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Week – 01

Lecture - 02

As we try and explore how the world is evolving and learn to understand the nuances and the importance of interactive teaching learning, I thought I should share with you a clipping of an excellent interview with a renowned physics professor, Eric Mazur, that he had shared in a master class. He said, I have some confessions to make and what I have learnt as a teacher in moving away from lecture-based learning. So, the talk is titled Confessions of a Converted Lecturer. So, coming from a renowned person in a renowned university, sharing his experiences will kind of enlighten us all with the challenges of teaching learning that has been traditionally going on for ages. And Through this talk, he tries to highlight how he learnt from the feedback of the students and the audience and how he tried refining his own teaching style. This has happened probably about 10 years back, I think if I remember right, this talk is somewhere around the year 2014, when technology had just started evolving.

to capture audience feedback and things like that. Now, in today's world, we have a lot more sophisticated tools which make it a lot more easier. But what is most important is to understand the context of change that is coming out beautifully in this video. So let me play out parts of it and I'll share reflections as he speaks.

And, no, I titled my talk confessions because there are a couple of confessions. And the first one is that when I started teaching, I never asked myself, you know, I mainly accepted the assistant professorship because I thought it's a way of, I was enjoying my life here in Cambridge and I was enjoying the research I was doing. I thought it's just a way of extending my postdoc another couple of years since, you know, not many people received tenure at that time at Harvard. I thought, you know, it's just a way of, you know, without many obligations, but I had to teach. So that was my first venture into the classroom.

And as I started teaching, I never asked myself the question, how am I going to teach? No, when you do something new in your career, that should really be the first question you ask yourself. It didn't even come up in my mind. It was perfectly clear what I was going to do.

I was going to do to my students what my teachers had done to me. Here's actually a picture of me teaching as an assistant professor.

It's a very old picture. It was taken BC, before computers. You see I'm still using an overhead projector there. And you know what happened? to make matters worse was that I very quickly received feedback that I was doing the right thing. What are the ways by which we typically evaluate the quality of teaching? Well, I can think of two of them.

One is the end of semester questionnaire. Well, I was asked to teach the class that none of my colleagues wanted to teach, physics for pre-meds. You know, these students were not taking physics because they wanted to take physics, no. They were taking physics because they had to in order to get into medical school. And most of them already hated physics before setting foot in my classroom.

Now, I thought I'll pause here. Because what he's mentioning about physics for pre-meds is not just only about physics. It happens in many undergrad colleges of different streams too. And it also happens in school. A lot of us, when we were students and even now the current day students, there are some pre-requisite courses and not everything is an elective.

So, some people, many people have to do certain courses. and when they don't have a liking for the course or they have an inherent bias or fear because of past difficulties faced, we tend to form impressions about a particular subject that it is difficult, it is boring etc. It might have been caused because of history, the way prior teachers have taught, the syllabus, the curriculum, whatever it is. I mean, it's a whole plethora of factors. But what I'm trying to highlight is, it's a forced thing, that it's a prerequisite.

So, that's not only the situation here, but it prevails everywhere. Most of my colleagues didn't want to teach it because the end of semester evaluations were not very kind. And they would come close to committing suicide at the end of the term when they saw the result of the end of semester evaluation. But not so for me.

I got a 4.5 out of 5. So clearly the students liked what I was doing in front of the classroom. Not only that, but I could give them really hard problems on the examination, problems that were so hard I wasn't quite sure that I would be able to solve them. under the time pressure of an exam. So they liked me, did it well on the exam.

Very quickly, I started to believe that I was the world's best physics teacher. So what happened, Eric? Well, you know, I should have seen the writing on the wall very early on, you know, because in spite of giving me high ratings, some students would write at the bottom of their questionnaires, physics is boring. So they would give me a high rating and

then they would write physics is boring or physics sucks. I never could make any sense of that. I thought, you know, how can they like me as an instructor? And how can they not like the beauty of doing science? I mean, what is more beautiful than understanding how the world around us works? Same thing when I go to a party and people ask me what I do for a living and I tell them I'm a physicist, you know? I get these looks, oh, I had such a hard time with physics in high school or in college.

It always makes me feel embarrassed. I never really understood where that was coming from. In any case, what happened, as Dean Ryan described, was that somewhere in the very early 90s, I think it was about 1990, this was the seventh year or so that I was teaching, I came across an instrument, basically 30 multiple choice questions to measure whether or not students understood Newton's third law. Newton's third law is F equals, no, sorry, it's F1, 2 equals F2, 1.

