Catalyzing Computing Podcast Episode 24: Game-Based Learning and Integrated Photonics with Erik Verlage (Part 2)

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, 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. If you haven't heard part one and would like to, go catch that and come right back. In this episode, we continue our discussion about building educational games and using games, virtual reality and augmented reality for job training. Enjoy!

Interview [00:01:17]

Khari: So you're part of a team that just got a new five million dollar award. Can you talk a little bit about that project?

Erik: Sure. So we recently received a grant to develop content for advanced manufacturing education. This is a project that is a collaboration between MIT, Clemson

University, and University of Arizona. We are currently in the beginning stages. We just started in October. We're in the early stages of creating these interactive modules that are built around educational simulations and educational games.

We have three separate thrusts of these types of interactive content that we're creating. We're creating optics and photonics fundamental simulations; we're creating tool training and VR simulations, and that's an area where Clemson University is taking the lead; and we are also creating application focused educational games. And for the application games, that's an area where MIT's Education Arcade is bringing there many years of experience creating educational games and creating instructional material for teachers who are using the educational games. They're bringing all of that background and all of that expertise to bear to this project.

So we're very excited about how we can create more engaging real world application systems built around things like hyperscale data centers and wireless avionics communication and LIDAR systems for self-driving cars. So we're we're trying to create content that at the same time is both instructive in terms of the technology that we're trying to teach our students about, as well as giving them a good sense of what type of real world applications the technologies are going to be useful for, and having that be part of the game based learning environment that they're going to be exploring.

Khari So the grant you were talking about, it's between MIT., Clemson, and Arizona. Is that correct?

Erik: Yes.

Khari: So in terms of your on the ground trials and stuff...I'm assuming the kinds of populations in those three cities that you are working in are areas might be pretty different. Do you guys have concerns about that or do you have ways to sort of control for those aspects?

Erik: So one of the aspects of the project is that we are trying our best to bring in students from many different backgrounds. As you can imagine, students that are at a graduate level at a university, they aren't necessarily the best test subjects when you're trying to create content for other types of learners. We are currently...every month we're bringing in new community college students from all our community college networks, and we're trying to make sure that we're testing with our target audience.

In terms of the geographic location of our teams, we're also...one of the reasons that Clemson University joined the team was that the southeast of the U.S. is a very large specialty fiber manufacturing center. Although there are many optical fiber companies who are working in the southeast of the United States, Clemson University has a Center for Optical Materials Science and Engineering Technologies, COMSET, and they are one of the only universities in the U.S. that have a full fiber draw tower for glass based fiber drawing. They are definitely one of the leading experts in academia on fiber drawing technologies, and so we are very excited to be collaborating with them and to be able to tap into that whole network of optical fiber and specialty optical fiber manufacturing industries.

Khari: Ok. Is there anything else about that grant that you'd want people to know about?

Erik: So I guess one thing that I'd like people to know is that it's very much an experimental grant where we're trying to deliver content in a very new way. Here at MIT we're actually creating a series of online courses for the edX platform. And these are all standard online courses that you might have seen before where it's instructor pace and the instructor decides what content the student will be seeing. In this grant we're actually going to try to host our content in a different way. We're going to try to allow students to get enticed and brought in by these game-based learning simulations. So after they play these application focused games, we're going to allow them to explore

our content in a more modular way where they can access specific instructional modules and be able to explore the content in any way that they'd like.

So if you play a game about hyperscale data centers and you're interested in, “Oh, I didn't realize these optical interconnects were being used in data centers.” You can then explore that technology on the side. And if you're interested more in how these integrated circuits that use photonic components are designed: “what are the fundamentals of these photonic components?” You might then go down a different path and explore that technology. The end result of this grant is going to be some exploration of different methods of content delivery that we're quite excited about.

Khari So if someone is interested can they play one of these games? Can they participate in the research that is going on?

Erik: Absolutely, we're constantly beta testing our products. So we're...as we create these interactive simulations and games, we are always looking for adults and community college students who would be interested in playtesting the content. By the way, all the content that we're creating is available in browser. We're definitely targeting these online courses and the online platforms like the edX platform that we're hosting our content on. So we're able to send links to people and have them playtest our simulations and games and then send us feedback. If you're all interested in playing with these interactive simulations and games, send me an email at everlage@mit.edu and I can send you a link.

