[MUSIC PLAYING]

CHRISTOPHER TERMAN: This was more than just a listening experience. These virtual labs take courses from being a listening experience with maybe some pencil p-sets to you know your hands are active. So you know hands-on, brain on, right? And when people's brains turn on, they remember it.

SARAH HANSEN: Ever wonder how we go from the building blocks of atoms to creating things like Amazon Cloud? And how educators introduce the architecture of digital systems to future engineers?

CHRISTOPHER TERMAN: So here I was, I was riding on the Hong Kong subway, and some young adult comes up to me and says, "I took your MITx course." And I'm sort of going, wow. I mean, this is--

SARAH HANSEN: It's incredible.

Welcome to *Chalk Radio,* a podcast about inspired teaching at MIT. I'm your host, Sarah Hansen, from MIT OpenCourseWare. Today in the podcast, we're diving into the world of *6.004 Computation Structures.* This is an MIT course designed to teach undergraduate students how digital systems are engineered. Some students come to the class with prior experience in programming and some understanding of how computers are structured, but others come knowing little more than how to use a browser. Through the iterative teaching practices of a team of instructors, this course manages to engage all of these students in learning this cutting edge information.

Today I'm speaking with one of the key educators in this course, Senior Lecturer Emeritus Christopher Terman. We'll run through what it takes to connect and educate an audience whose experience might vary from complete novice to virtual professional. In our conversation, Terman shares his insights on the evolution of this course over the last 20 years and how its current design is so effective at engaging its broad student base. We'll start off with Terman's own story of getting engaged with computation structures.

So how did you become interested in computation structures?

CHRISTOPHER TERMAN: Well, in the early '70s, I was a college student trying to earn my way through college. And so I was the computer operator on the third shift for the campus computer. That was in the era in which you could only afford one. And since watching the blinking lights was boring, I pulled out the schematics for the computer I was running for the university, and I started trying to figure out how the computer worked. Ever since then, it's been sort of a lifelong interest in figuring out how do they actually put together these components to make a machine that can do computation.

SARAH HANSEN: What kind of background experiences do the students bring related to computational--

CHRISTOPHER TERMAN: It's all over the map. It's all over the map. So some of them will come having programmed computers for a long time, and maybe even know a little bit about how the computers are structured on the insides. Other people have not done beans, and so they come with interest, but no background at all.

SARAH HANSEN: So how do you structure a course to meet the needs of people with diverse backgrounds like that?

CHRISTOPHER TERMAN: Right, so to handle really diverse backgrounds, you have to have a huge range of material. So you need something that somebody who's just, "I need to start at the beginning," you need a beginning for them to start at. And for somebody who's sort of past the first half of your material, you need a second half which will engage their interest. So I create a huge-- I think of it as a buffet. There's lots of dishes, and you can start at the beginning of the buffet and sort of pick it up from scratch, or you can say, let's skip the first couple courses and I'm ready to dive in sort of in the middle of the conversation somewhere.

So I think the real key is having a huge selection of materials to draw from. And that's, I think, one of the hallmarks of 6.004 has been that we have every possible way of learning the material. So not only for different backgrounds, but for different learning styles. There's sort of an emerging best practice about how to explain material to people for the first time. So you know, you want to do a short bites, sound bites, video bites, those short segments of learning where you introduce a single skill or a single concept.

And then you take a moment to actually give them some check yourself questions. So the idea is, well, in theory you just listened to this or watched it, I'm going to ask you some simple questions. Not puzzlers, they're just if you understood what I just told you on the video, then you can answer them. And I think the students appreciate it. Everything is more bite-sized. You know, we both know.

You can imagine pushing "play" on a 50-minute video and long about minute-- well, I'm going to say 37, but long about minute 6, you're going to be, maybe I should check my email while I'm listening to this. So it's, you know, keeping things short and sweet. Plus, it's asynchronous. In other words, they get to choose their time and place.

SARAH HANSEN: This must be just such an exciting time for you as someone who's really interested in the scholarship of teaching and learning, and then the emergence of these digital tools to enable that learning through best practices. I can feel your enthusiasm for kind of the era that we're in.

CHRISTOPHER TERMAN: Yeah. Well, you know, those of us who teach at the university level, we get handed a piece of chalk and be told to teach. Unlike the teachers for your kids in elementary school, who've actually gone through a program that teaches them how to teach, we're just said, here, teach. And so it's all anecdotal. It's all trying to remember how people taught you.

Finally, we have, you know, the online courses are providing a real educational laboratory. We're able to try out different techniques, we're able to make fairly accurate assessments, how well did that just work, whether it was an exercise or a video segment or a design problem. And so we can actually do A/B tests in the same cadre. So you know, it's pretty neat having a lab. I mean, as a scientist and engineer, you can build a hypothesis, test it through a bunch of experiments. We can really do the experiments with the MITx platform. And so that's been great.