$F_{12} = F_{21}$

You may have heard it as action is reaction, or the force of object one on object two is equal in magnitude to the force exerted by object two and object one when they interact.

Well, it turns out that if you replace one by heavy truck and two by light car, students forget everything about Newton's third law. So on this instrument, for example, there's a

question that asks, consider a heavy truck and a light car colliding head-on on the highway. Is the force exerted by the light car on the heavy truck larger than that of the heavy truck and light car smaller than, or are they equal? As I said, according to Newton's third law, they're equal, but intuitively most students answer, and I saw it only before they had taken physics, that the heavier object exerts a larger force on the lighter objects. Well, I read about the results that had been obtained with this instrument, and I thought, no way.

Not my students. But, you know, I'm a scientist, so one of the things I've learned is not to make, not to rely on anecdotal evidence. So I thought, you know what? I'm going to show that in my class at Harvard, things are very different. So we were close to the end of the semester. We had done Newton's third law in the first week of the semester. And of course, it comes back over and over and over again.

And I gave this quiz, as I called it, to my students. And within five minutes, I tumbled out of my ivory tower. One student raised her hand. I walked over to her. And she asked me, Professor Mazur, How should I answer this question? According to what you taught us? Or according to the way I usually think about these things? I had no idea how to answer that question.

And by the end of that quiz, I'd been dragged out of my ivory tower. And it was very clear that my students hadn't mastered even the most fundamental concept. So how did you, as a result of this, change your approach to teaching? Yes, so a little prelude to that, perhaps. Perhaps, you know, at that point, I start to ask myself, what is going on, right? I mean, I could clearly not blame the students, right? Sometimes you think, well, the students are just, you know, not smart enough. But, you know, we have Harvard students here.

So there was an argument that didn't hold up. The other problem could have been the teacher. But that was me. And I got high evaluation. I was the world's best physics teacher.

So that couldn't be true either. So put yourself in my position. What would you have said? What was another option? just out of curiosity.

Come on. Somebody speak up. Put yourself in my position. You've given this test. Students do very poorly. You cannot really blame the students.

The test, exactly. There had to be something wrong with this test. But then I did some testing on my own by basically comparing word-based questions with formula-based questions. And I found that the students could manipulate the equations without any difficulty, but the word questions, they could not answer. They clearly had not understood the basic principles. So, then I thought, what is it exactly that happens in a lecture? Let us

take this picture.

These are beautiful ways that he analyzes where things are going wrong by scientifically analyzing where the real problem is. The students are not at fault, they are probably the brightest and the teacher has also got a great evaluation. So, where do things go wrong? What kind of problems are difficult? So, he comes, he observes that the conceptual understanding is not great, but they are able to apply it in a formula, they are able to get it right and formulas can possibly be memorized or you can just plug and play from the word problem and somehow get things right. So, he goes into those details and tries and digs out where the problem is actually happening.

Let us watch further. Picture of me delivering a lecture here. I would like you, to actually describe this process that is on the screen there. It was a verb, ideally, but the two verbs I do not want to hear are learning and teaching. So, blurt it out, I'll repeat it so that the audience that is remote can hear it too.

Go ahead. What's going on there on the screen? Sitting, observing, listening, sleeping? These are my students. You know, I had anticipated that he would say that, I don't know, maybe we'll talk after the talk, but I can't resist quoting the French writer Albert Camus, who once said, some people talk in their sleep. Lecturers talk while other people are sleeping. Okay, anyway, look, they have their heads straight, so they're not sleeping. So, Let's hear some more words, because all of the words we've heard deal only with the students, but I'm there too.

I'm definitely not sleeping in front of the class, nor am I observing. Demonstrating, but that's only me, not the student. Is there a way that we can capture the whole process? Thinking, we would hope so, but.

.. Mimicking, okay. Presenting, but that's me again. Can we capture both the students and me in the process? Communicating, but you see, when I think about communicating, I think about something going back and forth, like we are doing now and in most classrooms that doesn't happen, right? I mean, broadcasting, very good. What is being broadcasted? Information. That's when I realized that in a lecture, you actually focus on the transfer of information, but education is so much more than just a transfer of information. And I found out that the result of just transferring information was lack of learning, as evidenced by these test results, and lack of retention.

