**Korbit**

**Craig:** Hi, I'm Craig Smith and this is Eye on AI. Today's episode is with Turing award winner Yoshua Bengio, and his colleague Julian Serban, the co-founder of Korbit, an AI ed-tech startup with the aim of democratizing education. This is the first in a two-part series on the AI in education.

In the past few years, researchers have turned their attention to enhancing education through the application of deep learning systems that can track student behavior predict their performance and delivered strategies to both improve that performance and prevent students from losing interest.

It's a powerful new technology that could eventually redefined education as we know it. this episode, Yoshua and Julian, and talk about the current state of their work and how they see the field progressing with the application of attention mechanisms and the eventual use of virtual avatars to address the psychological aspects of student teacher interactions.

A side note, Iulian or Julian spells his name I U L I a N and so we alternate between pronunciations. He's fine with both.

I hope you find the conversation as important as I did.

**Craig:** I'm particularly interested in education. I think that the problems in education in the United States in particular are at the root of so many of our social issues. And education has been in trouble for a long time. Now with the pandemic it's really in crisis, as we all know. But there are solutions with artificial intelligence that can go a long way to improving education delivery and education content and effectiveness.

**Yoshua:** And especially in a remote context, like we have right now.

**Craig:** That's right. That's right. So evidently the genesis of Korbit, your education startup , predates COVID. So why don't we start. Yo shua assuming everyone knows who you are. My listeners. Iulian, can you start by introducing yourself? And then Yoshua, you can give a briefer introduction and then talk about how you came about starting Korbit and how it's really, in a sad way, serendipitous, because never before have we needed an education platform like this.

**Iulian:** Sure. so my name is Iulian and I'm the co-founder of Korbit. I guess I can give you a little bit of background about myself. I studied machine learning, artificial intelligence with Yoshua for about five years exploring personal assistants. Systems like Siri, Google Now, Amazon Alexa, and trying to find ways to make them more intelligent so that humans could interact better with this kind of technology.

And obviously that is a huge research goal in itself, like building intelligent personal assistants is very difficult. It involves many different problems along the way, including natural language processing, reinforcement learning and many of these areas, like lots of unsolved problems. So the idea was by to try to tackle this grander problem, we would also make a lot of impact in fundamental research in NLP, in reinforcement learning along the way. So, so that's a little bit about my academic background.

The reason I care about education so much is because in a sense I've been privileged most of my life. I grew up in a developed country. Both my parents were well-educated and they taught me since I was very young. Like apart from school, I got lots of homework help. I got lots of support. Even at school, I was in small classrooms, I had teachers who cared about their work. I think very few people are so lucky. And actually, when I was about 17, I was graduating high school, I decided to join a nonprofit called Operation A Day's Work. And that nonprofit was specialized in education. Like how do we democratize education? Specifically, what they did is have students from around the world take one day off from school, go and work and then take all the money that they earned that one day and donate it so that other kids could have an education.

So, we'd actually go out, collect the money from our work, and then we would donate it to build schools, train teachers. After high school I joined the organization. I was a board member. I was a full-time volunteer. I did all kinds of work. We had a project in Niger in Africa at that point, and I went there to visit different schools, talk to teachers. Like basically build a PR campaign around it so we can raise more financing.

And so, through that work I realized the importance of education. And then having been very privileged myself, I saw the different impact of education. COVID-19 has really exacerbated it, but I think there has been a huge inequality in the world's education. And it is probably the deciding factor between how economies and societies develop. Much more than even pure infrastructure, education is the long-term solution and the long-term approach we should take to improving society in general.

**Craig:** Yoshua, why don't you introduce yourself and then how you came to the Korbit project.

**Yoshua:** All right. So, I'm a professor at the University of Montreal. I'm in computer science. I'm the scientific director of Mila, which I also founded. And that Institute is bringing together researchers in machine learning from several universities, focusing on deep learning, reinforcement learning, with both a goal to advance basic research, understanding the underlying principles of intelligence, but also to act in a way that's beneficial for society. For example, with AI for social good applications, and even thinking about things like governance of AI.

