Thanks, Diane, for your introduction. I think I want to hire you as my agent.

I’m going to talk about talking heads today. Talking heads are sometimes called avatars, animated conversational agents, or animated pedagogical agents. They’re pretty much the same thing, although there are subtle differences between them. Today I’m going to talk about learning and how we can build things to help people learn.

This slide is just a sample of the different agents that people use to help people learn. Some of them are cartoonish, some are realistic, some male, others female, and some are in groups. Together, these agents can provide powerful learning environments that you can’t really replicate in a classroom or with a human tutor, and you have precise control over how you can manage their worlds. Here’s one of my favorites: The Tactical Language Training System. This is the 2005 Outstanding Technical Achievement Award winner for the Defense Advanced Research Projects Agency (DARPA). People learn how to speak Arabic. It’s actually being used by some of the military personnel at this time. Learning a language with this system is not what I remember doing: Using those audio tapes you have in your car and within twenty minutes you’re tuning out. This system is embedded in a virtual world with a culture. So it’s not just language -- it’s also embedded in culture.

The next slide has some of the systems we have built in Memphis. Memphis is one of the havens for building these systems with animated agents. The one on the left is AutoTutor, a tool that helps people learn by holding a conversation in natural language. The one on the right, iSTART, helps thousands of students in the Memphis area read at deeper levels. When many students read, they read at a shallow level. So the researchers get these agents to exhibit deeper learning, and give them feedback when students try to read. The one on the bottom helps people learn about research ethics in a comprehensive learning environment. Sometimes these learning environments are so complex that you don’t know where to begin, so these agents can be a navigational guide in touring the system.

There’s more at Memphis in the recent projects, as shown on the next slide. At the top there’s a project about learning how to apply critical thinking about science. This Critical Thinking Tutor is a collaboration with Keith Millis and Diane Halpern. Imagine reading one of Diane’s books on critical thinking electronically, but then up pops a tutor-like agent that will help them learn critical thinking at a deeper level. Next is the SEEK Tutor, with Jennifer Wiley and Susan Goldman. This system trains students how to read websites at a deeper level. As you no doubt have heard, most websites have true information and false information, so you need to learn how to discriminate the two.
This unveils many secrets how you should do that. Next is a new system coming down the pike with Roger Azevedo and Daniel McNamara, called Meta-Tutor. This agent trains people on meta-cognitive skills and self-regulated learning. And below is iDRIVE. Imagine student agents that are curious, asking good questions and getting answers; this is something you rarely see in a classroom. If you can imagine learning environments simulating all of these social and cognitive processes, you have a sense of the power of what these agents can do.

Let me zoom in a little on AutoTutor, one of my favorites. One important point I want to make is that you need a team when you build these. It takes an interdisciplinary village. You need the psychologist, the computer scientist, the education folks, the artists, the linguists – all of these forms of expertise to make this happen. It is a lot of fun and sometimes a lot of stress, but you end up building things that psychologists could not do alone. This is AutoTutor, where you have a talking head, and a tough problem. To answer this problem, it might take a paragraph of information. You do this by holding a turn-by-turn conversation. It may 200 turns back and forth to answer this one question. So, it’s really conversation that is providing the learning. The next slide has AutoTutor embedded in a simulation environment. The learner gets a question, there is a talking head, the learner can control parameters of this situation (like the mass and speed of vehicles) and the system simulates what happens. In this collision problem, for example, you simulate it, see what happens, and then you describe it. We believe that all these activities together provide deeper learning. When we talk about these learning systems, we’re not talking about shallow learning but rather deeper reasoning and deeper learning. This next slide has a version of AutoTutor on computer literacy. I’ve always wanted an electronic arm that can point to these things, but it’s actually not easy to build a talking head than an intelligent arm, as it turns out.

The next slide provides a glimpse of the new system that I am developing on a project with Diane Halpern and Keith Millis. This has a trialogue. Imagine a tutor-agent talking to an ignorant agent, who in turn can also talk to the human learner. The hope is that deep knowledge will be experienced with this trialogue.