Khari: Ok, cool, and I'll include a note about this in the podcast summary.

I kind of already asked you this, let me ask you again, how did you get into building games, particularly educational games?

Erik: So I actually was a grad student at the time when I really got into creating educational games. I was a grad student in materials science working in a lab, and from my time at the MIT Media Lab I really missed the human interaction that you had to think about and engage with back when I was working on educational software. So in my spare time while I was a grad student, I started to join an online game development club called Home Team Game Dev, and I was making games with people from all over the world. We would pitch games and then work on them for a month to three months and then release them and then move on to the next game. And so I started to pitch games around what I knew best, which is optics and photonics, as well as a few math games.

We created a game around cross products and dot products, and we also created a game around geometry where we had the user flipping around shapes and painting in a canvas using geometrical shapes and solving geometry proofs using those geometrical shapes.

So we had a lot of fun creating these small HTML5 games, and that was really what got me into going in this direction. I really loved the idea of using simple interactive simulations and games to allow people to solve problems in an intuitive and easy to use way. Something that you could use as a casual game that you'd play on the subway and be learning something in five or ten minutes that you have to play a game as you're commuting. So this was always a very interesting field that I really wanted to get into, and I was then able to join a project that was working on exactly that. Coming from a background in optics and photonics, we were able to use these game-based learning concepts to create content that would be useful for online learning. This is by far the most interesting project that I've had an opportunity to work on, and I'm quite excited about the content that will be developing over the course of the next three years.

Khari, Wow. Yeah, perfect fit. So you said you'd pitch the games that you developed. Who were you pitching the games to? Like other members of the site

or were there people that were sponsoring these games and paying for you to build them?

Erik: Everyone working on these projects is a hobby game developer, and we all volunteer to make these games in our spare time. Home Team Game Dev is an online club that meets by video chat every Sunday to share updates on the four to six games that are in development at any time. And it's never a commercial venture — completed games are always available online for free upon release. The real purpose of the group is to help everyone practice for game development skills and build their portfolio. It's a very supportive community and it really helped me prepare for the next stage of my career.

I started as a postdoc here at MIT and we were trying to create new ways of data visualization using the simulation results that we were generating using commercial software for different components in integrated photonics. A lot of the data that we were generating, there's no real good way to visualize it in the commercial software that's available right now or at least it really takes an expert to understand what they're seeing and to also set up and run these simulations.

One of the unfortunate facts about commercial software that's very advanced is that they're used in classrooms all the time. So once you have a professor with a research group who is using commercial software to run simulations they'll then, when they teach the subject in a classroom to undergraduate students, they'll use that complicated software, the very advanced software, in their instruction. And this is sort of like bringing the most advanced flight simulator and bringing it to the classroom and saying, “All right, you guys want to learn about flight? Here is the most advanced flight simulator, here’s the instruction manual, go and explore it.” As you can imagine there's a large cognitive barrier for students when they're just starting out.

They're trying to learn both about the fundamentals of the topic as well as learning how to use the tool. And while these tools are very advanced and are very powerful, they're also very complicated to use. So one of the main objectives when I came early on this project was to try to create something that was a little less like a flight simulator, that was very complicated and heavy to use, and a little more like an RC plane, where all of the fundamentals, all the physics that you want to learn about flight, are going to be present in that smaller, more intuitive, and easier to use interface. But at the same time you're not overloaded by all the knobs that you could turn. We wanted to give students the ability to explore these environments and understand what's happening on a device level, or on a component level in these optical circuits without having to also think about the complex and advanced commercial tools that are used in industry.

Khari: Okay, wow. So have there been any specific games that you thought were the most fun to build and design?

Erik: So one of my favorite games I made early on, and so was it was one of my first forays into game design and game development. It didn't end up being that large of a game or even that great of a game, but I had a lot of fun with it because we were trying to create a game that was simulating an optics table. So in a way that a grad student builds and uses a laser source and then uses a series of lenses and mirrors to direct that laser around on an optics table, we were trying to recreate that feeling in a game we called Optiverse.

