[SQUEAKING]

[RUSTLING]

[CLICKING]

JUSTIN REICH: Go ahead and turn to your neighbor and start. One thing you could do is pull out the main reading that we did about situated learning, because we'll do a close read of that today. So pull that up on something. And then, in the minutes that we have-- we usually start at 1:05. But in the minutes that we have, turn to your neighbor and start thinking about why babies would give cognitive load theorists conniptions.

[INTERPOSING VOICES]

AUDIENCE: I think the first one is like--

AUDIENCE: Right, like when you're a kid. It's like--

JUSTIN REICH: Just as one level-setting thing, in case you haven't hung out with babies in a while, in their first few years of life, how would you characterize the amount and rate of learning that babies do?

AUDIENCE: Insane.

JUSTIN REICH: Insane. It is bonkers how much babies learn. I mean, a very strong feeling I had when I was first a father was like, I do not improve at all in a week or in a month or really most years. I'm really not that much better than I was at the beginning of the year.

And you're just watching these infants who are totally transformed because they are learning things at an amazing rate that you can see daily, weekly, monthly. Incredibly accelerated learning. So we'll just use that to level set. Let's take it as a given that babies learn an amazing amount in their early years.

Now, keep talking. Why would that prove to be such-- why would that give cognitive load theorists such a conniption? And you can think about how it connects to some of the stuff that you've been reading about situated load theory. Keep talking.

AUDIENCE: I guess presumably--

JUSTIN REICH: All right, good. What are some observations that people made?

AUDIENCE: All my good habits of schooling.

JUSTIN REICH: What are-- babies are significant. So what are some of the observations that you made? What were you guys talking about in the back? What was your group talking about, Gloria?

AUDIENCE: I was saying that if cognitive load theory was true, then that would say that babies probably can't learn anything because everything is extraneous knowledge to them, and they don't have any long-term memory. They haven't formed any feelings yet.

JUSTIN REICH: All right. Yep. So they're not drawing in. They don't have a lot of long-term memory to draw on. They are the canonical us looking at Sanskrit letters, where everything is its own discrete part. So you would think they are working memory.

I mean, this video, I think, is helpful for that. Everything on this screen is brand new to them. There's nothing that they've ever seen before. And it's filled. There's a slide and a dad and that other thing back there and all this stuff on the ground, and people are talking, and the sun is out, and all these things are happening at once. Good. What else do people talk about?

AUDIENCE: It's also like, the speed with which they learn doesn't really connect with the bottleneck theory and the theory of-- it takes a while for you to compile all of this information, but it almost seems like a baby sees it one time and is able to retain it.

JUSTIN REICH: Yeah, babies seem to do exactly the thing that Sweller said people should not be able to do, which is to be-- I mean, would you-- like, this baby learning stuff, would you generally characterize their experience as open-ended problem solving, or being carefully walked through a series of worked examples? Well, how would you describe it?

AUDIENCE: [INAUDIBLE]

JUSTIN REICH: Yeah, I mean, I'm just going on the slide and going down. It's not like dad's like-- I mean, I think you'd find more structure and stuff like that, but there's a lot of just like, wow, I'm a baby. I'm out there. I'm doing my thing. And the worked example effect and the expert reversal effect suggests that should not be very effective.

The most effective way to teach babies should be through careful, devolving scaffolding of language and things like that. And that's not what we do. We just throw babies in with people all the time. And they learn language. They learn movement. They learn a few other things at an extraordinary rate. So what connection do you see between this set of ideas and situated learning?

AUDIENCE: There's a lot of trial and error in it. We were talking about, hey, when they see a block they want to go get, they start to figure out the different ways that they can go get that block but through trial and error-- trying to stand up, trying to crawl, trying to drag themselves.

JUSTIN REICH: Yeah. All that kind of stuff. [INAUDIBLE], come on in. Sit with me.

AUDIENCE: Sorry.

JUSTIN REICH: No, no. Delighted to have you. Yeah. Yeah, I mean, this certainly looks a lot more like situated learning than it does look like a carefully sculpted classroom. And so for situated learning people-- I think we'll see this more in some stuff that we read-- the experience of babies seems like something that's pretty important to draw from.

How would you characterize the feelings that babies have as they learn language? Are they happy? Are they sad? Are they angry? Are they frustrated? Are they joyful? Are they playful? What kind of feelings do babies seem to have as they're learning words? What would you say, Jaren?

AUDIENCE: I was going to say, they seem kind of fearless and like there's no social pressure to try and pronounce this word correctly. They'll just say the word. And we'll be like, oh, good job.

JUSTIN REICH: Just make noises come out of our mouths whenever. Yeah, do you want to grab another chair in?

AUDIENCE: It doesn't seem like there's a lot of fear behind trying to practice what they're learning.

AUDIENCE: But I think, in addition to that, there can be a lot of frustration as well.

JUSTIN REICH: OK. Yeah. Yeah.

AUDIENCE: The consequences of not knowing how to say specific things.

JUSTIN REICH: Yeah. Or if you watch babies when they're-- I mean, they cry when they can't articulate the things that they want to be able to say. What are you thinking?

AUDIENCE: Yeah, in addition to frustration, I think there's a bit of happiness when they actually achieve what they're trying to communicate and they feel understood.

JUSTIN REICH: Yeah.

AUDIENCE: I think there's some sort of pride in that.

JUSTIN REICH: What were you going to say, Courtney?

AUDIENCE: Same.

JUSTIN REICH: Same kind of thing.

AUDIENCE: I also wonder--

JUSTIN REICH: My daughter, we used to-- we used to just-- I guess it was my younger one. We used to just list vegetables and list things you get at the supermarket. And she thought that was the funniest thing ever. You would just be like, pears, [SCREECHES] Just in the back of the car, just saying stuff. And she's giggling the whole time.

I mean, if you watch a video like this, this is clearly delightful. There's not a lot that's Sweller and colleagues have to say about being delighted. I think, if you were to situate the moral ethic of work around learning in cognitive load theory, it's very, like, learning is hard. We persevere through a hard thing, and we control the hardness of it so that we can scaffold it for people.

And for situated learning people, they aren't really-- these aren't arguments. Sometimes they're explicit arguments. Sometimes they're just tones that you find in the way people talk about these things. They'd be like, oh, learning is great. Learning is the thing that we do and get better at stuff. It's nice and natural and things like that.

Can anybody think of a thing that you've learned in which you got better at the thing, and it was just playful, enjoyable, natural to get better at it? Anybody can shout out one or two things that was like that for you.

AUDIENCE: When I first learned how to use a power drill.

JUSTIN REICH: Awesome. Great. Learning how to use power drill. Very satisfying, immediate feedback, things like that. Yeah. Other things that people really enjoyed learning?

AUDIENCE: I think, similarly, tactical things, like learning how to do pottery.

JUSTIN REICH: Oh, great. Yeah, pottery seems like a good one.

AUDIENCE: Learning how to swim.