You test students two months after the end of a one semester physics course, and they're back to where they were at the beginning of the semester. So what good is it even to do this? So here is again an important insight, If we just transfer information one too many as

a teacher continuously, somewhere it's just transmission that is happening and we have no idea what is going on and that too this was recorded 10 years back when there weren't as many distractions I would say or attention span challenges like what we have in 2024 today. Our ability to pay attention has significantly reduced both for students as well as adults because there is a lot of short-form consumption, small videos, social media, constantly getting bombarded with emails, SMSs, etc. So the ability to focus and pay attention for prolonged duration is a significant challenge. And this was felt like he has illustrated 10 years back.

So you can imagine how much worse it might be today. Let's continue to hear on. So for a while, I thought, you know, Eric, you know, it's clear that you're not such a good teacher as you thought. maybe you should teach graduate courses.

But I wasn't willing to give up that quickly. And it turns out that the solution presented itself serendipitously, completely serendipitously. You see, I was shocked by these results of the FCI, but the students were just as shocked that they had done poorly. And they had a midterm examination coming up, so they were worried. And they asked me for a special session, where I would explain everything about every question. So I booked a room in the science center, the biggest classroom there.

My class was 250 students then. And I went through every single question on this instrument, this force concept inventory, as it is called. And when I got to this question of the heavy truck and the car, to me, that was an easy question. I couldn't actually even understand how students answered it incorrectly. So I made a drawing of the car. the truck I drew the forces of gravity the forces up from the road and then the force of the truck on the car the car on the truck and i said by newton third law these two forces are equal what more is there to explain about it I turned around because I've been with my back to the students and I could see at once from their faces that they were confused so I said is there a question They were so confused, they could not even articulate the question.

I thought, this is serious. So I thought, maybe I should bring in more equations and formulas. And maybe they're confused by the fact that the truck is less affected by the collision than the car. So I thought, I'm going to explain that was Newton's second law.

So I raised the board. I started all over again. And after eight minutes, the entire board was covered with equations. I gave the most brilliant explanation you could possibly imagine. At the end of eight minutes, I turn around, you know, my coat jacket covered in chalk dust, triumphantly thinking I'd nailed it, only to see that they looked even more confused. And they could still not articulate a question.

I didn't know what to do. I had no idea what to do. And in a moment of despair, I knew that 50% had given the right answer. So in a moment of despair, I said to them, why don't you discuss it with each other? And something happened I had never seen in my classroom. Complete chaos broke out. They all started talking.

They forgot about me in front of the class. I mean, I could have gone away. They would not even have noticed it. And in two minutes, they figured it out. I thought, how can this be? I, the expert, spent 10 minutes unsuccessfully explaining it to them, and in just two minutes, they figure it out? Imagine you have two students sitting next to each other, Mary and John.

Mary has the right answer. John does not. On average, Mary is more likely to convince John than the other way around, simply by the force of logic. But here's the key point. Mary is more likely to convince John than Professor Mazur in front of the class. Why? Because she has only recently learned it, she still knows what the difficulties are that the beginning learner has. Whereas Professor Mazur learned it such a long time ago, to him it's so trivial that he cannot remember what the difficulties are.

He cannot even imagine what the difficulties are that the beginning learner. Okay, this is a very insightful point. So somewhere, this peer-to-peer learning that has to be enabled in a classroom. Classroom is not about teacher to talking to the students, but students also, number one, interacting and asking the questions in front of the teacher, in front of the class, but that can be a bit scary . In the sense particularly if the subject is difficult, what if I go wrong, what will the professor think of me, what will be the other, my co-students think of me, there is always that worry there and here he talks about students learning from each other, discussing with each other and he brings out a beautiful point about Mary, the student whom he named Mary, a person who knows the concept, explaining to John who is just learning, who is still not yet understanding.

The beauty is about, Mary knows, the one student who knows, knows the pain of not knowing it and just having learnt it. So, they will be able to relate to each other better and probably explain better. compared to an expert who has learned it long time back and is a master in the topic. So that's a beautiful point that he's bringing out.

We forget how we learned. Things become second nature. So I went, wow, that's amazing. And I should really do this in my classroom. So the next year, I decided to basically change my approach radically. Because it's not the transfer of information that's the key.

What is really the key is making sense of that information. Think about your own classes. Where did the 'aha' moments occur? Where did things click and come into place? Was it

while you were sitting in a room like this one listening to your instructor speak? Probably not. Probably it was when you're doing homework or reviewing your notes that you went, oh, now I figured it out. So I like to think of education as a two-step process. The first one is information transfer, right? No information transfer, no education.