So we created this game where you were...you had lasers and you were trying to shoot them at different enemies and you had to manipulate lenses and mirrors in a virtual world in order to shoot your laser at the correct enemy. This was a lot of fun because we got to actually use the real physics of what's going on. We got to use Snell's law and other features that we added to the project in a very kind of playful way where we were creating something that allowed students and users to explore the space themselves and to find different solutions to problems of the present.

Khari: Okay. And is this game still out? Could someone find it and play it?

Erik: Yes, you could. [Laughter] With an asterisk that this is one of the first games I released, so don't judge it too harshly.

Khari: Fair enough. [Laughter] So I also saw there was this report...what was it called? It was on MIT's website. Hang on, I can pull it up.

It's called *Better Learning in Games: A Balanced Design Lens for a New Generation of Learning Games*. So I'm sort of curious if you had any thoughts about these three major models of game design that they posit. In this report they have the "content model," which defines the knowledge, skills, abilities targeted; there's an "evidence model," which describes potential observations and behaviors of students that would give evidence of their ability; and a "task model," which describes aspects of situations that are likely to evoke and provide such evidence. Are any of those models, do you think, more important to focus on in building the learning-based games that you're designing?

Erik: That's a great report — they were talking about evidence centered design for learning games. You definitely have to have all three in mind. These are different lenses that you can look at the game design process. To break down what they were talking about, you need to figure out what content you want your subjects to learn, so that's the content model. You need to figure out what tasks they can do in game or in the environment that you're creating that will both lead them to engage with that content and will hopefully have them learning about that content, and also you need to think about what evidence can the game collect or what data can be collected that will show that learning has happened.

The third is by far the most difficult at the moment. We can come up with many things we want the game to do. what content we want the game to teach. We can come up with tasks that are related to it and that we hope will be leading the users to have to engage with that content and practice those skills. It's actually almost on a case by case basis you have to think about what evidence can you gather, what data can you gather and what evidence can you use to show that the learning has happened.

To give an example, one of the games that the Education Arcade is currently working on is one in which you have to solve different puzzles that are using shadows on different walls from different perspectives to show you a design. You then have to use shapes to create that exact shadow. So this is a game where what they're trying to do is they're trying to figure out what data can they use to learn about your spatial reasoning skills. If you bring in a cylinder and you try to rotate it multiple times along the axis of symmetry then maybe that is an indicator that you can't project into the space and figure out what would happen if you rotated in that direction. But you always have to be careful because what if they're clicking on that button multiple times because of the user interface or maybe they're just not that familiar with the controls.

There's a lot of times when you're trying to use the evidence model or the lens of how do you gather evidence to see whether learning has happened, what you might call assessment in the game or stealth assessment. This is something that is very difficult to design. You have to then show that that activity or that action is telling you that the student has or hasn't learned a certain concept. So, yeah, it can be pretty complicated and it's something that researchers are still looking at and still trying to figure out.

Khari: What is stealth assessment?

Erik: So one of the ideas, and this is a powerful idea, is that instead of having all these tests that students have to do, where they have high stress and they have to stop their learning process in order to take a written exam, what if instead we had them play a

game in which they are learning, and as they are playing the game we can tell by how they interact with the environment or how they play the game, we can tell what they know. That's a dream that we have at the moment of being able to create assessments in a game format that stealthily figures out if the learning has happened or is currently happening. We're calling that “stealth assessment,” in that the software itself is going to assess the learners current capabilities and learning processes as they happen in real time.

Khari: Ok.

Erik: The hope is that this would decrease the amount of testing that has to occur since we're going to be getting that data during the learning process, as well as decrease the stress that students have around testing.

So maybe you know that some amount of assessing is going on while you're engaging with the learning activity, but at the same time if that data is being used in a conscious way by the teacher maybe the students then don't have to be as worried about it since it's continuously happening and the amount of progress that you're making within an environment, let's say a learning game, maybe that progress will be something that we could capture and be made visible. We want to really roll into one the learning process and the assessment and be able to allow students to...or allow teachers to really understand where students are at and what they're struggling with in real time and then make interventions. And use maybe AI — there's a lot of ideas about using AI to change the curriculum or change the content that the student is seeing and direct that content in a direction that is helpful to the student. So, yeah, there's many different ideas of how you might use stealth assessment in your classroom, and a lot of what we want to accomplish is to make sure that the assessment is telling you what you think it is. That's the difficult part that we're trying to tackle at the moment.

