for biology students who are used to rote learning and regurgitating facts. Equally difficult for them was the story format of my exams. I love setting exams based on narratives including Game of Thrones, "boring professoritis" (a disease they were trying to cure), sickle cell anemia and others. As a result, many of them would perform poorly, even though they practised this format throughout the semester. By including team activities and presentations, I was able to offset their struggles during my exams. The value of all forms of evaluation in student learning has been clear to me from the beginning. Using multiple forms of evaluation has led to almost no students failing the class.

Relevance of the topic to their lives: Weaving the subject into the everyday lives of students certainly catches their attention. For UG classes, I would start the lecture with a futuristic scenario. Imagine that you do not need to take the JEE for entry into IIT Bombay and instead give us a drop of blood on which we will do a DNA test to determine your suitability as an engineer. For MSc classes, I would start every new topic with "Who cares?". One fun example was how understanding DNA replication can tell us our biological age. This has been used to experimentally test Einstein's theory of relativity where the biological age of astronauts shows slowing after being in space for a long time. Which Covid-19 vaccine the students took is a great way of starting the topic of immunology. This strategy has been crucial at IIT Bombay where the engineering students think that biology is a boring subject that is not relevant to their lives.

Interacting with young people is one of the most fun aspects of my job. After all these years, I am convinced that it is also the biggest impact that we will make as faculty. Because of this, my request to faculty starting out is to email me with strategies that have worked for you so that I can try them in my classes as well.

Links for the articles and video

(1) https://indiabioscience.org/columns/education/scientist-and-teacher
(2) https://indiabioscience.org/columns/education/experiences-in-using-scientific-method-as-a-structure-to-teach-biology
(3) https://www.ted.com/talks/sugata_mitra_kids_can_teach_themselves