[MUSIC PLAYING]

SARAH HANSEN: Let's talk about learning in the classroom and teaching large lecture classes. What strategies do you have for keeping students engaged?

CHRISTOPHER TERMAN: Well, that's interesting. Because we have so many different materials, really, the only students who come to lecture are the ones who are-- for whom lecture is how they learn. I was such a student.

SARAH HANSEN: I see.

CHRISTOPHER TERMAN: So the people who are there are not a draft army. They're all volunteers.

SARAH HANSEN: Self-selected, right?

[LAUGHTER]

CHRISTOPHER TERMAN: So they're prepared to be somewhat engaged by a vocal presentation. So I have a well-developed set of materials that I present in class that have sort of been debugged for having not too much or too little, a progression that most people can follow. It's a very relaxed sort of experience, you know, I tell jokes, I tell stories from my career. And it's interesting to me how, you know, when the students are making comments at the end of the semester in the evaluations, many of them say, I really liked the stories. So it's, you know, after boring you with technical details, it's fun to say, and then when I tried to use that, you know, this following thing happened. And all of a sudden, they're sort of perking up saying, oh. You know.

SARAH HANSEN: And I think it helps them remember the related content too.

CHRISTOPHER TERMAN: It does. When you think about what you remember from lectures, it's almost never a technical nugget. It's a joke they told or an accident that happened or a mistake that was made. And so it's-- there's this concept called fluency, which is basically how smoothly things are going and everyone's nodding, but your mind is starting to drift because it's all-- so it's actually good to try to put a little disfluency into your lecture to actually have a, you know, you stop and you tell a joke, or you make a mistake, or you drop the chalk and say, darn, and you look at the floor.

SARAH HANSEN: Right.

CHRISTOPHER TERMAN: Or-- and here's what I like to do, is you walk out from behind the lecture table or lecturn, and you approach the audience. And you can see them sort of like, wait, he's escaped.

[LAUGHTER]

And so just anything that sort of switches up, you know, the sort of I'm just going along with the flow here. So you know, making little flows that have things that change make a lot of difference in keeping people engaged.

SARAH HANSEN: I was curious about the teaching team behind a course like this. So I asked Chris to tell me a little bit about the team of people that make a course like this work.

CHRISTOPHER TERMAN: We have a little cadre of people who are instructors. I've been part of that cadre every semester for a very long time. But we have other people who come in from the outside. In recent years the department has added lecturer resources, so there's another lecturer associated with it, and then faculty come in. And then, you know, they provide a little depth to the gene pool.

SARAH HANSEN: Sure.

CHRISTOPHER TERMAN: But then we have graduate TAs who teach recitations. And we have student undergraduate TAs and then lab assistants. So we have this whole hierarchy. They've all taken the course. They've all loved it. So sort of like me, there's an enthusiasm that sort of bubbles out.

SARAH HANSEN: Right. It's contagious.

CHRISTOPHER TERMAN: Yeah. And the students actually-- you know, I listed things sort of-- well, I was going to say top down. I'm not sure if lecturers are at the top or instructors are at the top. But the students actually prefer the other thing, which is actually asking an LA is not very intimidating, to the students. Maybe they just took it last semester, and so they have fresh in their minds what it is they needed to do in order to get whatever it is they're trying to get.

And then you sort of work up the hierarchy to get an answer of people below. And that way, you're only asking questions of the more intimidating people when you're pretty sure that no one else has the answers.

SARAH HANSEN: Right. What's the role of the online fora in the course for helping students feel comfortable asking questions? And how do you monitor it? How do you run it productively? This is something that educators sometimes struggle with.

CHRISTOPHER TERMAN: To me, it's a wonderful asset. For the first time, I'm able to make a thoughtful answer to a question and have 180 people look at the answer, instead of one. And then the next person has the same question. You say, well, I just spent 10 minutes, you know? With a large class, you can't spend 10 minutes for each of 300 people.

SARAH HANSEN: Right.

CHRISTOPHER TERMAN: So it's a great place to ask questions. And so many of the questions are, look, I've read the material, and I'm still not getting it. I need an example. I try to make students feel very comfortable asking. There's no cost. They can ask anonymously, so that removes some of the barrier. I think, Fall 2017, we had about 2,500 contributions to the forum.

SARAH HANSEN: Wow.

CHRISTOPHER TERMAN: The average response time is about 20 minutes. And so a lot of us who are involved in the course, we put the notification, postings on real time. And so we get an email right away. And I think the fast response time really reduces the frustration level of the students.

