

MIGUEL JIMENEZ: The crux of the class is really teaching the students how to read the primary literature and read research papers. We wanted it to be engaging for them, so we're kind of dealing with papers, specifically looking at the microbiome and synthetic biology and drug delivery.

SARAH HANSEN: So what are some strategies that you use to teach students how to critically read the primary literature?

MIGUEL JIMENEZ: Yeah, yeah. So I mean, first of all, we choose a variety of papers-- some that are simpler to read and some that are-- with tons of figures. But really, we're always asking them what would they do differently if they were the researchers.

ALI BEYZAVI: Or maybe, what are some of the controls that are missing or what are some of the experiments that the authors could do to improve the study? We always get started asking the questions, OK, what is the abstract? And what is the main claim of the paper? And then, we were guiding them, figure by figure, to understand the article and explain it in the class.

MIGUEL JIMENEZ: And so we always take this kind of step-wise approach, where instead of just taking everything as a given when you read a paper, which is maybe what you would do if you're reading a magazine, here, we're really kind of-- they first start by reading the abstract and considering what the authors seem to be suggesting. And then, later, they look at the data just on its own, just the figures, and then think for themselves, do the figures actually match up with what the authors were saying in the abstract?

SARAH HANSEN: So let's talk a little bit about the role of questioning in the course. I had the opportunity to sit in on one of your class sessions. And I noticed that instructor-led questioning seemed to be pretty important throughout the session. So talk to us about the role of questioning. How do you select the types of questions that you do? Is there a learning curve for students, in terms of their confidence and how they respond to these questions?

ALI BEYZAVI: So we try to challenge them a little bit. And we try to ask them, one by one, to explain each figure. And we're trying to keep a balance between the questions we ask and also the explanations and information we provide to students.

We also study a lot before each session. Maybe for every two hours of the class, we did four or five hours of reading by ourselves to get ready. And when we are asking the students, the

students were somehow forced to read in advance. And when they read in advance, then they learn much, much faster.

MIGUEL JIMENEZ:Right. And I do think there was a learning curve for the students. And Ali, right from the very beginning, had a very cool idea to kind of pick on students at random. And so the first class I think was a little bit-- the students were like, whoa--

[CHUCKLES]

--we're going to have to answer. But I think, very quickly, the students were great. They knew that. And so then, they knew they really had to read. And they also learned to read efficiently with their time, so then they can be ready for any one of the questions. And I think, when you came in, you saw that. Like, after several sessions, they could already kind of on the spot be engaged and really reading the paper. So I think that was a great strategy to do it that way.

And I think another thing that maybe worked well was that the kind of questions and in the order, even, we asked them was almost very similar from session to session. So obviously, the paper is very unique and very different, but we always ask like, what's the main claim; which of the figures is the most important figure to support their main claim; and then, what controls were done? What controls could be done?

And so that was kind of like these five key questions. And we always asked those questions, so I think the students also were-- became prepared to answer those types of questions. So I think that probably when the students were reading the papers in the later sessions, they were already reading the papers with those questions in mind. So I think that also helped them in the actual class session.

ALI BEYZAVI: Absolutely. This is a famous assay microbiologists use to see if the bacteria has been able to penetrate the eukaryotic cell. So gentamicin kills everything outside. And if the bacteria has already invaded the cell, it's protected inside. And then, when you lysed it-- tumor cells-- you can extract the bacteria inside.

MIGUEL JIMENEZ:If you guys were to do the next figure-- kind of expand this paper-- what should be kind of the next step?

AUDIENCE: I would think they would want to combine both the quorum sensing and the anaerobic.

MIGUEL JIMENEZ:Yeah, definitely, right? Because their figure 1 shows that they're trying to make this system

that only invades tumors. And so, that's what the anaerobic point is for. And what is their argument for why they want this quorum sensing aspect to it?

AUDIENCE: Because of the typical density of the bacteria at the cancer cells.

MIGUEL JIMENEZ: Right.

AUDIENCE: They enjoy that environment.

MIGUEL JIMENEZ: Right. Right. They don't want to have it just invade random cells all by itself. They want for them to only invade the cancer cells all in one batch.

SARAH HANSEN: Let's talk about the midterm assignment in the course. What was it all about?

ALI BEYZAVI: So in the midterm assignment, we tried to give two papers to students without giving the title of the paper. We only selected the figures and tables and put it in a PowerPoint and asked the students to look at the figures and try to connect the dots, trying to understand what's the story of the paper.

We explained a little bit about the caption of each figure, so that students could see the figure, read the data, and read the caption. And then, they were in charge of understanding what the whole paper is about, what is the main claim, and what is the story of the paper.

MIGUEL JIMENEZ: And so, yeah, we were really trying to kind of flip what we normally do in a class kind of upside down, so they were really then intended to write an abstract, based on the figures, rather than judge the figures, based on the abstract. And so I think when we first gave it to them, they were a little bit concerned.