We need that. But we live in the information age, so it's not necessary to do that the way they had to do it in the Middle Ages before Gutenberg invented the printing press by just reading the book and have everybody in the audience be scribes. But that's not enough. We need that second step. making sense of the information.

In the traditional approach to teaching, step one takes place in class. And step two is left to the students on their own outside of class. And I think if you think about it, it's step two that's the hardest part. So we should really have the teacher present during that step two.

I didn't call it the flipped classroom. I didn't come up with that term. And I said, we should really invert this sequence. And instead of doing one in the class and two at home, we should focus on that second step. So I basically said, okay, the students are going to be responsible for the information transfer outside of class. So in class, I can do more meaningful things.

Now, it was the flipped class movement that started in the past 10 years. There's been a lot of discussion of the out-of-class component. To me, that's not the important thing. To me, that's the trivial part, the information transfer. So the question I'd like to address here is, what do you do in the class if the students are responsible for the information transfer outside of the class? And basically, the answer to that question, it's very simple.

And it's nothing new at all. The answer is, let's teach by questioning rather than by telling. Who said that first? Socrates more than 2,000 years ago. And here we are still mostly teaching by telling all around the world.

So I come into class and I teach by questioning. I pose a question. I give the students an opportunity to think. You see, in a lecture, normally you cannot think, right? There's no time to think because you're listening. In a sense, you're held captive by the speaker.

I'm holding you captive right now. If you start thinking, you're daydreaming. your thoughts wander, and our brains are simply not wired to multitask, so you're not listening anymore as you're thinking. You can maybe think very superficially and quickly, but to really think, hmm, how does this work? There's no time for it. And I don't know about you, but I've never had a student in my class raise his hand and say, Professor Mazur, could you please be quiet for 10 minutes? I need to think.

It's never happened. So there's no opportunity to think in a class. But here, there is, because I pose the question and then they think. So this is an opportunity that a faculty has to create for his or her students consciously because it's not easy as we dealt with earlier to ask for time. What will others think of me? Am I the only one who is lagging? Am I the only one not following? So that periodic pause and interacting with the teachers to, with the students to check on their knowledge and awareness and to facilitate discussion is something that Professor Mazur is trying to highlight, which I think is becoming more common these days. But again, it is not yet fully prevalent. And as a part of this entire course, we will try and see what are the opportunities to make that happen.

And after they think, I poll them. I poll them so that there's a commitment. We'll talk about that in just a second. Initially, I did it with a show of hands. Then the clicker was introduced.

Now we actually use consumer devices to do that. Then I tell them, now turn to a neighbor. I mean, provided more than 30% have the right answer, right? Because if the percentage of correct answers is too low, then you can have them talk as much as you want to each other. They're never going to get anywhere. Also, if the percentage of right answers is too high, It's not going to work either because they're going to be off task very quickly. So ideally, you want the question so that between 30% and 70% get it correct.

I ask them to turn to a neighbor who has a different answer. I tell them, if the one on your left has the same answer as you gave, say, thank you very much, and turn to the person on the right. If everybody around you has the same answer, get up and walk around. Find somebody who has a different answer and try to convince that person that you are right and he or she is wrong. Then poll them again, typically with a much increased number of correct responses.

And then I explain, or I have one of the students explain it, and then it's cycle basically. Yeah, this seems to be very sophisticated. A lot of takeaways here, providing time to think, asking the right kind of questions so that it is neither too easy nor too difficult. It involves a certain amount of thinking and he is suggesting not everybody gets it right, not everybody gets it wrong. He is looking for a 30 to 70 percentage mix so that there is an opportunity to interact with a student who has a different opinion or probably way of thinking. And he is suggesting that they interact to understand each other's viewpoint and get conviction in their approach.

And he does a repolling. which is a very nice way so that as a part of those discussions one party would have gotten convinced hopefully or they could have chosen to retain their

own thinking but nevertheless what he's been observing is that the amount of correct answers has increased which means that those discussions have resulted in one set of students agreeing to an alternate answer hopefully because of better understanding and discussions. So, this is a simple facilitation that he enables, he has enabled for amongst his students so that they interact with each other and their comfort zones will be far higher versus the student versus teacher, which is a very big challenge to overcome because even the students who are probably confident they may be hesitant a lot of times to ask in front of a large class repeats until the end of the class and of course the key part of this is this discussion that's where the students actually learn let me show you a little video of how this works in practice and then we'll do it because that's part of this master class right. So I read the question. So the question is, what are the magnet forces on the four different sides? Don't worry about the question, okay? I won't be examining you on that.

