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**SARAH HANSEN:** Today in the podcast, we're talking with teaching legend Professor Gil Strang.

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**SARAH HANSEN:** Welcome to Chalk Radio, a podcast about inspired teaching at MIT. I'm your host, Sarah Hansen, from MIT OpenCourseWare. One of OCW's most popular courses is Professor Strang's *18.06 Linear Algebra,* a key foundation for his new course on machine learning, in which he's teaching students to teach computers.

Professor Strang is known for inspiring students through his teaching. One YouTube commenter sums it up well. Quote: "This is not lecture. This is art."

We wanted to talk with Professor Strang to see how he's been able to make complex math concepts engaging and accessible. We'll pick up our conversation with his explanation of what his new course, *18.065 Matrix Methods in Data Analysis, Signal Processing, and Machine Learning* is all about.

**GIL STRANG:** So this is my adventure into the subject of deep learning. For example, recognizing an image, recognizing a zip code, a bunch of numbers, translating languages, or playing chess, so that's what the course is about. How does the machine learn?

Essentially, the idea is say take an image, then the deep learning system leads the machine to look at the examples. We all learn from examples. The machine learns from examples, and from many examples, or many chess games or many pages of Chinese, you learn what's happening.

And what the math part is is that the machine ultimately tries to assign a certain weight to a certain number, big or small, to each part of the image. So perhaps, if you're drawing a three, the computer recognizes a three, of course, by the curves and gives less weight, or zero weight sometimes, to the empty space around the three but picks out that three. So that's the idea of deep learning.

**SARAH HANSEN:** Traditionally, math courses have been defined by testing, which honestly makes sense. There's typically a right and a wrong answer in math. If you know the operation, if you do it right, you should get the answer. Tests can be a great vehicle for strengthening and measuring students' skills, but Professor Strang's approach is different.

**GIL STRANG:** So I ask everybody to do a project. There is no final exam. Actually, there is no exam at all. I shouldn't like say this, but that's really what the subject is is having an idea of how-- OK, I'll use deep learning for some thing. Like the recent proposed project was can you identify what makes an image or a picture attractive?

**SARAH HANSEN:** Hmm.

**GIL STRANG:** So somebody has to say, these pictures are attractive. These are not. We have to tell the computer something.

**SARAH HANSEN:** What did that feel like to try something new, pedagogically?

**GIL STRANG:** Oh, it's fun. I like teaching, and this is a subject where students just come from everywhere. Because they know what stuff to learn, and they've heard about it. And some of them know more than me, and then those students write even better projects.

Yeah. So I do the lectures for the first three quarters of the course, and then I try to get them to present which is a great experience for them. So it takes a little urging to get them, but yeah, it's really just wonderful.

**SARAH HANSEN:** What insights have you gained about having more of a student-led course and a project-based course?

**GIL STRANG:** You realize, slowly but finally, that that's how people learn, by doing. You couldn't give them a better way to learn than create a project. Usually it's on some topic they know about or they they're interested in. Like how do you find a criminal in a bunch of people?

Yeah. It's a very effective way to learn, and it's something that gets remembered. Where doing exam questions that I might make up, sort of mathy questions, I don't know if that's remembered 10 years later, but I think people's projects are.

**SARAH HANSEN:** Along with this new approach comes a new paradigm for measuring student learning. Projects involve more than right and wrong answers. Projects are subjective, and bringing the subjectivity into a math course comes with some initial skepticism, especially from students who are so used to the typical "learn the subject, perform on the test" way of doing things. One of the things that makes Professor Strang and his courses so special is that he's not attached to these paradigms. In 18.065, in one of the videos, you talk about grading students' work.

**GIL STRANG:** Yeah.

**SARAH HANSEN:** And you tell them that, although this is important, to grade their work, it's not your main concern. That your main concern is actually learning with them.

**GIL STRANG:** Right.

**SARAH HANSEN:** Could you talk a little bit about that?

**GIL STRANG:** Yeah. That's right. So typically, the first few days of class, these guys ask, what's the class average going to be? How are we going to be graded? I don't have any answers for that stuff.

So I say what is totally true, that I don't feel my main job is to grade them. My job is to teach them or learn with them, and that's what I continue to do, and gradually they begin to believe. At the beginning, they still think, OK, but he's got to give me a B or C or an A, but really that's not what 18.065 is about, a grade. It's just not.

Math is something you do. You don't just read. You have to do it. You have to think about it. The way to learn math is to get into it and work on a thing which takes some thought. You don't see it immediately, but you see it eventually.

**SARAH HANSEN:** One of my favorite takeaways from Professor Strang's approach is that he centers his lessons around the humans in his class. For him, it's about engaging with the students in his course as people, and the learning is done by everyone.

**GIL STRANG:** Well, first, I like students, and I want to help. And maybe the key point is to think with them, not to just say, OK, here it is. Listen. Listen up. I think through the question all over again, as they do, and you have to give time.

You can't zip through a proof, because the class has to be thinking with you. And it happens that I lose the thread, or I come up to a dead end, where I don't know what I'm supposed to do next. But well, that's OK, because students are going to hit dead ends. So it seems to me it's OK for me to get stuck too and then given they see, oh, OK, maybe this is the way to get out of that corner.

I suppose, I try to think it through once again, and then you automatically see the word. You recognize what words you need to use and what the steps are. Yeah. If you're not thinking it yourself, then you're probably going too fast and not connecting with the thinking of the class.

And of course, you don't know what everybody is thinking in that class, but overall, if you stay conscious of the class, conscious of where they are. That's I think the same for any speaker is to be conscious of the audience, and it's maybe the key point is to make it human. You're a person, like the student is a person. The book isn't quite a person, but it was written by a person, and to see that it's just like a natural thing to do. Yeah. So essentially, I think the thing is, I like students, I like math, and putting them together is just the best job in the world.

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**SARAH HANSEN:** Professor Strang shares additional thoughts on teaching linear algebra and matrix methods and data analysis, signal processing and machine learning in videos within the Instructor Insights sections of his OCW courses. You can find them at ocw.mit.edu. While you're there, download the teaching resources from his courses, and watch his lecture videos. Discover the magic of his teaching for yourself.

We're so happy to bring you conversations with MIT faculty who are passionate about impacting the world in positive ways. Write to us to share your story of how you're using OCW materials to shape your world or those of others. Until next time, I'm Sarah Hansen from MIT OpenCourseWare.

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