JUSTIN REICH: Learning how to swim. All right. We're saying a lot of physical things. Good.

AUDIENCE: Video games.

JUSTIN REICH: Video games. Video games are-- there is a whole science. We won't read it. There's a guy named James Gee, who wrote a great book about learning and video games. It's a little bit like Tocqueville coming to America, if that's a reference that you know. But Tocqueville was this European who came to America, and he saw America incredibly intimately in a way that only an outsider could, in part by becoming an insider.

James Gee is an old guy who was like, why do my kids like video games so much? And he starts playing with them. He's like, these are amazing learning experiences. Think about someone learning a really hard game, like *Civilization 6* or *Stellaris,* or put in whatever game you've been playing recently that just has incredibly complicated systems in them. There aren't a lot of people who are-- *Minecraft,* redstone building in *Minecraft,* stuff like that.

There aren't people who are like, god, it was such a drag that I had to take all those classes on redstone to be able to, blah, blah, blah. These games have systems built within them. They're-- almost all of them-- canonically situated kinds of things, where you're just immersed in the environment, you're encouraged to play. There are some peer structures around to help you learn and stuff like that. But it's extremely pleasant, even when people might find it frustrating or things like that.

I think a lot of-- in families, cooking is something that-- learning how to cook, which has both tactile and scientific measurement, mathematical, language components that people often find quite pleasurable.

AUDIENCE: And this connects a lot to the material I'm learning in CMS 587 about assessments. We're learning about the different theories of intelligence and how, if you believe that your intelligence isn't fixed and it can expand, then you can learn a lot more. And that's kind of like young children or babies, because they're not really afraid of failure. And they're just-- they're very resilient.

JUSTIN REICH: Yeah, yeah, yeah. They don't care what's going on. They're just trying to figure things out. How many of you have had experiences that you're really happy with, where learning was hard, where you persevered through a challenging set of learning experiences and got better at it? And you were like, yeah, that's great. I'm super glad I did that. What things come to mind for that for you?

AUDIENCE: I think, for me, learning to code was like that. I think differently from some people in the room. I didn't learn to code in middle school. I learned it in university. So there were traits associated with it and things like that.

JUSTIN REICH: Yeah. Yeah. You watched a bunch of lectures and did Psets and turned them in.

AUDIENCE: But I remember the first very complex Pset that I completed and my program worked perfectly. And I was like-- it was an amazing feeling.

JUSTIN REICH: It felt very satisfying, even though some of the learning experience of doing that-- yeah, yeah. So that kind of-- I think there's a moral story that emerges around a lot of instructionist learning, which is like, it was hard. We put our nose to the grindstone. We sacrificed. But after that sacrifice, we had this great feeling of relief.

And I think most of us have some kind of learning experience that goes like that. And then situated learning people have more of the story of, we just naturally found ourselves in this space surrounded by opportunities to learn. And it was playful, and it felt easy and natural. And that's what we're trying to restore there.

So actually, the cognitive load theorists have, to me, what I think is a funny way of dealing with this. There's just a guy who proposed that there's two categories of things that are learned, called biologically primary and biologically secondary kinds of things. And we're evolutionarily wired to naturally learn biologically primary kinds of things, and everything else is biologically secondary and is much harder, so that you're naturally wired to learn how to walk, how to eat some basic parts of socializing, recognizing faces.

Language ends up being a real problem for this because it's like, are you biologically primed to learn your first language, to learn multiple languages? Why would you be biologically-- why was it easy for me to learn English when I was young, but Spanish was really hard when I was older? Did my brain change? Did evolution-- anyway.

I actually find this theory totally unsatisfying. Are any of you familiar with the idea of epicycles? Before the Copernican revolution, everybody thought orbits were circles, not ovals or whatever it is that they're supposed to-- what is it? What's the shape of them?

AUDIENCE: Ellipses.

JUSTIN REICH: Ellipses. And there was a period of time when they realized, oh, circle measurements don't work. And so they added circles to the circles. They believed that there had to be perfect circles making the orbits. And so they believed that somehow there were orbits within the orbits.

And then I think it was Copernicus who came around and was like, actually, it's just like this. And that works a lot better. But to me, biologically primary and biologically secondary things operate-- that seems a little bit like an epicycle to me. We haven't quite figured out what's going on there.

But that is how, canonically, the cognitive load theory people just wave all this away and say, ah, babies, whatever, biologically primary. We don't have to worry about them. Everything after you're four years old or something like that is cognitive load theory works.

But for the situated learning people, not exactly, but in a lot of ways they're trying to recapture the learning experiences that we have when we're very young, where learning is natural, playful. It's not always happy, but often socially satisfying and extremely effective. I mean, what babies learn in a short period of time is just bonkers. It's one of the most fun things about being a parent, or an auntie, or an uncle, or all the other ways you get to spend a lot of time with kids.

OK. Let's just get oriented here. So again, we're in foundations. We're trying to get a hand of these two contemporary learning theories, cognitive load theory, situated learning, that these two ideas about how people learn are ancient, that you can find people like Plutarch, "For the mind does not require filling like a bottle, but rather, like wood, it only requires kindling to create in it an impulse to think independently and an ardent desire for truth."

This is Plutarch making a case for situated learning and against cognitive load theory, though he wouldn't have known those terms because they didn't show up for another 2,000 years. But you can hear the resonance of the debate in his mind.

Here's a little chunk from a 2017 *New Yorker* article. "For nearly a century, public education in America has been influenced by two opposing pedagogical approaches-- traditionalism and progressivism." A thing that you've got to catch is that there are these two ideas that each of them has 8,000 different names. But anytime you notice this dichotomy.

"Broadly speaking, in the traditional approach to education, a teacher imparts knowledge to students through direct instruction and embodies a disciplinary culture in which obedience is both prized and rewarded." That's a nice-- she frames it. Here's the pedagogical piece. Knowledge is imparted through direct instruction.

"And embodies a disciplinary culture in which obedience is prized and rewarded." Obedience was not prized and rewarded amongst the baby on the playground. What was rewarded was screwing around. "The purpose of the classroom is to equip all students to meet measurable academic standards. At progressive institutions, a teacher develops a curriculum but urges students to treat it as a staging ground for their own intellectual discoveries, often through hands-on activity and group work.

Allowances are made for differences in the way individual students learn. Progressivism was inspired, in large part, by the work of John Dewey, the American philosopher and education theorist." Maybe I'll say that last line. "For Dewey, the classroom was not simply a place for acquiring academic credentials; it was also a venue in which students learned crucial values about being citizens in a democracy."

So maybe these things are laden not just with pedagogical ideas, beliefs about human architecture, cultural values, but even maybe the outcomes of education. Maybe we believe differently about that, though not necessarily.

The person who's probably the best counterpoint to John Dewey is this guy, Ed Thorndike, who is a very early educational psychologist. I often think of him as a guy who was like, no, no, no, pail filling is great. A particularly great thing about pail filling is that we can measure pail filling. You can measure the rate at which you pour things into people and the rate at which it falls out and how leaky people are and some of those kinds of things. So he was very involved in testing.