Now the AI for social good theme is something that we have explored at Mila in many directions, including a lot of work in climate change and healthcare. But education is sort of the new baby, if you want, in terms of research directions. And as Iulian is saying, it's probably one that is going to have the most impact in the long-term, as well as a way to improve for all the other aspects that I've mentioned. in terms of democracy, in terms of making people take better decisions like those in climate change and for themselves in terms of health care or contributing to the wellbeing of others in society.

How I came to this particular project is really Iulian who wanted to do something about this area and he was very enthusiastic and convinced me and Aaron Courville and other faculty at Mila to support this project. And we've been very excited to be part of it.

**Craig:** You're working on a suite of products. Is that right? That you're planning on rolling out. Can you talk, first of all, sort of theoretically about how you apply artificial intelligence to teaching and then talk specifically about some of the applications you're working on?

**Iulian:** Sure. The core idea that we started with was to personalize and make education active. And so, the idea was that by personalizing it and making it active learning, students will learn more effectively, better, faster, and they will be more motivated. And so, sort of out of that idea of "here's how we would like education to be," we started to work our way backwards towards "what would the technology solution look like?"

" And the solution that we've come up with is a so-called AI tutor, a personalized AI tutor that guides the student from the beginning to the end, from, from the moment that they start studying with Korbi, the tutor, Korbi is creating a personalized curriculum for them, assessing where they are at, the knowledge they have, the knowledge they want to acquire, the skills they want to acquire, builds up a personalized curriculum and then teaches them one-on-one. And the way it teaches is obviously proved through typical approaches, like video and texts, but also through interactive exercises, hands-on exercises that students have to solve and then they get feedback from the AI tutor. We have programming exercises as well where they get feedback from the tutor.

So, this was the kind of approach, is it's a platform today with about 10,000 students studying. It's Korbit.ai. Anyone can go and sign up for free. And so that's, the approach and, sort of, there are many AI problems in there. A lot of natural language processing NLP problems that we have to tackle along the way.

**Craig:** I wrote about AI tutors for The New York Times. And at that time there weren't many on the market, and those that were predominantly expert systems that depended on rule-based logic or decision trees to lead a student along a path. If they get this wrong, then they're shunted in one direction.

If they get that right, they're shunted in another. Is this a rule based system like that? And the limitation with those rule-based systems is you needed to build up a knowledge base that was very time intensive for the decision tree to work through. As opposed to a system that could adapt to any domain, any subject domain. Can you talk about whether yours is rule based or whether it's something else, maybe deep learning based? And the differences between yours and the old systems that have existed for a while?

**Iulian:** Yeah, that's a great point. It's exactly like you said, the old systems that have existed for a couple of decades, like for example Auto Tutor, they were all rule-based. And the researchers who created these systems would spend months, sometimes years to create just one course. And that was a huge drawback and probably one of the main reasons why they were not in widespread use. Korbit, on the other hand, started with deep learning and state of the art AI. And that state of the art has advanced tremendously the last half decade and it's advancing even faster now than ever before. So, the Korbit system is not a rule-based system. Of course, there are some rules in there, but it's mainly based on the latest technology within NLP. The deep learning technologies, the natural language processing, word embeddings, sentence embeddings, the new technologies in reinforcement learning.

And so, the idea is that by using this kind of technology, we can create new courses a lot faster. And in fact, we have teachers now who are creating these courses and they can create new modules in a couple of hours. So, we've certainly overcome that hurdle of having thousands of rules and a big decision tree.

**Craig:** And so where does the content reside? If someone's creating a course, can they just upload the content that they would normally use in the course instruction? Or do they have to put it into a special format?

**Iulian:** It does require a bit of a special format. It's easy enough that a person can learn it in one or two days. But the AI tutor needs to know which video corresponds to which concept and which exercises corresponds to that video or concept. So, it needs to have some kind of alignment. In terms of content creation, it's just part of the process. It's no different than teachers creating their own videos or Coursera, or Udemy, or one of these other platforms creating your own content. It just needs to be rearranged and labeled a bit afterwards. And so, it need access to this. And then the other thing that Korbit does is it goes out and scrapes the web, like Wikipedia, for example. Open educational resources, OER. It scrapes literally hundreds of thousands of content resources, and then processes them and trains machine running models on these.