There's nothing like being stuck on something and saying, I wish I could ask somebody. Well, for the first time we can say, wait, I can ask, and I can get an answer. And the students really, really appreciate that. So the forum has really, I think, changed students' level of frustration when they get stuck. Being stuck is just a 10-minute process, not a two-day process.

SARAH HANSEN: Right.

[MUSIC PLAYING]

Let's talk for a minute about the lab experiences in the course. So students get hands-on experience doing digital design.

CHRISTOPHER TERMAN: Yes.

SARAH HANSEN: Could you talk about a few of those experiences? And also, does that take place here where we are right now?

CHRISTOPHER TERMAN: Well, you can do it anywhere. It's browser-based, so there's no software to download. It's just on the web, you go.

SARAH HANSEN: I see.

CHRISTOPHER TERMAN: 20 years ago, I gave you software to download on your computer to do this stuff. [LAUGHS] You know, landmine that was. Everybody's environment was a little different. "Oh, you don't have the latest version of that library? Well, you can't run this. But if you update your library, you can't run that." And it was really a nightmare.

So packaging up these lab experiences in a way that they can be used by people around the world. So here I was. I was riding on the Hong Kong subway. And some young adult comes up to me and says, "I took your MITx course, and I really loved doing the circuit stuff. And I didn't have to download anything." And I'm sort of going, wow. I mean, this is-- you know?

SARAH HANSEN: It's incredible.

CHRISTOPHER TERMAN: It's interesting to be stopped by people.

SARAH HANSEN: Right.

CHRISTOPHER TERMAN: And they start talking about how this was more than just a listening experience. So these virtual labs actually take courses from being a listening experience with maybe some pencil p-sets to your hands are active. So hands-on, brain on, right? And once people's brains turn on, it's amazing what they-- you know, they remember it.

SARAH HANSEN: Right.

One of the distinguishing and most interesting parts of this course is that the learning is greatly enhanced by deductive reasoning. In fact, the ability to apply prior knowledge to solve a problem in front of you is one of the main skills students come away with from this class.

CHRISTOPHER TERMAN: A lot of students aren't very good at taking the information they do know and using it to deduce the next thing to try, or the next thing to test, and narrow down where the problem is. So it's something you have to learn how to do, is to be organized about taking something that isn't working, or a complicated thing-- so parts of it are working, but something isn't-- and trying to work back from both ends to somewhere in the middle that doesn't work. And so that's a skill that you have to practice for a while.

SARAH HANSEN: Right.

CHRISTOPHER TERMAN: And so we try to help with that skill. It's sort of neat to watch them make the transition from coming in as answer-focused to leaving, like, OK, you can ask me anything, because I actually know how to do things from scratch. I can not only recognize the right answer when I see it, I can actually make right answers.

SARAH HANSEN: Right

CHRISTOPHER TERMAN: People feel empowered when they can do that.

SARAH HANSEN: We'll close out this episode with a moment from the interview that really struck me, because it captured how Chris strives to humanize the learning experience in 6.004, how he understands that students are whole people who bring their lives into classroom spaces.

CHRISTOPHER TERMAN: Doctors have this saying, "Treat the patient, not just the disease." And so when students are struggling with material, I find it's often the case that there's issues that are not just what's the technical concept or skill that we're talking about. And so I've learned over the years to make myself, as best I can, accessible to students who need to talk about their life as a student, their life as a person here at MIT. And everybody comes with a bit of imposter syndrome, so you need to help students deal with that a little bit.

So there's a lot of issues that aren't on the syllabus in 6.004 that affect how they do in 6.004. And I've learned that it's good for me to invest my time in helping them think about, talk through their larger issues. I'm not very good at writing prescriptions, but you can listen. And you can try to offer a bit of perspective.

I think what's interesting is that, over time, you begin to appreciate, if you're going to put effort into something, it might as well be the best you can do. It doesn't cost you any more to do better. And it's sort of interesting to me how many people say, oh, they'll give that lecture, but I won't really care.

And so you go, no, no, that's not the right approach. You should actually say, look, if I'm going to spend 40% of my time each semester teaching students, wouldn't it make sense to figure out how best to do it?

SARAH HANSEN: Right.

CHRISTOPHER TERMAN: So I think everybody comes to that. The more you're here teaching, the more you realize that you might as well teach well. Why the hell not?

[MUSIC PLAYING]

SARAH HANSEN: If you're interested in learning more about computation structures, you can find the course materials on our website at ocw.mit.edu. And if you're an educator, check out our educator portal at ocw.mit.edu/educator.

Thank you so much, for listening. If you enjoyed this podcast, please consider subscribing and rating our show. Until next time, I'm Sarah Hansen from MIT OpenCourseWare.

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