He actually played a really important role in developing ideas that educational progressives hold dearly. One of the things he studied, which we'll talk about as the course goes on, is this idea of transfer. So in the 18th, 19th century, people in America or Europe believed that a great thing about learning Latin and Greek was it strengthened these kind of generic thinking muscles. Like if you got really good at learning Latin and Greek, you would just be a good thinker.

And he was like, that's dumb. If you learn Latin and Greek, you're good at Latin and Greek, but you're not actually good at anything else. The brain is not general purpose like that. But that kind of thinking-- that kind of thinking, if I learn this thing, it'll help me generically with these other things-- shows up all the time. The most contemporary version of this is-- have you ever encountered the idea of computational thinking?

What people mean by computational thinking, almost all the time, is we're going to teach you computer programming. And if you learn about computer programming, you're going to learn how to break ideas down into smaller parts, and you're going to learn how to think algorithmically and do all these other-- and it's like, no, you're going to be good at programming computers.

If you want to be able to break ideas down in poetry, learning computer programming will not help you do that. I mean, it will help you about as much as learning Latin and Greek will help you do that, which is to say, not that much, that a frustrating thing about teaching is the things we learn tend to only help us in very near cognate areas.

So these are the two-- again, I'm trying to give you the sense that these two big ideas are millennia old. They have a scientific basis that's at least a century old. And you're getting what I think are some of the best, most recent contemporary formulations, like the work of John Sweller and some of these other folks, like the little piece you read from Mitch Resnick for today.

And then maybe just to give you a broader overview, overwhelmingly, Thorndike has won. If you were to walk through a typical American school on a typical American day, you would see very little education as life itself, and you would see a lot of direct instruction. The canonical experience of students in schools is very organized around direct instruction.

However, if you were to ask teachers who their favorite educational philosopher is, you would get a lot of answers that are Dewey, and you would not get a lot of answers that were Thorndike. So Dewey is beloved in a way that Thorndike is not, but Thorndike is actually the person who inspires more of our ideas.

All right. Let's do just a little bit of close reading together, which is mostly me telling you about some things that you should read closely. This is what we looked at yesterday. One thing that's fun about the cognitive load theory people is that they're really good at stating clearly what their models of human cognitive architecture are.

I think the situated learning people have cognates. I think they have things that they believe are central about the brain, how learning works, but they would draw a different model. This is not what they would draw. And they're less explicit about it, which makes our job a little bit harder.

But a thing that you can be thinking about now is, what is the situated learning cognate of this? What would be the pieces that they would put in the model that would be most important for their developmental learning? We'll play with that as we go along a little bit.

OK. How many of you have ever used the Logo programming language? Oh good. How many of you have used Scratch? OK, then we got everybody. So Scratch is a descendant of Logo. Logo is a programming language that was developed by Seymour Papert in the Media Lab, one of the first efforts to bring computer programming to kids in schools.

When I was in the fourth grade at a Montessori school in South Natick, not far from here, we had a little computer lab, and Logo was the language that I learned to do a little bit of programming in. You'll see that a lot of it is about shapes and geometry, but what I really loved about it was Choose Your Own Adventures.

So you could essentially write a program or function, whatever it is, in which someone types a word and that triggers the display of a set of text. And so it wasn't that hard to make Choose Your Own Adventures. You're at the front of the house. Do you want to walk up? Type "porch" if you want to walk into porch. Type "knock" if you want to knock on the door. And then knock is a program that releases another set of text, and you can make a Choose Your Own Adventure that way.

How important is that for you to know? I don't know. But here is a few minutes of Seymour Papert, who was a student of Jean Piaget, who's another kind of major social constructivist thinker. Here's what Logo was supposed to look like in the classroom in the 1980s, about when I was a kid.

[VIDEO PLAYBACK]

- The idea is quite simple. Let a child learn mathematics by speaking in mathematics about things that really matter to him. So at MIT, we've given computers the power to turn motors, to make sounds, to draw pictures, and we've found ways of giving children the power to control the computer.

So the child can make the computer do anything that he can describe in a suitable mathematical language by typing on a keyboard like this.

- Play it.

[PLAYFUL TUNE]

That's what P1 sounds like. OK. Tap P2.

[PLAYFUL TUNE]

That's P2. And P3.

[PLAYFUL TUNE]

- A computer-controlled turtle is made to draw and dance by programs so simple that all children invent them in the first days of the course. Thus, the child acquires a taste of math power that grows and grows as his projects become more original, more complex, and more varied.

- So you have the first one, then the second one, then the third one, then the first one again for the ending.

- OK.

- Now they will put the little tunes together to make a bigger one.

[LONGER PLAYFUL TUNE]

- Try it.

- Now I'm telling it to do it. Oh no. Sometimes I get into the box like this and it'll-- when it was doing it in his mind, the little turtle, the little triangle thing, was on an angle. So it drew the picture on an angle. So now I'll go back and have it draw it in its mind again while it's in the right position.

- And so the child doesn't have to be told by a teacher whether he's right or wrong. He can see for himself whether it works. That's what science and knowledge is about.

- So this procedure is named Fancy. And then you have an input, which means you can vary the size. I'm going to make it 100. Right now it's doing a procedure called Top. And each one of those little fins is called Fin. And that's another subprocedure on Top. Now it's doing Inside.

- There are identifiable techniques for working on a problem. One of these is known by these children as writing procedures as subprocedures.

- Inside and Top are the two main subprocedures. And the other one, the tail is made out of odds and ends, just put together.

- The technique's very well known. Subdivide the problem. Split the difficulties. Make a procedure out of subprocedures. Make a whole--

[END PLAYBACK]

JUSTIN REICH: I'll just tell you one second about this little robot, which, again, is iconic to my childhood. I had a commercialized version of this. But it takes the same commands and uses the same language as the turtle that's on the screen. So you tell it Forward 10. And there's some equivalent to Forward 10 that also shows up on the screen.

It has a pen that's mounted in it that's controlled with Pen Up and Pen Down. So you can make varying kinds of shapes using that. And then if you see the cable that the person is walking around with, that was a serial cable, which is the primary thing we used to use to connect computers to peripherals. So before wireless or before USB or other things, that was the cable that they were using to move things around.

[VIDEO PLAYBACK]

- --subprocedures. Make a whole out of parts. Understand each separately. Everybody knows that, but they don't do it.

- Now it's moving across the screen the way I told you it did it before, but this time, this is the way I taught myself to get it across the screen. It's the first time I had done it. And so the way I had the little one to go is every time it moves up a little, it subtracts a number, a little bit of a number. And then it's a small number. And when it's a certain number, I tell it that it should stop.

- Martha is getting mathematical knowledge in a meaningful context for use now.

- It just told me I can't move off the screen.

- When I was at school, they told me to learn long division because I would need it when I grew up. And I think I knew it was a lie. I think it was to make me despise the teachers a little more.