And that's one of the powers of deep learning. It can deal with a lot of unstructured content. Early algorithms that were used could not deal with this, but deep learning can really chunk this and learn representations that are meaningful. It can learn representations of any domain. And education happens to be an area where there's lots and lots of free content out there. And by scraping that content, the AI is learning from it.

**Craig:** That's fascinating. And it exists now as a platform. Is that a platform for educators to take and adapt and then apply to their students? Or is it a platform that has courses already loaded that students can access? In other words, is it a B to C platform or a B to B platform?

**Iulian:** We're concentrating on the B2B enterprise platform. We realized that there was a huge demand in enterprise training. There's lots of companies that need to re-skill, up-skill their employees. And actually, the topic that we started with was the data science and AI. That was our core knowledge from when we created the startups so we could inject our own. I literally created the first few videos, and then a year later I got Yoshua and other professors to create more. So, we started with AI and deep learning and data science. And now we see there is a huge demand for this in enterprise. And so, we're really looking at the enterprise market.

We've done a study, for example, with 600 employees at a large outsourcing company and they loved it. And now they're doing a second pilot with us and it seems to be working very effectively. Because the reason you need personalized training in enterprise is that all the employees are different. You can't assume that they belong in one cohort. Everybody has a different skill set, a different background and they have different destinations. They have different projects they need to work on. Different skill sets they need to acquire. So, the personalization is absolutely key here.

**Yoshua:** But the users of Korbit are not teachers. First and foremost, they are students. I think what Iulian is talking about is the business model. It's not individual users buying the use of the platform, but it's their company buying the use of the platform for a whole group of people. But really, for the courses, the teachers are operating with the help of the Korbit experts and not independently.

**Craig:** Given the current crisis in education because everything has moved online, the bulk of K through 12 as well as higher education, I guess the first question is this can be applied to either K through 12 or tertiary education. Is that right?

**Iulian:** Yes. And in fact, we have students all the way from high school to university students, to professionals who are taking the online course now. Yes. But we are focusing on the enterprise. Especially like professionals who are cross-disciplinary, people who have some kind of science or engineering background, and are getting into data science is sort of the target audience.

But we have students from all backgrounds and from all over the world who are using it. And there is no limitation. I think the main constraint is that you have the technology, you have a tablet, a phone, a computer, and that you speak English, and you're able to work with a system like this, an AI tutor online. That's the main constraint.

**Craig:** When did you start developing the platform?

**Iulian:** We started in 2017. It started as a side project, really. I was working from home and trying to brainstorm ideas. I got together with our other co-founder, Ekaterina Kochmar, who is a professor at Cambridge University.

She had spent half a decade looking at AI in education, she was looking at teaching reading and writing skills. And so, we were thinking like, "Hey, why not come up with a personal assistant?" I had worked on personal assistants for years and that's exactly an area where it made a lot of sense. And so, we kind of came to the idea of the AI tutor from there.

**Craig:** And the interface is through speech or through a keyboard?

**Iulian:** It's through texts that you type on a keyboard or on your phone. It would support speech, too, but if you want to do equations or you want to do programming exercises, it's going to be painful to speak it out loud.

**Craig:** And what sort of benchmarking have you done? There was a private company in California called Acuitus. I've never really been able to figure out the nature of their programming, whether it's rule-based or neural networks. They're pretty closed mouth about it. They developed that system for the Navy. And there was a study done that looked at AI tutors that were participating in some DARPA programs and they came out on top. Have you done any benchmarking like that? Or are there any metrics that you can talk about that measure how this works as opposed to someone taking a MOOC or some other online course?

**Iulian:** That's a great question. We've done lots of studies. Our founders, like, I spent five years through my PhD, Katrina a professor at Cambridge, we have a very academic and scientific approach to things. We test everything, we set up experiments, we do cohort studies. We've done lots of these with thousands of students and we've published papers on these.

I think it's published on Elsevier. We published two papers in the AIET 2020 conference. We have two more papers in the works, so we're relatively open compared to other startups. we don't give away all the secret ingredients, but we definitely believe in sharing the research insights and contributing to the community.

