Catalyzing Computing Podcast Episode 25 - Game-Based Learning and Integrated Photonics with Erik Verlage (Part 3)

Intro [00:00:10]

Khari: Hello, I'm your host, Khari Douglas, and welcome to Catalyzing Computing, the official podcast of the Computing Community Consortium. The Computing Community Consortium, or CCC for short, is a programmatic committee of the Computing Research Association. The mission of the CCC is to catalyze the computing research community and enable the pursuit of innovative, high-impact research.

In this episode I interview Eric Verlage, a research scientist at the Massachusetts Institute of Technology (MIT), who creates digital learning tools for photonics education. He's developing 3-D virtual lab environments that allow users to interact with micron-scale photonics circuit components, enabling self directed learning for the emerging photonics workforce. His research areas include integrated photonics, photovoltaic materials, and photoelectrochemistry.

This is part three of my interview with Eric Verlage. If you haven't heard part one and two and would like to, go catch that and come right back. In this episode, we discuss the future of augmented reality and virtual reality systems, as well as photovoltaics and how optical fibers work long term.

Interview [00:01:10]

Khari: Where do you see, sort of, VR or AR or just game-based learning making an impact to key social structures like education or manufacturing going forward?

Erik: So I think it's already starting to happen that VR and AR are making an impact on workforce training. I don't know if you've heard recently that Wal-Mart purchased 17,000 Oculus Go VR headsets to train all its U.S. employees.

Khari: I did not know that, no.

Erik: Yeah, so that's an exciting new development. They're creating their own content to train their employees to be working in their super centers. We definitely have a lot of industry interest in this, and it's not that surprising that this is an effective way to train a workforce. The military has known about the use of games for a long time to train soldiers, because in a lot of ways training on the job is not really that feasible for the military. They have to create simulations and games where soldiers can get experience before they're actually put into combat situations.

Another industry that has really gone ahead with this idea of training using games and other types of interactive environments is the medical community. Another case where resources are scarce and you can't necessarily put people through training for, let's say, a nursing program. You may not have that many patients available, so [an] old way of solving this problem [was] to hire actors to pretend to have certain ailments and then have your nurses treat them accordingly. But they find, over and over, that it's just an expensive way to do things: to have to hire people and bring the whole team to a room where training can happen.

One of the problems with online learning, let's say in that environment of nursing, is that you really need it to be contextual. The learning has to be in the context that it would be used for it to be efficient training that will prepare the nurse for an emergency situation with the patient, and so it really helps to be in a room and to have somebody there. One of the ways that they're trying to get around this problem of scarcity is they are bringing in body dummies but then having AR on an iPad, where you have a patient who has specific symptoms that's overlaid on top of or instead of this body that's on the table.

And so a lot of times what is most useful for these training situations is to have even a virtual instructor on the side that [the students] can point the iPod in that direction and see the virtual instructor tell them what they should be doing.

I think the military and the medical community has definitely seen the use of this for training purposes. In our field, in optics labs and in photonics applications, we definitely have similar constraints: we have expensive equipment that is maybe breakable, so you definitely want people to practice digitally before they are put in charge of the machine/schedule time on machine, and you have a bunch of other constraints that make it so it's difficult to train people on certain things. So, in the end, I think this is going to accelerate quite quickly and we're going to see workforce training happening using AR and VR, and also using games where you make it engaging, make people form good memories about a situation.

Another example of how games can be a little bit of a different learning experience than just your standard instruction. A lot of doctors...they recently had a game that they designed specifically for training doctors about people who are coming into an emergency room with specific symptoms, and what they found was that compared to a test case, where they just gave doctors or gave medical staff a standard online instruction: where you are clicking through, reading text, and then giving answers to assessment questions...it’s been known for a long time that emotional connection to something is a good way to help people remember something and be able to apply it in a context. So they created this game where doctors could make decisions, but instead of just getting an X or a checkmark they had a simulated patient that they developed a relationship with over the course of the game that could die because of that decision that they made.