- Now it's telling me to give a subprocedure. Now the bottom of the fish.

- Steven is using the ideas of angle, of subprocedure, of arc, and of circle in a confident, purposeful way.

- The tail, the triangle part, is made out of a procedure called Try 1. First you've got to do Right 16 and Forward 50, Back 50. Left 60, Forward 50, Back 50. Left 60, Forward 50, Back 50, and so on and so forth.

Now it's doing a Firm. That's a radius of 300 and an arc of 90. I made a big radius. And then I went left, which will go right over it and bring it back. And then I made a smaller radius of the same arc. And then it would do that again.

Then it's an even smaller one. It will do that again. And that's how I got the fern. There we are. There's the finished picture.

- I've made a big song, and I used that for part of it. And then I made an accompaniment with it with the drum. And that's--

[PLAYFUL TUNE]

- The kids tell me that's a spiral. And I think that was a new mathematical word that was born there that's going to stick. I'd call that real discovery.

[END PLAYBACK]

JUSTIN REICH: Good. We won't spend time with this. Turn to the people next to you. Talk to them a little bit. What are the things that you saw in there that cohere with ideas that you read about from other communities of situated learning? What are some things that you saw in there that cohered with cognitive load theory? Do you see evidence of direct instruction that was in there anywhere?

And then, what kind of learning environments have you been, where you learned in this kind of way that was pleasurable, and have people been in learning environments where you've learned in this way that you found very unpleasurable and unlikable? Discuss that for a couple minutes. Ready? Go.

AUDIENCE: Every time. It's awesome.

JUSTIN REICH: Good. What are some connections that people made? What are some things where you saw examples of situated learning or cognitive load theory, or things that seem pleasurable or frustrating? What did you talk about in your groups?

AUDIENCE: We were talking about learning programming in general, or it seems like you always need some base level of whether it's the instructions or knowing whatever commands there are in Logo, and that most likely comes from more of an instructional place. But then you can get into these situations, like we saw in the video, where it becomes open world. But it still seems like you need some base level where CLT needs to come in.

JUSTIN REICH: Yeah, or some kind of direct instruction. What evidence of direct instruction did people see? Where were you like, eh, that kid didn't figure that out on their own.

AUDIENCE: I mean, just the terminology. They figured out procedure, subprocedure, all of these things hard phrases. A kid wouldn't just figure this out.

JUSTIN REICH: Yeah. Yeah. It doesn't seem like Steven came up with the term "procedure" and "subprocedure." Pretty sure somebody taught him, sat down, and said, here are a couple of useful definitions that will allow us to communicate with this more clearly.

AUDIENCE: Also, we were talking about when the two girls were talking to each other. It was like one at the beginning was instructing the other to actually make the music.

JUSTIN REICH: Yeah.

AUDIENCE: So I guess that's kind of--

JUSTIN REICH: Oh, very direct instruction.

AUDIENCE: Yeah. Direct instruction within a situated learning environment.

JUSTIN REICH: Yeah. Yeah. I mean it's-- yeah, yeah. It's a kind of worked example. Oh, I'm going to show you how I made a thing. We're going to make this thing together right now by, first of all, play each of the pieces. Now we're going to play all the pieces together. I've already learned how to do that. What makes it a kind of peer learning, situated learning kind of thing is it's one young person teaching it to another person. But it does seem to be direct instruction, for sure.

AUDIENCE: That kind of led us into a conversation about how, within situated learning, that there's two ways that it can be seen as you have someone who's an old timer, like the other girl explaining to the other girl about the situation that they were working with. But then there's also the instances when it was just the student and the computer and that you lost that social aspect that you have of learning from another person.

And then we went into an interesting conversation about whether maybe the student was having a social interaction from themself and learning with the computer as a tool, or maybe they were having a social interaction with the computer itself and they were learning from the computer and the computer was learning what they really wanted the outcome to be.

JUSTIN REICH: Yeah. Yeah, good. Yeah, that's definitely something we'll think about more as we go along. What kind of agent is the machine? What kind of relationship do we have to the machines? How does the machine motivate? How does the machine explain? The thing that seems pretty rad here, that Seymour Papert is telling us, is that the machine gives some great feedback, although lots of other things do.

Hand drills give great feedback. When you go through the wall, you know it. And when you hit something metal or something like that, you know it. And you get that kind of instant feedback. There are other things that we teach people where it's just hard to imagine where that instant feedback might come from. Writing is often that way, especially writing other people.

There's nothing that is-- we haven't built things very well where a machine can tell you, oh, that's a compelling way of expressing that idea, in the same way that I can be like, oh, my swan is on its side. So different technologies and different things that we study have different capacity to give us immediate feedback of what we're doing.

Good. Has anybody ever been in an environment like this, where you're like, oh my gosh, this is the worst? Anyone have experience in this kind of open-ended learning, where you're like, this is terrible?

AUDIENCE: Yeah, I remember this one-- I guess this is a more recent MIT experience, where basically one of the classes' final project was very open ended. And they were like, oh, just design this game. And I was like, wow. It would be nice to get some kind of--

JUSTIN REICH: Yeah, will you please show me how to design this game? Someone has figured this out before. I don't want to explore this space forever. No, I've definitely had people who have taken this class, and they watch this video, and they're like, give me a break. Just show me how to use the turtle.

AUDIENCE: I would say, in high school, a lot of the AP Computer Science classes are very into this kind of situated learning. But then, if you have certain classrooms where-- in my instance, it was just overloaded with people who just needed an elective. And they were like, you have to take this class. Then it becomes-- that peer-to-peer interaction becomes an issue where it's like, OK, you have three people who are trying to teach 30 other people how to do a specific thing because you're in the same group and they have to pass, and they don't really care anyway.

JUSTIN REICH: Good. People have different motivations. I mean, a huge problem that computer science education has is that people-- unlike other subjects, people come to it with very different levels of background experience. So none of you probably ever took a geology class where a third of the kids were like, man, I just love geology. I do geology all the time in my spare time. I'm way ahead of you guys.

But that is essentially what just about every computer science class we teach is like, where a chunk of people are way into it and know a bunch more already. And in fact, those open-ended environments can be really great for those folks who have that extra expertise, and they can be a real bummer for people who can't jump in as naturally. Harmon, what were you going to say?

AUDIENCE: I think what this made me think of is how CLT and situated learning cannot be really separated from each other. Sometimes you need to CLT to give framework for students, and then from that, I guess, you can fire the wood and the situated--

JUSTIN REICH: Yeah. Good. I like it, I like it. Yeah. Yeah. What are the-- I think that's a great question to ask. What are the different combination and permutations-- the reason why these ideas have existed, that we can find evidence of them for 2,000 years, is that they both seem pretty good. They both seem useful in different ways.

Seymour Papert is once talking about his teachers lying to them and despising schools. But you can also find school things, like we're going to need some definitions that I teach you that are kind of woven even in this extreme example. Let me give you a few pieces from the thing that you read from a guy named Jean Lave, who, with another person named Etienne Wenger, really advanced some of these ideas.