And I think in general in ed-tech, I'm very happy to see this, but lots of companies are actually publishing and sharing their results. It's often hard to compare unfortunately because every company has their own content, their own user bases, different approaches. Some of them have textbooks, some of them are online, some are in classrooms. It's a bit hard to compare, but there's generally a very open community. And so, we've done lots of these studies at Korbit. For example, we did a study with about 600 students and we compared them using Korbit versus a regular MOOC. In the regular MOOC, they would get videos and multiple choice quizzes. And what we saw was there was a 73% increase in the study time with Korbis. Students were spending, three fourths times more with Korbi. So that's a huge win in terms of students studying. And we're hoping we can push this to a hundred percent increase. We're hoping we can get students to study twice as much with Korbi. That would be an amazing result to share with other people and to really demonstrate the power of AI tutors and AI in general in education.

**Craig:** Yeah, absolutely. Yoshua, can you talk a little bit about how this could really change the landscape, these kinds of technologies going forward? I don't expect online learning to go away now that it's been forced upon everybody.

**Yoshua:** Yeah, absolutely. I think that the potential impact of these kinds of technologies, especially, as Iulian was saying at the beginning, in those less fortunate countries could be huge.

There’re just not enough skilled educators to address the needs of a large number of young people around the world. And it's not that we want to replace them, like we need as many teachers as well possible. But what tools like Korbi can bring is complementary by providing something that's more personalized.

Like ideally there would be one teacher per student, right? But even in rich countries this is not usually feasible. So, what you can have is a human teacher who helps a group of a certain size, but then each of these individuals can, in the day-to-day exercise-for-exercise course of their learning, get personalized guidance as to, "Exactly what exercise should I be doing? Which part of my knowledge is lacking and which example could be presented to me to help me fill in that gap?"

So that personalization is really where machine learning comes in, because you don't want to have one video for everyone like in classical MOOCs. You want to learn about what does the person know and what does the person not know and even what style of learning works better for that person so that you can present the best possible pieces of material.

**Craig:** And right now you're dealing with companies that want to retrain workers or maybe specific education companies or institutions. How far are we from every kid in the world, at least the English speaking world, with an internet connection, being able to log on and be led by an AI tutor through arithmetic, algebra, geometry, calculus, and into the higher sciences?

**Yoshua:** I think it's a matter of years. I think it's a matter of scaling up. Right? So that's what the companies are good for. And right now, Iulian and his collaborators are focusing on a small niche market, but I think the idea is to build up the platform, build up the expertise, and then, as fast as is possible, scale up to a larger breadth of material, covering not just these fairly high high-end needs, but also the early education. And it's probably going to be not just one company. I think as people start to realize that there's an important potential here, I expect that there'll be a number of organizations trying to take advantage of the progress in AI.

In particular, one area I'm interested in is how we can build better natural language understanding. This is how Iulian's thesis really started. Dialogue understanding at the level which goes beyond just a sort of pattern recognition, but actually understanding what those words and sentences refer to in a knowledge base, which is what education is, really concerned with.

There's, interestingly, also a lot of fundamental challenges to make progress in that direction. So, it could be that it might take more than a few years, maybe a decade or more, to reach the point where the personalized tutor has the kind of natural language fluidity and semantic understanding that would be really necessary for touching everyone on the planet. That we don't know yet.

I think what's important to know is there's a lot of research in front of us, but we've reached a threshold in the last few years. If you think about speech recognition for example, for many decades we had speech recognition, but it was just not good enough. It didn't pass a threshold of usability. And I think something like this is happening now for these kinds of educational and personal assistants, that Korbit is showing that we are able to pass this threshold where it now has positive impact. That people can use it. Even though the NLP isn't perfect and the system is not perfect, it's good enough that it's providing a service. And so, I think this is why it's going to be possible to scale up, that there's going to be potentially a lot of investment to bring that to the whole world.

**Iulian:** And just to circle back. I said at the very beginning that the first thing we were working on is cracking the content problem. That's on a scale that we solved, and now we can create content as fast as any other online platform. Shoot your videos, make a couple of exercises and you can upload it on Korbit. And so, we've cracked that problem. And now we're working on the hotter NLP problems, but already we're seeing big improvements in student retention, study time and learning outcomes.

