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Welcome and thank you for standing by. At this time, all participants are in the and only mode. During the question and answer, please press star one, today's conference is being recorded. If you have any objection to disconnect at this time. I'll now turn the conference over to Janet [Indiscernible last name], you may begin.

Hello, my name is Janet and I am pleased to welcome you to the last one this year's talks in our series of distinguished lectures on designing learning technologies. Today we have Chris [Indiscernible last name] from Harvard who is going to tell us about how immersive learning environments have several different kinds have been augmented and virtual reality can form learning and allow data collection to create assessment and feedback. Before he begins, I want to say a few words about the series and Chris. The series is organized by the Cyberlearning and future learning technologies working group at the National Science Foundation. The Cyberlearning program is a joint effort of 424 directors, computer information sciences and engineering, that is five, communication and research easy, EHR, social and behavioral economic sciences, and engineering mission of the Cyberlearning program is twofold. First, to imagine and anticipate the next generation learning technologies, but they might be and how to use them, the ones that will be used on a regular basis and 10, 15, 20 years from now, in and out of school and by people of all ages. The second part of the program's mission is to advance our understanding about how learning happens, how to form and assess learning, with special focus on learning that happens in context for learners can have experiences made possible by tech knowledge he and where technology can collect data that could not be collected otherwise. Another part, I second that the part of the mission is to advance our understanding of how to design learners. As a speaker today, Chris, has been leading the way along with the students and postdocs, in designing immersive, interactive learning environments and learning how to collect and analyze data in those environments that will allow understanding, what learners understand and [Indiscernible] understand what capabilities are and what help they need. In order to learn to better understand. His software,River The city, allows learners to explore the virtual city with a disease of break and figure out where it came from and what to do about it. In that environment, they got a chance to interact with virtual members and populations, all of them do different things and had different expertise needed to understand issues and science and epidemiology. He will talk today, possibly about that, but mostly, I think about eco moves, and immersive learning environment for learning about the environment. And, Chris was supposed to be here in art, I was really looking forward to us playing with his software in hearing about it again, but he was snowed out, so I'm really glad that we had a chance to reschedule him and that we will be able both to hear about what he has been doing, and to play with the software this afternoon at 230. So, this afternoon to do that, and for now, welcome Chris, You take over.

[Applause]

Love, Janet, thank you and I am delighted to be here and to share some ideas. The title, New Wine and No Bottles is a play on a current problem in education and technology which is the wonderful new tools and media, longbow use them to automate our old ways of doing instead of using them to innovate. So, it is New Wine and Old Bottles.What I'm going to talk about today with immersive interface is particularly with augmented reality, is for the bottle itself disappears, soAnd no bottles. To illustrate the general concepts about virtual worlds and augmented realities, I'm going to revert to our work on eco-moves and Eagle mobile, those projects that 18 people have done, so I'm as the representative of 19 Tina [Indiscernible last name], who is my colleague in science education have Harvard graduate school of education has many NSF grants related to understanding causality, Amy [Indiscernible last name] is an ecosystem scientist with a PhD in [Indiscernible] which is one of these -- water-based ecosystems and Sherry Metcalf is a pewter scientist who developed a system called Model Ed in the late 1990s that was influential in shaping ideas about simulation. When I talk about projects, talking about the work of a team of people, not just about me. So, this should advance. I hope. No, me trying up here. No. Not advancing here any thoughts, Karen? Alright so Karen is going to work on this, and I'm going to talk, because anybody who works with technology knows, you've got to be able to advance. What was the magic we managed to do?

[Indiscernible - low volume]

It is to come get it for me. So, it is this? It was the hero? Okay, it is too complicated for me. What can I say? I don't want to start with technology because when you start with technology, you have a solution looking for a problem which is never a good thing. So instead I want to start with a report that the national research Council released two years ago talking about education for life and work in the 21st century. And the fact that a really good education in 1995 is now not a good education, because we don't have a national industrial economy anymore, we have a global knowledge base innovation centered economy and that has changed a tremendous number of. -- Things.