And then enter your answers. They think for about a minute or two, and it's quiet. I don't want them to talk to each other. Please enter your answers. I can see on my screen what they answered.

I do not share that with the students. Disagreement clearly here. So turn to your neighbor and see if you can convince one another of the correct choice. I noticed the aha moment here.

Initially, when I saw these aha moments in the classroom, and now we have... absolutely overwhelming majority for choice number two the bottom and that second distribution i do show that to them so they see that the second distribution what's going on here? One is it's active learning the passive so he has encouraged discussion and he has encouraged participation. Now one may be thinking that was the technology that really enabled this transition? Yes and no. Probably technology enabled the easier facilitation and polling of answers and display of screen. And this was back in 2014 when they did not have probably mobile devices, but they had some equipment to do this polling. And if our settings do not allow that, there are certain institutions that do not encourage mobiles in classrooms.

There are alternate ways by which the same thing can be achieved. The main point is to get the student opinion. It can be done by some color coding, giving color sheets, they raise their hands. The important thing is it has to be anonymous. In the case of this polling, we will be seeing a tool down the line in this course, how easily the same thing can be achieved with mobiles.

But as I said, mobiles is not the important thing. We need to find a way by which everybody gets to speak up their answer. They can just put their answer in a chit. The thing is the student who is worried about his answer or her answer, I think we can just make it

as an anonymous poll in terms of writing their answers in a chit and putting it in a box. It may take a little bit of time, but at least the same effect can be felt.

So what I'm trying to highlight is that it's not about the technology. Technology certainly makes it, I would say, faster and more sophisticated. But the important part is getting the opinion of every student in the class in a fail-safe manner. It's impossible to sleep through my classes because every few minutes your neighbors start talking to you.

The second thing, it's a two-way flow of information.Right, Just not only from me to the students. It's information coming back. And if they don't understand it, I see it then and there when I can still do something about it. I don't have to wait till the exam or any type of assessment. The last thing is that it's continuous formative assessment.

The students continuously get to test out their own knowledge without any penalty. And people have shown, and I'm sure most of you know this, But that formative assessment is so incredibly important, much more important actually than summative assessment. Lastly, it sort of personalizes the instruction, right, because student A can address student B's problem, but student C can address student D's problem, and the two problems don't have to be the same. So even if you have a class of 250, it personalizes the instruction. Do you want to try it? So, multiple benefits by this simple technique and I'll start with the last.

It humanizes the interaction in a large class setting. Today, there are large classrooms and even if it was a small classroom, let's say, let's first deal with large classrooms. Large classrooms are always a challenge because it's all the more scary to get up and volunteer answering a question. And it's impossible for the teacher to know whether the class is understanding, not understanding, whether students are distracted. And even for the students, they feel uncomfortable in a very, very large setting. So, one beautiful way is to encourage peer-to-peer discussions with your neighbor or maybe make them move around a bit and interact with another class member with whom they will be a lot more comfortable with.

So, that is one beautiful benefit and then he talks about the periodic checks. Once you teach a concept, even if it's by lecture, you check on it, whether they have understood it or not and encourage small debates. And so that, both the professor, the teacher and the students don't get a surprise in terms of their understanding levels. These answers give kind of like a indirect feedback on how difficult the topic is and how well it has been understood by the students. So, multiple benefits by this simple technique.

The most important, of course, the one that he highlighted is people don't have to be passive listening to a speech. They are continuously participating, which is probably the

single most important thing why interactive learning and teaching is the need of the hour. I will probably pause this and I think the last minute or two of the video is very key where he has highlighted those four benefits that he has seen. In fact, in his own lecture, as a part of this masterclass, he is actually actively interacting with the audience. Although for the last couple of minutes, he has been speaking, earlier he was actively trying to interact with the audience now and then. So, I thought I'll use this video as a precursor for a couple of things, once again to emphasize that even in elite institutions, elite well-renowned faculty, it's not about the mastery of the subject.

All of these are expert people. It's not even about the content. It's about that communication and it's about how do you make that environment a fail-safe one, a friendly one where people feel comfortable voicing their opinion and interacting with each other. How can you enable peer learning without a one-to-many kind of a learning? During the course of this NPTEL program, we will see several different techniques and tools board games, card games, variety of things we will get to see and digital tools of course that enable the same thing that the professor has spoken about. But this entire video and coming from a person who says that confessions of a converted lecturer, I thought it's a great setting and start, to setting the background of this particular course.