That's something that really hasn't been explored that much in terms of online assessments and online courses — if you create these kinds of human connections and you have a doctor who's made a decision that then results in a patient's death, virtually, that's maybe a situation that will stick with you much more. That emotional connection and that sense of “I made a mistake and something bad happened.“

We don't necessarily only have to have that emotional connection happen when doctors make mistakes with real people. That emotional connection and that learning from mistakes can also happen in a digital form without the loss of life that might have happened if the doctor hadn't had that emotional connection. So this is something that we're still exploring, we're still figuring out, but I think [it] has a lot of potential in this case, to figure out how do you use these digital formats to recreate scenarios that really stick with you. That lesson that you learn and that you'll never forget.

[Laughter]

That type of depth of learning, we can definitely start to explore that using game based learning.

Khari: Yeah, that seems like it would be huge. What do you think are specific research gaps, maybe that we haven't touched on already, that still need to be overcome, and if you were designing sort of your dream federal research program what would it be?

Erik: Right.. So one of the key gaps, especially around these types of interactive simulations, is we've only just started to understand how identity plays into all of this and how it affects your mind. There's been some very exciting work recently at University of Barcelona by VR researchers who are working around this kind of empty chair technique. How do you get people who are going through therapy to engage very creatively with some situation you want them to think about? Ok, talk to the empty chair as if you're talking to the person that you're having problems with, or...there are many different techniques that require that the patients themselves be very creative and kind of thinking through [things] in their mind.

These researchers at the University of Barcelona thought that VR might be a great application, a great space, where you can kind of relieve the people who need therapy from that requirement that they have a very creative and active imagination to be able to go through this therapy; and so they created a simulation where the users put on a VR headset and they could look in the mirror and see an avatar of themselves. So they were themselves in this VR space and then they got to talk to Freud.

They would explain to Freud what their problems were, and what the researchers did — which was pretty creative, I think this is great — they then would record the avatar and the voice of the patient describing what their problems were, when they were talking to Freud, and then they'd flip it — they'd put the patient in the shoes of Sigmund Freud. So now they were Freud, when they looked in the mirror they saw Freud's face, and when they looked across the table they saw them themselves. Now they got to experience that whole situation again from a different perspective, from the perspective of the psychologist. So they got to be Freud listening to the recording of them explaining their problems.

The whole point here is that these researchers were really exploring how does being in that chair...now you're on the other side and this is really something that only VR can give you: the feeling that I am Freud. How does that identity change what's happening inside your brain? At a certain point, feeling like you are in a position of power or feeling like you are not in a position of power, maybe a standard computer simulation might not give you that same type of perception as being in the environment in a VR headset. And so that's something that's really cool, and that they're very much breaking new frontiers on. But it's those types of things that we can really start to think about meeting these needs. What can this new type of identity forming VR technology be used for? It's an open space and I think there's a lot of cool stuff to explore that in that area.

Khari: Wow. Yeah, that's that's pretty interesting. You can almost give yourself therapy.

Erik: Right, and these techniques have been around where you talk to an empty chair and you talk yourself through a problem, but VR opens up many doors where all of a sudden it's much lower barrier. Like, anyone can do this because you just look in the mirror and all of a sudden you're Freud and you give yourself advice in that way.

[Laughter]

Khari: Yeah, I guess you could also use that kind of technology to help people develop empathy or something, you know?

Erik: Right.

Khari: Imagine you were a kid or you were some kind of person that you're not or whatever.

Erik: Absolutely. Think about like, workforce training in terms of H.R. and asking people to understand what it feels like to be discriminated against at work. It's hard to do that with a video, right? If you show a video of someone being discriminated against, your mind doesn't necessarily put yourself in the shoes of the person that the instructors want you to. VR is a way that you can definitely make it very personal. You are now that person and you have to experience the world in that way, and, yeah, there's a lot that can be uncovered when we have that capability.

Khari: Is there anything that we didn't talk about already that you want to mention?

Erik: Yeah, just that one of the main areas that we're currently working on, and in the past few weeks we've been really focusing on this for the virtual manufacturing lab: one of our main goals is to create new methods of data visualization for electromagnetic fields. We are really focusing not just on freespace, when an electromagnetic field is moving through a medium. For integrated photonics and for fiber optics a lot of what we care about are guided modes.