And I want you to be thinking about, so how is it like-- what are the methods that this person uses to study? What are the kind of arguments they make? What are the implications for pedagogy? What's their framework about human beings and how they learn? And where do these things lap and overlap?

It can often seem like when you're writing about-- if you read a bunch of stuff on cognitive load theory, it seems like they're just talking about instruction, and they mostly are, but there are ways that talking about instruction that evoke their beliefs about culture, that evoke their beliefs about values, that evoke their beliefs around methods and outcomes, even if they don't talk about those things as much.

"In this chapter, I propose to consider learning not as a process of socially shared cognition that results in the end in the internalization of knowledge by individuals, but as a process of becoming a member of a sustained community of practice." So anytime you read anything, a thing that you are almost all probably trained to do is try to figure out, what is the person's core argument? What is the thing they're arguing for?

An equally useful thing to do, almost any time you read anything, is to try to figure out, what is this person arguing against? And people are often not that explicit. He's not saying, these jerks who are really big on schools and direct instruction have totally missed this stuff. But that's kind of what he's getting at in here.

And it's a radical statement. Learning is not the internalization of knowledge. Last week, I told you that, for some of these kind of educational psychology people, memory is the residue of thought. The entire endpoint of cognitive load theory is to store facts as memories in our long-term memory.

"Not as the internalization of knowledge as individuals, but as a process of becoming a member of a sustained community of practice. Developing an identity as a member of a community and becoming knowledgeable and skillful are part of the same process. You cannot separate storing things in long-term memory from building relationships with other people, with the former motivating"-- one of the key things that we remember our colleague Michael Pershan, not a theory of everything, where is the motivation?-- "with the former motivating, shaping, and giving meaning to the latter, which it subsumes.

It is difficult to move from peripheral to full participation in today's world, including workplaces and schools, thereby developing knowledgeably skilled identities. This is because the processes by which we divide and sell labor, which are ubiquitous in our way of producing goods and services, including knowledge, truncate both the movement from peripheral to full participation and the scope of knowledgeable skill.

Taken to an extreme, these processes separate identity from intended forms of knowledgeable practice. This view implies that learning and failure to learn are aspects of the same social historical processes, and points to relationships between knowledgeability and identity as important focus for research." These jerks, these education psychologists, keep trying to convince you that what learning is is just shoving stuff in your brain. It's not.

There are always people around when we're learning. Even when we're learning by ourselves, reading books and stuff like that, there are people in our minds, in our communities that we see ourselves being part of. Trying to understand how learning happens in schools or any other learning environment without thinking about the social environment that people learn is bonkers. It's nuts. It denies a crucial part of our humanity.

Here is a blog post that you can look at later if you follow this link. It's by a wonderful math educator named Dan Meyer, who has been trying to explain to people why he thinks AI chatbots are a stupid idea and will not work. And his core issue is, nobody wants to talk to a computer.

Maybe the computer can provide a perfect, direct instructional sequence, but the kids who are in my eighth grade algebra classroom, they don't want to be there. They're not interested in algebra. I love this framing. "A student attends school to answer two questions-- who am I, and how do I do this?" Those are the two things they're thinking about all the time. Who am I, and how do I do this?

A chatbot cannot help you at all with the first question. But the other thing that I want to bring up here-- and you can disagree with that, and we'll talk about it more when we talk about chatbots. But who am I, and how do I do this? This is exactly what Jean Lave was discussing, that identity cannot be separated from the acquisition of knowledge.

And I think most of you probably-- if you think of your own classroom experience, think of your own school experience. I spent a lot of time in middle school and high school thinking to myself, in one form or another, who am I? What do people think of me? What kinds of relationships do I have? Why am I here? What am I supposed to be doing?

"Jordan has carried out extensive field research on the Yucatan Maya midwives whose apprenticeship is quite different-- more effective and less exploitative-- than the butchers of Marshall's study. The apprentices are peripheral participants, legitimate participants, and legitimate peripheral to the practice of midwifery."

What did you all take away from what you think-- what is legitimate peripheral practice or periphery? What does that mean in your own words? What do you think, Dana?

AUDIENCE: They're doing work that matters, but they're not doing the main work. They're doing side tasks that are helping them understand the main process, but they themselves are not giving birth to the child.

JUSTIN REICH: Good.

AUDIENCE: [INAUDIBLE]

JUSTIN REICH: And there's a space there. A space is held for those people. It is expected that there are going to be some folks who are hanging around midwives who are not quite midwives yet, and that's normal. They're supposed to be there. It's not a classroom of 20 people all lined up who are supposed to be doing the same thing all the time. There's supposed to be some people in the middle, and there's supposed to be some people on the outside.

AUDIENCE: I want to pose a question too, to think of the relationship between what Jean Lave was talking about, the midwives and the butchers, and the thinking, what's the difference between peripheral participants and legitimately peripheral participants? Do folks remember what they described about the butchers?

AUDIENCE: Yeah. It was that the butchers, even though they were doing peripheral work, they were separated in space from the experts. So they wouldn't really pick up on things, as opposed to midwives who would still observe what the legitimate-- the expert was doing.

AUDIENCE: Yeah. So what does that mean in terms of being a part of that community, and then shaping the learning that they're able to acquire? If I'm a butcher and I'm part of the community, if I'm standing over here cutting my meat, using my tool, that's all I get to do. And then Justin's over there, hanging out with the pig or whatever it is, right? What am I losing then?

AUDIENCE: The social aspect.

AUDIENCE: The social aspect. Am I able to observe him? Can I see what he's doing? When he leaves, can I pick it up from watching? Totally miss that. But then, what about the midwife? How is that different? How do they describe the midwife relationship? Justin, I hope this is OK.

JUSTIN REICH: Yeah, sure.

AUDIENCE: I love this book. So yeah. Go ahead.

AUDIENCE: So I think one of the main differences is beyond the fact that it wasn't supposed to be more efficient. So there was no capitalist aspect to it. There was a lot of culture embedded in it. So the daughter of a midwife would become a midwife, meaning that at five years old, they would already be present in that situation and start picking up on what was going on, and then progressively have a more protagonist role to that experience. So.

AUDIENCE: Yeah, so although both could be argued as peripheral-- we're in the same space, we're hanging out-- who's welcome in the community, and what type of knowledge are you able to gain from that type of peripheral participation? It's kind of cool. It's subtle, right?

AUDIENCE: Yeah.

AUDIENCE: All right. That's all I got.

AUDIENCE: Can I make--

JUSTIN REICH: Yeah.

AUDIENCE: OK. The previous paragraph, I had a lot of reflection about it. And I don't-- that in some aspects-- I'm not sure how you feel about it, but I really like the point that he makes about learning kind of forms your identity as part of this social group, right? And I think that really applies to kids, for example. They come from this peripheral existence and develop their own identities and become a committed, functioning part of society.