So, we're at a point where, at least from our core studies with our 10,000 or so students, we can see that students learn better and faster and they are more motivated. That's what we can see at this point. Even though we're not perfect, we make mistakes. And just as an anecdotal point, two weeks ago we swapped in a new machine learning model called the B We put it into our system and we saw a big boost already, and we're kind of running new experiments and seeing, "Oh, how does this impact?" Because since we started four years ago, the technology itself has evolved and we have some metrics that seem to be skyrocketing, and we want to see how it impacts students.

Our machine learning team is eagerly waiting to see what's going to happen the next couple of weeks as the much higher accuracy model is in production and students are learning. Like, is it going to blow them away or is it just an incremental improvement?

**Yoshua:** And Iulian, you should also mention the publications that are coming out that are presenting all of these benchmark studies that you're talking about.

**Iulian:** Yeah, right. I mean, we published two papers in AIET, and we were working on another two papers. We have a study with a company with about 600 employees. We're also starting a study with Dawson College, Concordia University and the AI Launch Lab in Montreal, funded by the government. We're basically also studying the use of AI tutors in classrooms in universities. So, we're very, scientific, research based and we try to document everything that's happening. At the same time scaling up.

**Craig:** Yeah, that's fascinating. I'm just looking at the Korbit.ai website. So, you do have content loaded already that students can participate in, focused really on data science it looks like. Is that right? Can anybody register and study the courses that you have prepared for free?

**Iulian:** Yes. Anyone can go sign up the free, they just need to have a working internet connection and a phone, a tablet, something.

**Craig:** In these studies you've been doing, have you been contacted by any Universities or colleges or, school districts that are interested in using this.

**Iulian:** Yeah like I just mentioned, we have a project with Concordia University, Dawson College in Montreal, and we're starting to put it in classrooms. We have had a lot of incoming requests from other colleges, universities, professors who want to research. We've had to say no many times, unfortunately, because our time and resources are limited and we have to focus. One challenge at a time, we are still a startup, but there's definitely a lot of interest.

**Craig:** Because it seems this could solve so many people's problems if it were available.

**Iulian:** I would also take a step back and say the AI tutor we have today is sort of like a cell phone in the nineties, you know, it's this big block, satellite connection is slow, it has only one app. What you're seeing is the first generation of widely used AI tutors. And it's going to take time to build them. None of these technologies we have today where built like in a couple of years, it would take decades to fine tune them. And so, you're going to see like a spread of this. Over time, the technology gets better and better.

More research has conducted, more data sets. Users get used to it. Universities start adopting it. Companies start adopting. It's going to be a gradual process. So, until we have that oracle AI tutor that can teach anything, anytime, perfectly it's going to take time.

**Craig:** And where are you in your, company launch? are you going to have a formal product launch? Or presumably there are some milestones.

**Iulian:** So we launched in 2019, May together with Mila. Yoshua made a lecture as well. And a couple of other professors made some lectures, and we put it online with Korbi and she was teaching it. And since then we have about 10,000 students on the platform. So that was the official launch.

A couple of months later, it was growing very fast. It was a lot of traction. We managed to secure funding from a couple of investors, the biggest one being Khosla Ventures. Vinod Khosla has been talking about AI changing education for I think almost a decade now. And there was a perfect fit. Actually, we've known Vinod since 2017 and he invested even earlier in that early stage. But he invested close to 2 million US dollars. And then other investors also pitched in and so we were able to raise a large, very large seed round and we went from six people working in a tiny office to 26 people I think our company is now bigger than the Mila lab was five years ago So it's amazing to see how fast things grow once there's momentum.

**Craig:** And then what's next on the roadmap? You're working with some companies and institutions to develop programs for them. You're working on the natural language processing. Is there a product roadmap that you can talk about?

**Iulian:** Yeah, I can give you like a high-level picture. So, like we are at a stage where we know the students learn more effectively with Korbit compared to a traditional online course. We know they are more motivated. We know we've solved the content problem.

But what we haven't done is generate any revenue. And we don't have people who are paying us for today. And so, we are really at that point where we have an amazing product, but we don't have what people call product-market fit. We don't have that group of users who absolutely love Korbit or that group of companies who absolutely love Korbit and use it all the time.