So these electromagnetic modes that are supported in the medium, in a waveguide, where you have a core and a cladding. You have it traveling down, let's say, an optical fiber or a silicon waveguide on a chip’s surface. We are really coming to terms with the fact that even industry experts and people who we're bringing to our bootcamps to learn about integrated products who have been working in the field for a while...a lot of these industry experts are still clinging to the ray optics perspective. A lot of the old learning that they did at university when they thought of light as a ray, as a vector with an arrow, they're bringing all of those preconceptions and those older ways of viewing this technology to the table when they come and they start to interact with our simulations.

It’s amazing to be thinking about how do you get people to think in a new way. To think more about the superposition of fields and to think about these guided modes as something that you want to kind of visualize changing as the medium changes. We really want to break people of the ray optics view and bring them more into mode theory, and thinking about the electromagnetic fields inside of these components as superpositions of guided modes. I think data visualization is an area that we really want to explore with the virtual manufacturing lab project. We want to find new ways of visualizing these 3D vector fields that will really help users understand the devices that they're working with.

Khari: So what is a guided mode?

Erik: You have in our technology, a lot of times when you're wanting to move light around on a chip surface, you need to have something that has a high index core, a low index cladding, and then you create basically a channel. And this channel you can use to transmit light from one area of a chip to another. In optical fiber you basically have the inside, the very inner cylinder of the fiber, that's the core with the higher index, and you have a cladding, the lower index.

There are many different ways in which light can propagate through these channels. A lot of times what you want to do is, you want to design your waveguide or design your optical fiber in a way that has only a single mode that's supported. You might have heard single mode fiber versus multimode fiber. These are talking about [the fact] that there's only one way in which light can propagate down fiber versus a multimode fiber, which has many ways that light could propagate down fiber. And the idea here is that understanding the dynamics of how those modes propagate down these waveguides or fibers would really allow you to design these circuit components in integrated photonics, but we have different ways of visualizing this.

A lot of times people really want to think about total internal reflection. That's the model they come to the table with. They want to think about ray optics and they want to think about light bouncing around, but in reality, when you think about guided modes, the light extends beyond the inner core. It's not totally confined inside of the core. It's actually extending into the cladding. So you have this evanescent field and that's part of the guided mode. That's not light that's being lost. It's being channeled the same way as the light that's inside the core that's travelling down the optical fiber.

But for our field, when you want to be designing these optical circuit components on a chip, we really want people to start to think about the full picture. To understand how these modes interact with each other and the ways in which you can design your circuit components to play around with light and to be using creative ways of resonance and creative interactions between different components in order to create interference patterns and to create what's called a directional coupler, where you couple light into different waveguides using a specific length of a waveguide.

Feel free to edit this out if it doesn't make sense. But anyway...

Khari: Well, I'm actually curious. I don't want to....I mean, we can go down this road. I'm actually kind of curious about this photonics component. It's been awhile since I took physics class so my perception of light is mostly like bouncing off mirrors or whatever. What is the mechanics of shooting light down an optical fiber?

Erik: Right, so think of...you have light that's coming from a light source, a light bulb, let's say, or a laser. And you're going to shine that light through freespace. So it's just light, waves in the electromagnetic spectrum that are just then flowing around, and then you have a fiber. Let's say you point that laser at the fiber — the light that hits the fiber some percentage of it will couple into a guided move. Some percentage will be lost — it'll scatter away or it'll continue in that direction but it won't be guided and if you end up curving the fiber then the light will just continue on.

But the percentage that is coupled in, it now is in what's called a guided mode meaning that the electromagnetic field as it propagates down the fiber is always self-contained within the core region. It's always going to continuously...as long as you don't turn too quickly or too rapidly, it'll be guided down that direction.

That's why we use optical fiber in this way. We shine light at it in pulses. So we pulse light through an optical fiber and then we go the stretch with the fiber and you can even curve it around and all the light stays inside the optical fiber. And at the end you can then absorb that light in a photodetector and then be able to interpret that signal, so you can receive those ones and zeros and be able to transmit that data from one end of the fiber to the other. So, in a lot of ways, the guided modes are the bread and butter of fiber technologies and guided modes within a waveguide, within a silicon waveguide on a silicon chip. That's the bread and butter of integrated photonics.