But then it really made me think, oh, how do we think about it from an ableist perspective, where people cannot acquire certain knowledges or certain abilities, and does that mean they have less of an identity? I really thought about that for a while.

And at the same time, there is a criticism in the book about commoditization of knowledge because before, with midwives, et cetera, it was this really specific group of people teaching this very kind of expertise, whereas today, we have universities and we have schools where you can get to whatever class and learn things.

But it's not necessarily all bad, right? Because that would imply that if you're the daughter of the midwife, you don't really have a lot of say into becoming or not a midwife. The way that society was structured back then, that likely you would kind of become one, because that's what expected of you. Whereas when you can choose that, you have some sort of agency and power, even if you won't have that exposure as a peripheral participant since you were a kid. So it really made me think of many things.

JUSTIN REICH: Great. Good. And none of them have to be resolved either. Probably some important things to take away are like how Jean Lave assigns values to these different kinds of institutions. He thinks it's a big problem-- a big problem with schools and university is ripping knowledge away from these broader social contexts, that you go and take a physics class, and in the vast majority of Physics 101 classes, no one is trying to get you to be a physicist.

They're not trying to get you to develop the identity of a physicist. They're just trying to teach you the physics. And what is lost in that? Of course, what's pretty rad about walking into a campus full of people who'll be like, yeah, I'll teach you any of these atomized little things for you to learn. That seems kind of cool, too.

"It is worth noting that it would be difficult to find evidence that teaching is the mode of knowledge 'transmission' amongst the midwives." He makes his claim that you wouldn't find direct instruction amongst the midwives. I mean, Jordan did the fieldwork and not me. That seems totally laughable to me. I've spent time with lots of people of lots of ages, learned lots of kinds of things, and people are always transmitting and explaining stuff. It's always nested in there.

But there's a kind of politics of Jean Lave, like, we don't even need to explain these things. We don't even need to teach these people. We can learn it just like babies learn it, in their natural environment. Just like you have to surround babies with language and they'll learn language, you surround young girls with birth and pregnancy and they learn midwifery.

"Apprenticeship happens as a way of, and in the course of, daily life. It may not be recognized as a teaching effort at all." Again, this is doubling down. There's no instruction here. If there's instruction, the people are lying to you, and you should despise them.

"A Maya girl who eventually became a midwife, most likely has a mother or a grandmother as a midwife. Girls in such families, without being identified as apprentice midwives, absorb the essence of midwifery practice as well as specific knowledge about many procedures, simply in the process of growing up. They know what the life of a midwife is like, what kinds of stories the women and men who come to consult her tell, what kind of herbs and other remedies might be needed to collected.

As young children, they might be sitting quietly in their corner as their mother administers a prenatal massage. They would hear stories of difficult cases, of miraculous outcomes, and the like. As they grow older, they may be passing messages, running errands, getting needed supplies. A young girl might be present as her mother stops for a postpartum visit after the daily shopping trip to the market.

Eventually, after she has a child herself, she might come along to her birth, perhaps because her ailing grandmother needs someone to walk with, and thus finds herself doing for the woman in labor what other women had done for her when she gave birth. That is, she may take a turn at supporting the laboring woman. Eventually, she may even administer prenatal massages to the selected clients.

At some point, she may decide she actually wants to do this kind of work. She then pays more attention, but only rarely does she ask questions. Her mentor sees their association, primarily one that is of some use to her. 'Rosa already knows how to do a massage, so I can send her if I'm too busy.'"

That is just a beautiful description of legitimate peripheral participation moving from the periphery to the center. You just watch this thing for a while. And then your mom's hands are a little sore, and so you do the massage this time. And you know how to do the massage because it happened to you. You've seen it a zillion times. Are any of you part of clubs or groups at MIT that have learning that feels like this?

AUDIENCE: I guess, technically, a lot of theater clubs are similar.

JUSTIN REICH: Good.

AUDIENCE: People are just doing this. How do you become a stage manager? I don't know, look at what the stage manager does.

JUSTIN REICH: And the other thing is like, you start as a stagehand. Yeah, yeah, yeah. You watch some theater. Yeah, just stand there. And between the second and third act, hand this prop to that person. And you're probably never going to take stage manager class. You're just going to hand that prop once, and then you're the prop master. And then the stage manager gets sick, and you do it for the night, and then you're the stage manager. Yeah, I think theater has a ton of stuff like this. That's a great example. What were you going to say, Omar?

AUDIENCE: In *The Tech* and *Technique,* we have what's called shadowing. So when we go out for photo assignments, where there's a studio photography assignment or something out in the field, we can always have someone shadowing us, and they can also be taking photos with their own camera. And sometimes, we will use their work as well. So they can also do legitimate periphery work.

JUSTIN REICH: I love it. And you have intentionally held space for that. You've kind of designed like, oh, yeah, come along, hang out with us. And you probably have parties and other kinds of things like that where it's like-- where some of it you're just goofing around, but some of it you're like, oh, the story that we got, da, da, da, da, da. Them telling the stories of difficult cases and miraculous outcomes. I'm sure the tech has other similar kinds of difficult cases and miraculous outcomes.

AUDIENCE: I was going to say, on sports teams, when people become captains, not often is the coach sitting them down and being like, this is how you be a captain, this is how you lead people. It's more like they just naturally have this personality of doing that, of maybe they grew up and their mom was a girlboss, or they just grew up seeing stuff like that. So then you have that natural progression into just learning by doing.

JUSTIN REICH: Good. Yeah, yeah. What were you going to say, Sabrina?

AUDIENCE: OK, this is kind of a dumb example--

JUSTIN REICH: I like them.

AUDIENCE: I'm really bad at *Smash,* so I always get placed with the best *Smash* player. And then we're on a team against two other people who are also really good. But this person is so good that--

JUSTIN REICH: They carry.

AUDIENCE: They carry. But I'm kind of learning along with them. And I kind of hold off onto the side, where I just kind of try to hold lives while they destroy the other people. And I think that's kind of periphery.

JUSTIN REICH: Oh, yeah, yeah, yeah, yeah. I mean, in that particular community, it's a space of legitimate peripheral participation, which somewhat exists because of this fairness, balancing kinds of things. And so every learning environment, the substance of *Super Smash Brothers* determines where the legitimate-- and it determines spaces for peripheral participation that's different than journalism, different than sports. They're different.

But this theory is giving us commonality, where we can talk about really different things that might arise in different circumstances. But I think that's actually kind of the same thing. And there's kind of spaces that I'm finding for learning.

"In short, when official channels offer only a possibility to participate in institutionally mandated forms of commoditized activity, genuine participation, membership, and legitimate access to ongoing practice-- of a practice considered worthy of the name-- are rare. Practice is not to be found in schools and workplaces. At the same time, schools and school-like workplace educational enterprises accord knowledge skill a reified existence, turning it into something to be 'acquired' and its transmission into an institutional motive.