We also didn't focus on it until now. We first wanted to grow the technology and that's kind of our background and the approach we took. And so now we're really all about finding the product-market fit, finding that group of enterprise customers who really need Korbit to train their employees in data science and AI. And that's really the next milestone. So, we have already pilots going on. We were setting up more pilots and we're sort of exploring would we work very well in enterprises? And then that's sort of a jumping point to the next stage of scaling up more.

**Craig:** And Yoshua, is there foundational research being done in other places that people should pay attention to beyond Mila and University of Montreal?

**Yoshua:** I think that as, the work that we're doing with Korbit gets to be better known, I'm pretty sure others will start doing similar things if they're not already doing it. In terms of research challenges, I think that there's a really exciting frontier that is opening up that is very relevant to Korbit and to educational tutorial system, the AI tutorial system, and that has to do with, what I call, system 2 deep learning. Most of the work in deep learning up to now has been, you know, systems that are good at low level perception and low level action, like recognizing objects in images. This is a huge success. And we've had pretty amazing success in natural language, but it's sort of lacking something which you could say is the sort of high level semantic understanding and reasoning which humans do consciously with attention mechanisms. And we don't have that kind of thing yet in deep learning.

On the other hand, we've made some progress with attention mechanisms precisely in the last few years. In fact, a lot of it came from Mila with our machine translation systems. And nowadays attention based systems like transformers are the state of the art in NLP. But they haven't really been integrated in a system that tries to understand how the world works. This knowledge about the world and how to represent it in a structured way so that you can reason about it on the fly. Humans are very good at that. And that ability of consciously processing high-level semantic content is intimately linked to our ability to make sense of language. In fact, our thoughts can usually be translated into sentences and vice versa.

And in order to make really fundamental and non-incremental progress towards natural language understanding, I believe that this line of work, which Mila and others around the world are starting to investigate to build next generation deep learning that captures the reasoning and high-level semantic manipulation that we do consciously, that line of work could really transform personal assistants, which use language to interact with users. And so, in particular, in education, I think this could change the game, but that may be something many years in the future, as we are starting to see signs of that progress,

**Craig:** And can you take just a quick deep dive into attention systems?

**Yoshua:** Sure.

**Craig:** And the transformer algorithm?

**Yoshua:** So the traditional neural network doesn't have attention. It's these multi-layer networks where each layer is processing a fixed packet of numbers, which we call a vector, and then feeding that transformed packet of numbers to the next layer, and the next layer, and this is a lot how your visual system works. Each level is transforming the images into a new feature representation.

But if you look at a lot of the higher level processing I was talking about, like when you're conscious of something, your brain is focusing on a few aspects at a time. When you have thoughts, they involve a few selected aspects at a time. When you read a sentence, the sentence is about just two or three things, right? The object, the nouns and the verbs. And so, this ability to manipulate information in a more selective way is at the heart of what attention brings. And it was a big surprise about five, six years ago when we started playing with these attention mechanisms, how they could really change the game in terms of helping to solve some natural language processing problems. And since then, they have become the bread and butter of pretty much all of the neural net architectures for natural language.

Now what's fundamentally different with these attention-based neural nets is that instead of processing these fixed size packets of numbers, you can think of them as like they operate on selected subset of elements, like, think of your current thought as a subset of all of the concepts that may be relevant in the current discussions we are having or what you're currently seeing or hearing. So, your mind is using attention to select a few elements that it wants to examine in order to imagine something, find an explanation for something, or simply conduct a computation that's sequential and looks at a few elements at a time.

So, language is very much like that. Like it's one sentence at a time. Each time we focused on a few elements at a time. And so, it's very, very natural that these attention-based architectures, which operate on sets, that means it's not the order that matters, but it's the content and how the elements interact with each other. Rather than these vectors, that's really a different paradigm for neural net.

It's maybe a way to think of a response to the criticism of neural nets from the eighties and nineties where classic AI people were saying, "There are things that these neural net architectures can never do." And in fact, they were thinking about the kinds of things you could do with classical logic and rules and variables, but it turns out that all of these things can potentially be done using attention-based neural nets. And that's where a lot of the research now is exploring neural net architectures that have these abilities, and the transformers are just the current, most successful example of these kinds of architectures.