Khari: Okay. So maybe this is getting too deep into the weeds, but on a particle level...maybe doesn't make sense to describe it that way because it's light, but like on a particle level what's happening to the photons when they enter the guided mode? Like how are they interacting with the atoms of the material?

Erik: So I'm actually going to show you using our interactive simulations.

[Laughter]

Let's see, I'll use this one. So here's an example of one of the interactive simulations that we've created for the fundamentals of integrative photonics course. You can see on the top left, this is the guided mode. The red and blue represent the electric field in the x direction. This is a vector field that we're taking a slice of. It's showing down the length of the rectangular waveguide. You can see the electromagnetic field oscillating back and forth and it's traveling down the waveguide.

This shows the cross-section of the field. You can see it's mostly contained within the silicon core, but in the silicon dioxide cladding, that's all around it, you actually have this evanescent field that extends out from the cladding. And so what happens is that...I'll show you this.

This is another guided mode that with the same wavelength of light can be guided down the waveguide. You can see that it's like a second order mode. Like it has a positive negative peak. And so this second order guided mode actually has a different speed that it travels down the waveguide. You can see it's faster than the top one.

Khari: Huh, ok.

Erik: A lot of times what we're trying to do is we're trying to let students explore, if you change the geometry of the waveguide what happens to these guided modes. And so as they change the width of the waveguide, if you make it much wider, then these modes are much more confined inside the waveguide. And if you make it much thinner all of a sudden it becomes single mode in that only one of these modes is supported, the other mode is not supported anymore. So, yeah, we're trying to...this is still a work in progress, this isn't the final version of the sim, but we're trying to allow users to explore this in a very easy way where they can interact with the data directly and then see how the different parameters affect these guided modes.

Khari: Wow. Yeah, that is pretty cool. It was definitely a good way to explain it.

[Laughter]

So as we wrap up, do you have any final thoughts for the listeners?

Erik: I would love to have people just watch this space and be open to having educational games and online courses and VR for training purposes. If you could just be open to having that enter into your field and especially for people who are in an academic setting. I think that a lot of these tools are coming down the line and will take a whole community to support and actively try to engage with this new technology. As long as people are open to trying something new and going through the hiccups of a new method of doing things or a new technology, I think that's that's where we can all kind of band together and try to make sure that games and VR are not something that are a new fad that go away. We want to make sure that these are here to stay.

Khari: Right. Oh, one other thing. Could you speak about the importance of the social sciences in terms of helping to design these games, building the psychology, the learning development, that kind of thing?

Erik: Right. So the Virtual Manufacturing Lab project actually is bringing a lot of learning science to bear. We have learning scientists on our team who are coming from a less quantitative point of view. They actually do a lot of interviews with students and try to understand the students in order to be able to help us create content that is going to engage with them and that is going to meet them where they're at. So a lot of our learning scientists are joining the team in order to assess whether the learning outcomes that we are going after are being met. And so we have learning scientists. We have graphical artists that...we have a bunch of software developers who are working with game engines, and we have a bunch of technical artists who are bringing a lot to the project. They are really helping us with understanding data visualization and understanding what the space is that we can explore.

I think there's been a lot of difficulty that technical people have with understanding what a graphical artist can provide to you or what a person who's an expert in UI and UX can provide to you as you're trying to create content for others to see and others to interact with. So we should definitely not let ourselves become too entrenched in our own fields.

There's a lot we can learn, I think, especially in terms of data visualization. You might have some data that you're visualizing in some way. Maybe there's a different way to visualize it. And maybe somebody who's coming from more of a graphical design perspective might be able to help you with that. I think that being open to those to this interdisciplinary nature of the work that we're doing is a really important thing.

Khari: Okay. Well, thanks for being here, Erik. It was great to hear about this.

Erik: Yeah. Thanks so much. It was great to be here. I'm very happy to share our experiences, and I hope to give you a great update later on at the third year of the project when we're wrapping things up.

[Outro 00:23:48]

Khari: That's it for my interview with Eric Verlage. We'll be back soon with new episodes. Until then remember to like, subscribe, and rate us five stars on iTunes. Peace.