So what about learning gains? The agents are all very nice and glitzy, but do they help learning? We have conducted a large number of experiments with randomized controlled trials. This next slide summarizes the learning gains. If you look at a human tutor in a school system, the effect size from that analysis is about .42 -- that’s about half a letter grade. One sigma is about a letter grade, roughly, although with grade inflation, who knows. Then there’s AutoTutor: about a .8 sigma. Fancy expensive intelligent systems get about a 1.0 sigma, or about a letter grade. We often ask, ‘what does a skilled human tutor do?’ That we don’t know yet, but one person estimated it at two sigmas.

The next slide has one of my favorite studies. We compared AutoTutor learning physics over the course of about three hours (not at the same time, we spaced it) with reading a textbook, versus doing nothing. Here’s the data. And by the way, when we tested it, it was a deep test, not a shallow test; that is, it asked tough questions. When you look at the blue bars, the adjusted post-test scores, you find that AutoTutor was pretty good at
helping people learn. But take a look at reading a textbook for an equivalent amount of
time, and compare that to doing nothing. (Laughter) We find this outcome repeatedly.
When people read a textbook, they get shallow knowledge fine and good. But they don’t
get the deep knowledge. It takes another sort of learning environment to make deep
learning happen. The next slide summarizes another study where we compared
AutoTutor to human tutors: Ph.D.s in physics who tutor college students. Here’s the
data. You might think the human tutor does remarkably better, but that is not the case.
All conditions in the graph have roughly the same learning gains. So these computer
tutoring systems are really making some impressive strides.

What about emotions? Recent versions of AutoTutor have tried to detect the emotions of
the learner, and respond to their emotions. What emotions are these? The emotions on
the next slide are the common ones. You find boredom, sorry to say. There is confusion,
and confusion is the best correlate to learning gains. Confusion is a great signal of
thinking. There also is delight, flow (when you’re very absorbed), frustration, and
surprise. We track these with sensors, which can detect these emotions from the
dialogue, the learner’s facial expressions, posture, and speech. From all these sources,
we find that the classification accuracy from AutoTutor is about as good as experts who
look at the same information. So these automated sensing devices are getting pretty
good. We can use data-mining procedures to find out what it is about dialogue and these
different channels that help. For instance we find that facial expressions are very
diagnostic, especially your eyes squinting and the corners of your mouth. The feedback
in dialogue also is important. A variety of things can be inferred from posture, as
measured by what we call our ‘butt-sensor.” When you are very attentive, you are on the
edge of your chair. You slouch back in frustration, and in boredom you are actually
fidgety. We investigate these characteristics and narrow down which ones are correlated
with different emotions.

In the next version of AutoTutor, the system will be responsive to those emotions. If the
learners are frustrated, then the AutoTutor gives a hint. If the learners are bored, they
need some razzle-dazzle. If they are in a flow state, you want to continue doing the same
thing, because something is happening right. If they are confused, you want to keep them
confused, because that is when deep thinking and learning is happening. We don’t know
yet how long they need to stay confused before AutoTutor needs to put them back on
track.

Let me end on a comical note. One of my students and a colleague at University of
Texas at Dallas built an android that won the open competition in robotics in 2005 for the
entire United States. The robot has a new type of material and texture on his face. It’s
controlled like a face, but it is different than a human, because humans have muscles and
this has a different kind of material. When they built this robot, there was the vision of
having these in a museum so that children and adults might interact with them. Imagine
learning from an android. One research question to explore is how well this android
agent will compare to the agents on a computer screen.
The final point I want to make is that it’s fun to build these systems in addition to testing them. I think you learn a lot by building systems…just as much if not more than you do by measuring systems. I think a big part of learning in the future is not merely responding to intelligent learning environments, but indeed building them.

That’s it. Thanks.