This process generates pressures towards the trivializing decomposing of forms or activity. The result is a widespread generation of negative identities, of misrecognized or institutionally disapproved interstitial communities of practice." Some of the things that might feel most academic might feel least identity-oriented to you because there's not-- think about, what degrees here would be like, I'm not sure there's a way to be a legitimate peripheral participant there?

There's a way to learn the stuff. There's a way to be taught the discrete parts of this course or subject or major. But I'm not learning how to be a part of this community. OK.

Here's three things that I'll have you do together for 5 or 10 minutes, which might involve some drawing. So grab some paper or some board space. See if you can draw the equivalent of human cognitive architecture. See if you can draw-- just like you drew these diagrams for cognitive load theory, what is the diagram you would draw for situated learning?

Based on that cognitive architecture, what is the pedagogy that follows? So based on the key fundamental principles of situated learning, cognitive load theory said, here's a model of human cognitive architecture. Here are a series of clearly defined effects. The situated learning people are not as good as enumerating in bullet points all of their pieces, but it's all in there.

What are some of the instructional practices that follow from this model? Think about those two things, and then also see if you can recreate some of your Venn diagrams of, what are the categories of things that seem separate from cognitive learning and situated learning, and what are the things that they seem to be quite similar on or quite together on?

Take 10 minutes to, again, grab one person or two other people, do some drawing, do some composing. Feel free to pull up your notes from your learning journal, where you should have done some of these things. And if any of these questions-- you don't have to spend equal time on all three questions. If you dive in on one, that's fine. But those three should keep you busy for 8 minutes or something like that. Make sense? Ready? Go.

So one thing I love about almost all of these drawings is it's kind of impossible to draw these models without drawing other people, that when you all developed a kind of human cognitive architecture in cognitive load theory, you're drawing one brain. And actually, most of your drawings, you didn't even really represent the rest of the world.

But in this model, it's impossible not to represent the rest of the world, and in particular, other people, because learning fundamentally is social, and your identity is fundamentally reflective of your connections with other people. So these are good.

You read a little piece of "Give P's a Chance." So four P's from Mitch Resnick about Projects, Passion, Play, and Peers. Hopefully you can now start mapping some of these ideas to what we talked about-- projects, open-ended explorations, making music, making funny shape, having a robot draw funny shapes somewhere. Those are spaces for open-ended exploration, for doing multiple kinds of things.

Projects have more space for peripheral participation, like multiple people can be making music even if someone's a little bit better at making music than the other person, that learning environments here are driven by interests. There's very little reference in cognitive load theory to things like, well, yeah, sometimes the kids don't like learning math, so they just don't, although that's very real.

Some of the young-- some of the daughters of midwives want to become midwives and some didn't. And for the ones who did want to become midwives, they followed that interest. And those who didn't went and did other things. And in these kinds of models of learning, that's actually OK and really important.

We're not supposed to make everyone better at everything. We're supposed to let people follow their interests and get good at the things that they want to get good at, that in environments in which there is a kind of lightness to the environment, lightness and play create space for multiple forms of participation. Things don't have to be optimized to get to the fastest, best trajectory for all people.

There can be room to play and mess around and try other things. And then doing it with other people is essential, as you can see in all of these kinds of things. And part of what, in some ways, the real genius-- Jean Lave was a woman. I misrepresented her as a man before, and Erin helpfully corrected me.

Etienne Wenger, her partner, is a co-writer, is a guy. It's not just people hanging out with each other. We can describe repeated patterns we see of legitimate peripheral participation of old timers and newcomers. There's lots in Lave's work that you probably read that was about trying to find new language to get away from the experts and novices, because that's part of it, but it's not just that. It's our time in a community, it's our space in the community, those kinds of things.

So just like in cognitive load theory you could say, here's a human cognitive architecture, here's a set of pedagogical principles that follow from that, Jean Lave can describe these social interactions. You can abstract from them some models of human cognitive architecture and say, well, OK. From those models, there are some instructional principles that follow.

If I were to draw one of these, I think a thing that I would pay a bunch of attention to is that the thing in both learning models, you learn what you attend to. Seeing is really important. A key insight of situated learning is that we attend to things that interest us and motivate us and where we find our identity and care about. If looking at something is essential to get people to learn about it, then we ought to think very carefully about what motivates us to look at a thing.

T-ball, for me, is a canonical example of a kind of activity which would be almost impossible to teach primarily through cognitive load theory. It's really hard to imagine teaching kids baseball where you're like, all right, sit down, everyone. We're all going to watch a worked example of how you hit a ball. We have to learn the rule book of baseball.

The way we teach kids baseball is we're like, what is the fastest way we can get young people, with limited coordination and no knowledge of the rules, to play something like baseball? How do we get them baseballing as soon as we possibly can? And some genius was like, don't do the pitching. Get rid of the pitching. Just put the ball on the stick, and they can just hit the ball.

It has some kind of cognitive, some relationship to part-whole practice, to devolving scaffolding and things like that. There's a researcher at Harvard who wrote a book called *Making Learning Whole,* where he said that one of the things that we can often do in curriculum that we underestimate is get people playing the whole game as early as possible.

We'll talk about this more. But think about, what subjects have you taken at MIT that let you start playing the whole game as soon as possible? And what require you to build up lots of elementary pieces before you can do the thing that whole discipline does?

But baseball instruction in the United States, very difficult to imagine in a cognitive load theory framework, very pleasant for millions of young people in a more experiential, situated kind of way. All right. You did this a little bit, which is good.

Here is one thing that I would like to have in the center of your Venn diagrams of things that are similar. This is a misconception that my students have had over the years that I want to correct. The cognitive load theorists and the situated learning people agree on what expertise looks like. They agree on what high-quality practice looks like.

I don't think you'd find these people-- they would not disagree about what a great baseball player, or a great carpenter, or a great surgeon, or a great lawyer looks like. They would believe that-- sometimes people think that the cognitive load theorists want people who are experts to be really rigid and disciplined and pattern repeating, and that is not the case. That is not what they want as the endpoint.

They want your cancer surgeon to be dynamic and flexible when they cut open your belly and find cancerous tumors and are pulling them out of there. They want poets to be creative and imaginative. They just think that the way that you develop the knowledge base that lets you be creative and flexible and dynamic and strategic is through really disciplined instruction. Because if you don't go through a process of really disciplined instruction, it's hard to get good at things because no one has showed you how to do fundamental pieces in clear ways.

I have a couple colleagues, Jal Mehta and Sarah Fine-- Jal's still at Harvard, Sarah was there for a while and was at High Tech High Graduate School of Education for a while-- who studied schools a lot. Studied very different schools with very different pedagogical philosophies and found that, across all of them, they tended to believe that expertise consisted of mastery, identity, and creativity, that you knew a bunch of stuff in the domain, that you developed an identity in that domain, and that you were able to do flexible, creative work.