Khari: So, I guess, sort of moving away from games, but I know you mentioned that mic you have was for a MOOC, a massive...What does MOOC stand for again?

Erik: Massive open online courses.

Khari: Do you teach any MOOCs at MIT personally?

Erik: So I was a co-instructor for our MOOC that we released on the edX platform back in April of 2019. and we're currently in the process of creating two additional...two new MOOCs that we're gonna be releasing soon. And we're really hoping to...in these new courses that are all for engineers focused on design of integrated photonic circuits we are really hoping to lean heavily on these interactive simulations that we're creating as part of this project.

Our project is called the Virtual Manufacturing Lab, and it's a three year project funded by the Office of Naval Research, and we are trying to create these interactive simulations and games that will be used in online learning courses. And we're not just creating the interactive simulations and games themselves, we're also creating content around it. We're creating video lectures and assessment questions and we're creating Jupyter notebooks and other types of interactive media, that's are all going to be bundled together as a submodule that will be used by instructors in bootcamps and other blended learning activities, as well as in the online courses that we'll be releasing in the next year at MIT.

Khari: Ok, so do you have any tips for professors who might be teaching a MOOC for the first time or trying to start one about best practices or anything?

Erik: Right. You'd be surprised, a lot of times when you're creating your hour-long lecture you create a bunch of slides and then you get up to the front of the room and

you're giving your hour lecture or your twenty minute lecture, and you're maybe calling on people from the audience. That's actually a lot easier than sitting in front of a computer with no audience and no interaction at all trying to make content. There's nobody's eyes you can look into to see are they are they getting it or are they not? So in a way, it's a very difficult thing to do for a lot of professors and instructors, to speak to an empty room and have nobody on the other side. So that's one of the challenges in creating these online courses.

There's also the challenge that you really want to stick to short video lectures or short video content. Any time that the student is passively absorbing something…you really want to make it as active as you can by cutting it up into short video lectures that are followed by assessment questions or some active activity, or some interactive simulation, or some type of activity that the student can use in the course. So MIT open learning has found that six minutes is about the time you want to shoot for these massive open online courses. Between each section, each video lecture that has assessments afterwards you want to shoot for a six minute video.

Khari: Hmmm. Have you guys ever tried game-ifying a MOOC? This would probably be pretty resource intensive, but I'm imagining almost like a choose your own adventure thing where it's like you ask a question and then someone selects from two options and based on that they get a prerecorded explanation or something.

Erik: Yeah. Well, it's kind of like Bandersnatch. Did you ever see the most recent Netflix movie where it's a choose your own adventure Netflix drama?

Khari: Right. Yeah, that's pretty cool.

Erik: Yeah, the main problem is that those types of ideas become very intensive because you have to think through each path that someone might go down and then

add content for it and then allow people to maybe have a different experience. It does get pretty difficult. [Laughter]

But the virtual manufacturing lab project, we are going to be exploring that direction in that we are hoping that these submodules that we're creating, that have video content as well as interactive simulations and games, and assessment questions, and Jupyter notebooks, and all of that roll into a submodule — we are hoping to have that become a new method of content delivery that allows students to kind of have a little bit more choice in what they're experiencing next. So once we have a library of these submodules, we'd be able to allow students to be drawn in. Maybe the hook is the application focused game where they're designing drones for different missions or they're managing a data center, and then we allow students to explore the tree of different learning content that's available on the site, so after you play the hyperscale data center game it might link you to the different submodules that you would be interested in that were featured in the game but maybe you want to explore more.

Khari: Interesting.

Outro [00:25:32]

That's it for this episode of the podcast. We'll be back next week with part three of my interview with Eric Village. In that episode, we discuss the future of augmented reality and virtual reality systems, as well as photovoltaics and how optical fibers work.