I think some of the difficulties they had was like how much background to include in the abstract. Or for example, something that they asked a lot of questions about was how much other readings should I do. Because it's a little bit like a quiz, where you give them just the figures, and then they have to come up with an abstract. So there's always the intention of trying to find which papers the figures belong to to read the original abstract.

And so we tried to actually change the legend, so that wouldn't be so easy. But we also asked them to not necessary directly look up the paper. But then, there was still struggle, though, because they still needed to understand the figures. And so there was some amount of background research they had to do.

And so, if they came upon some of the background, they were like, should I include that or not, and how much to do that. But I think, in the end, it was all OK, because really, just even thinking about what is the main claim without being given the main claim, I think that was really the key aspect of the assignment.

SARAH HANSEN: That's really interesting.

ALI BEYZAVI: More or less, it looked like solving a puzzle for them. So they had the pieces and they had to connect them in the right order.

SARAH HANSEN: Students in this course give a final presentation. What was that all about?

MIGUEL JIMENEZ: Yeah, so now, it's kind of giving them a little bit of-- allowing them to choose their own papers. So the whole time, we've been choosing papers for them or figures for them to analyze. And now, we wanted to see-- for them to have the freedom to kind of explore a certain aspect of the microbiome or drug delivery of their choosing, and then, for us, also to see kind of where they took it from where we left it off.

And so the way we designed this assignment was that we asked each student to choose two papers that they would like to present. And then, we went through and chose one of those papers for them to present, so at least we would have all the papers be kind of equal length or difficulty. And they would all be matched up, but at least, we gave them the ability to choose the paper.

And then, they were meant to just do like a 10-minute presentation to, again, go through kind of the same questions we'd go through in every session, kind of tell all of us in the class what is the main claim, kind of contextualize those, and kind of critique the paper as what other experiments could be done or what the researchers do really well.

ALI BEYZAVI: The day of presentation, I was extremely happy because I saw that students have really learned to go in to the literature, dig into the literature, find a paper, read it, and understand it. And I think-- I and Miguel-- reached one of the most important goals of discourse, which was teaching students how to read and understand paper.

MIGUEL JIMENEZ: Right. And it was really great to see it in a single session. We had eight to nine students, so we had all these papers all presented in kind of in the way we would have presented them. So it was really nice-- affirmation that they had really kind of understood kind of the whole point of

the course.

SARAH HANSEN: One of the interesting parts of this course is that students get to take visits to working labs. Could you tell us a little bit about that?

ALI BEYZAVI: Of course. We thought that, besides reading papers, it's very good to show students that things they read have some tangible, real application. And Miguel found a company called Ginkgo Bio. They're actively working on synthetic biology. And they're actively engineering the microbiome to get new applications.

And then, we took the students over there. It was amazing, because they saw whatever they have learned, and they are learning, and they're reading the papers to have some real-world applications.

MIGUEL JIMENEZ: So yeah, from the very beginning, when we were developing the curriculum, we heard from previous instructors that rather than taking them to an MIT lab, it would be very kind of enriching for the students to actually go out off of the campus. And so that's why we chose to go to a company, rather than showing them a lab.

And so interestingly, we didn't know that kind of going into the semester when we were already planning the visit to Ginkgo Bioworks, but most of the students were actually seniors with just a couple of juniors. So actually, they were all very interested in jobs and how do you translate some of this stuff that you learn and see here on campus to the real world. And so it was really interesting, I think, for me and for them to see kind of a lab, similar to where we are right now, but what it looks like really an industry kind of on a high level, very professional.

And so I think Ginkgo Bioworks was great for showing them they have like these foundries, or bio foundries, where they're doing synthetic biology kind of at a grand scale. And so that was really interesting for the students. And we asked them at the end of the course, and they were - that was like one of the highlights of the course. They're really very excited about that.

SARAH HANSEN: Why did you choose to teach this course as postdocs? And is it something you'd recommend to other people in your position?

ALI BEYZAVI: Yeah, I definitely would recommend it. As a person who has done a PhD and has been in the graduate school for a couple of years, I was clearly feeling that, if a researcher wants to be successful, he or she must be able to read the literature almost every day. And he or she must be able to keep up with the speed that papers are generated, at least in his or her particular

field.

And we thought that undergrad students should learn these skills as soon as possible. Even if they don't want to do research or go to grad school, even if they want to be successful in their own career, or if they want to go to industry or whatever, it's a great skill set for them to be able to search and learn from internet and from papers and articles. So we thought it's a good opportunity to pay back to the community and teach them how to read the papers and how to think critically.

MIGUEL JIMENEZ:For me, personally, it seemed like a very interesting way to look at the literature that I already looked at, but from a different angle. When you're trying to teach it and think about it critically, I think I felt like I also was able to, then, look at the literature even more critically through the eyes of the students.

And you have to balance both teaching and developing the course with your research, but I would really encourage other postdocs to take advantage of these opportunities. Because actually, in doing so, you actually get to kind of look at your own research from a different perspective. And so it's good to have that in mind. I would definitely encourage other people to take advantage of these types of things.