You know a bunch of physics equations and when to apply them. You feel like you're kind of a physicist and a scientist. And when you need to do something novel, like build a bridge or launch a rocket or something like that, you're not just following steps, but you're doing things that are creative and expressive. One way that I would-- I think the cognitive load theorists and situated learning people tend to imagine different pathways at getting at these goals.

So the cognitive load theorists tend to think that mastery is like the starting point. If you know the stuff, if you can do the pieces, then, A, we often most enjoy things that we're good at. So get you good at doing things. There's lots of debates in the country right now-- we'll talk about them some-- about teaching kids to read. And there are some folks who say, we just have to let kids explore books and find what they're interested in.

And there are other folks who are like, you know what's fun about reading, is actually being able to read. So teach them a bunch of phonics and explain to them the basics of how to construct words, and that's what makes reading enjoyable. That's what makes people feel like readers. Not when they have a beautiful library of things to choose from, whatever they want, but when they can actually make sense of what's in there.

There's some sense in that. You develop some kind of identity, and then you have the opportunity to do creative practice that builds on that mastery. There are other people who say, start with things like creativity. Start by getting people to play around in the space as much as possible so that they're motivated, so that they say, man, I am a this.

I'm a baseball player. I swung on a ball on a stick a few times. But now I am a baseball player. And because I'm a baseball player in my heart, I'll memorize all the statistics and learn the rules and go to practice, and eventually do really boring learning kinds of things, the mastery-oriented discipline kinds of things, but because I know how fun it is to play around in this space.

What do you think at MIT are the subjects or courses that you would take that would be more canonically mastery first-oriented? What are the subjects you would take that you would start with the smallest pieces, or by contrast, if it's easier, what are the ones that seem to be more creativity-first?

AUDIENCE: I think more bio-heavy classes would definitely be mastery-first, because if you don't understand the basics of cells, you're not getting anywhere. You can't go to chapter 2 without understanding--

JUSTIN REICH: Good. So it seems to be-- so eventually you can do some pretty rad computational biology, biological engineering here. But there's not a lot in Bio 101 where they're like, yeah, let's have cells start generating novel proteins or things like that.

AUDIENCE: I would say, most of the general requirements, especially the chemistry requirements and the biology requirements, are with the hopes that, hey, if you learned a little bit about this, maybe then you become interested and want to go further and want that to be your major.

JUSTIN REICH: Yeah. So which ones do that through giving you a bunch of facts, and which ones do that by letting you play the whole game? I mean, my understanding is that a number of the engineering departments-- like in mechanical engineering, you'd be more likely, earlier in your career, to be like, we're going to build a robot.

Do you know how to build a robot? No. Are you going to be good at building a robot? No. You're going to build a lousy robot. We're going to let you build a crummy robot. And some TA is going to put their arm around your shoulder and be like, that robot's OK. That robot's only OK because you don't know anything about control systems. But guess what? Guess what one of our junior classes is? It's control systems.

And you're like, I can't wait to take Control Systems. It's going to be boring. It's going to be a bunch of equations and other Psets and things like that. But there's a robot that you want to drive. The NEAT program, I think, at MIT is really about trying to create a bunch of these experiential experiences.

I mean, historically, if you were to look at our curriculum across MIT, many more things would be much more like this. I mean, our math curriculum, I think, is very much this way. You're just going to do math that other people have figured out for years and years. And maybe, by the time you get to the end of MIT, but you might have to wait till graduate school, you can do some new math that someone else has never done before.

My wife teaches in the Materials Science department. And some of the stuff with the Breaker Lab that they just developed and things like that, where they did an early exercise in one of her classes, which is, build products from the worst possible materials. So phone cases that were made of sponges and absorbed water, or locks that were made of clear plastic, where you could see all the tumblers and things.

Basically, play around with materials. Do stuff with materials. And then you're going to take some super boring, really hard classes, but you're motivated to take those things. So I think you can look across environments and see how they choose different pathways through these different-- and if you look at reading instruction in the United States, there's a huge debate right now about, do you start with mastery and facts and pieces and build up to readers, or do you start by exposing people to books and letters and words and the things they love.

And lots of time, in almost no course of study is the answer only one of those things. Nobody believes you should just do creativity. I think almost all of our subjects have classes which are like, OK, time to buckle down and learn this thing. But we can often think about how we order these things differently to produce more motivation or develop identity or other kinds of things like that.

But again, across different pedagogical philosophies, it's almost always the case that people have a very shared idea about what expertise is. So I think even people who are situated learning folks, they don't want you to invent midwifery anew. They want the babies consistently delivered in safe, healthy ways. So it's different beliefs about how you get there.

There are efforts to reconcile these things, which I didn't make you read. But if you wanted to explore a little bit more, I'll give you an introduction to one of them and the rabbit hole for this week. Ken Koedinger has a couple of things you can look at. But the lecture he gives is actually the easiest way of getting it. There's a video in there that's quite good.

The Knowledge-Learning Instruction Framework. And he says, one useful way to think about this is that there are more complex and less complex knowledge components in the things we learn. So there are things like Chinese characters, and there are things like anthropological principles about how society are organized. And there are different levels of complexity.

There's also learning processes, and there's things like flashcards, which is just for memorizing stuff. And then there's things like talk and explaining and sense-making and stuff like that. And he has this theory that, basically, you should be matching instructional components to how complex the knowledge component-- learning processes to how complex the knowledge components are.

He has a nice-- this is kind of a giant science, which is in process, where here are a bunch of things that people were trying to learn-- Chinese vocab, French articles, chem models, pressure concepts. Here are a bunch of instructional strategies-- optimal scheduling, feedback, worked examples, accountable talk, collaboration.

And you find that these are less complex to more complex teaching. This is less complex to more complex knowledge components. And that basically, where you get studies with statistically significant effects on learning is when you move through the middle of this space, when you map the right knowledge component to the right learning process. I don't know that Ken Koedinger and his colleagues have totally figured this out either, but it's one way to start reconciling some of these ideas.

OK. The most important thing for Wednesday is that we're meeting at the MIT Museum. Please try to be at the MIT Museum. If you can get there by 1:00 and get checked in and put your bag in the locker, then we can start class at 1:05. So make every effort to get there as soon as you can.

There's a few pieces of reading. The Stephen Wolfram thing is totally worth your time, and it will require a little attention. You'll have to move your way through it. But he does just a beautiful job explaining the fundamentals of generative pre-trained models, a little bit about neural networks, and things like that.

And then there's a bunch of other readings that are in there, some of which are about the exhibits you'll see at the museum, and some are some other educational things that me and some other folks at MIT have written about GPT. And then be sure you refresh yourself and you start thinking about working on the assignment, because you now have two of the crucial building blocks that you'll need for the assignment, which is some sense of direct instruction and cognitive load theory, and some sense of constructionism, situated learning, progressive learning kinds of things. And you'll need both of those ideas to do assignment number one.

And we'll talk a little bit about how we want to do assignment number one on Wednesday. Stay safe in the snow. Have a wonderful next couple of days, and I'll see you at the museum on Wednesday.