**Craig:** I see. I talked to the Alexa people about their social bot challenge and they had me talk to the winning entry. And it's very frustrating still, because it's clear that it's serving up pre -defined intents off of keywords. There's no reasoning really, and no, as you say, attention.

**Yoshua:** And no understanding. I mean, there is a form of understanding, but it's fairly shallow. That's why basic research in the high-level cognition in AI based on attention, I think is going to be so crucial for the next stage of these kinds of personal assistants.

**Craig:** And then once you have that you could marry it with an avatar. I mean, there's been a lot done in generative adversarial networks.

**Yoshua:** Which also comes from Mila.

**Craig:** Oh, is that right? There you go. That's why you won the Turing Award. But you could have again, drifting into science fiction, but you could have on your computer screen a realistic looking face of a person that is teaching you directly, it's your personal tutor.

**Yoshua:** I think there's a whole aspect which current AI tutorials are not looking at, which is the psychological aspect. And of course, having a visual interaction with a face that expresses emotions, that expresses support. We know it's very important for human teachers. And so, I think there's going to be a lot of interesting multidisciplinary research combining what we know in psychology, in pedagogy, in AI. I think exciting times for this line of research.

**Craig:** Why do you think education has not been a focus of research until fairly recently? I mean, of research in the AI community, is it that the basic components weren't there yet?

**Yoshua:** Yeah. I think we've passed a threshold that we've made enough progress, especially on the natural language understanding, that it becomes usable and, I mean, it took a lot of work from Iulian and his collaborators to build the system that they currently have. But it's going to be a lot better in a few years. We're just at the beginning.

**Iulian:** We should not underestimate the effort that came before. We've had research on education, a field called item response theory for decades. People analyzing how students do in exams trying to predict where students will struggle, when they will drop out, where they need help. This has been going on for a while. It just took a very long time to move beyond very simple data science machine learning models, linear regression, logistic regression and only the last couple of years have suddenly switched and are now exploring deep learning these new techniques.

So, I would say it's not that educators were not thinking about it. Researchers were thinking about it, it just didn't have the AI tool set, the deep learning is just such a huge gap to put it into practice.

**Craig:** And Iulian, you mentioned in an email that you have some sort of groundbreaking products that you're looking to release in the coming weeks or months. Were you referring to something specific?

**Iulian:** We have a couple of things coming out. One of them I'll talk about it because it's already out. It came out first day: interactive programming exercises with the AI tutor. So, you're learning to code in Python while the AI tutor is analyzing your code and giving you feedback.

It's the new step in coding. And obviously, again, back to my metaphor, this is like a mobile phone, like a cell phone from the nineties. It's very slow, it's painful, but it's the idea of personalizing it at that level, rather than just, let's say, sending a zip file to a student and asking them to just learn by themselves or have some general instructions.

**Craig:** Well, this is fascinating. And, as I said, it couldn't have come at a more dire time. If anything, I would hope that it progresses faster so that we can see it implemented in the education system. I'm going to leave it there. Is there anything that either of you would like to say before I stop recording?

**Iulian:** I think I just wanted to add that it's important that, we specifically democratize AI as a field. Right now, knowledge of AI and deep learning is highly concentrated in a couple of pockets around the world. And we have a lot of societal changes coming, ethical consideration. Issues like fake news, algorithmic bias, these kinds of problems are coming, they're already there you could argue. And to deal with these, we need to educate people in general about AI and data science. We think this is extremely important. So of course, we need to educate better. We need better schools. We need better ways of teaching. But we also specifically need to teach AI and data science to more people, and they need to be aware of the ethical consequences of technology and they need to have a critical mindset and be informed when they make decisions as both regular people as well as policy makers.

**Craig:** That's it for this week's episode, I want to thank Yoshua and Julian for their time. If you want to know more about what we talked about today, you can find a transcript of this episode on our website, eye-on.ai. I encourage you to visit Korbit.ai. That's K O R B I t.ai, and try using Korbi yourself.

And remember the singularity may not be near, but AI is about to change your world. So, pay attention.