One of the interesting things that the report does is divide the knowledge and skills into three areas. Cognitive, intrapersonal, and interpersonal. Because there is a lot of research that shows that yours after you graduate from any level of education, your interpersonal and intrapersonal skills have as much or more to do with your success is your cognitive skills. Now, that is not really a surprise, to those of us who have been out in the world for a while. I'm kind new Tories at Harvard because I once asked Dean if it was possible to use the term low maintenance and a faculty job description and it turns out that is illegal. But, we all know what that is because we have all worked with people who might have been really, really smart and knowledgeable but who were so dysfunctional on and interpersonal or intrapersonal level, that they were a liability rather than assets. In the 21st century in particular where a lot of work is done by teams and not necessarily teams face to face, the other skills are really important. And in that report, I don't want to speak for a long time about the report, it is not the focus of the talk, but the report is important in understanding how the object is of education are changing and if you look at these illustrative skills from the report in the three hole and, and map out where we spend our time the boat in precollege education and higher education, it is striking from the cels like cognitive processes and knowledge receive a huge amount of attention and other cells like creativity, flexibility, work ethic, leadership and conflict resolution, don't receive as much attention to one of the things to think about is that not every educational experience needs to do all of these things have the same time, but collectively, the kind of precollege and higher education experiences we provide should really have a footprint the lines. And that is not an intuitive.

So I have thought a lot about this and look at a lot of work in sort of exemplary models of education. And again and again the same themes seem to come up no matter what it is called so whether it is called personalized education or can it education or deep learning or whatever, some combination of really good classroom instruction, richly contextualized real world learning partnerships or internships, things he cannot teach in a classroom, and then learning immunities sometimes face to face, sometimes across distance, it is those three things combined that seemed able to produce a foot print covers these areas. And it is very difficult to imagine getting footprint with just 203, or unfortunately for many people, one out of three in terms of what is going on here. But of these three the one that is least developed, the one that we have spent the least resources and maybe explored the least in terms of technology is richly contextualized real world learning. In project, in precollege education if you have any school, you know even getting a field trip, a one-day field trip is a big deal. Let alone, doing an apprenticeship or internship-based program of the night that maybe the providences are noted for or high-tech-San Diego high schools that do this, get down to middle schools, and you typically don't find much of this except for service learning, and yet this is important in welding footprint I talked about. What I'm going to talk about today is how they must live -- immersive interfaces can help with this real world learning to try to help with the 21st century objectives. Understanding of the immersive interfaces can do everything as well. So for more than 20 years I have been studying the immersion and learning. We have all experienced immersion you go to the movies maybe you go to see The Hobbit, and about 5 min. after the movie starts, you are no longer sitting in a movie theater surrounded by strangers, you are somewhere in the world with Gandolph and Bilbo, so immersion is for psychological uveal located somewhere in your body is not and you can get immersion from reading really good awful. So there's nothing new about this. But, our interfaces for reducing this immersion has been much more powerful and in particular, in reading the novel or watching a movie, it is a weak form of immersion as it is passive you're just observing. But what my colleagues and I have studied his strong forms of immersion for your activity in shape the environment that you are immersed in. So, 22 years ago in 1992, a colleague and I were funded by NSF to study full-fledged virtual reality would have mounted display computer is closing, and then in 1999 I started the work on River City that Janet talked about and for 10 years with some for funding explored virtual environments. And more recently, and

starting in about 2005 I began to do early work with mobile learning and augmented reality. So these themes as the tech knowledge he keeps progressing have become greater and greater interest. And here I'm going to center on the second and third things virtual environment and augmented realities. So, virtual like Alice in Wonderland, you go through the monitor and become a virtual person. Augmented realities is like the movie, the Terminator, with the robot. You're wondering through the real world but have object-you can see an overlay on top of the real world that helps inform you and makes you more powerful. And for all of these interfaces, whether it is AR, VR, or virtual worlds, there are three E's, one of the things they do that is powerful for learning is a -- they evoke very rich centers. I talk to about richly contextualized real-world learning in the classroom, what do you do? Should people pictures, video, maybe have a guest expert, and across distance. But, you cannot really give people the feeling of being inside of the real world and these technologies are very evocative. Engagement. Will we see from games, Internet games in particular, the these can be very powerful in terms of engagement. But, when they look like the real world, they also see relevance and can also develop, as we will talk about, greater feeling that they themselves can help with whatever is being evidence. And then evidence, like you, these are things that live on a server, and so these immersive interfaces like. Rich and have data that if we understand how to interpret it, can really help us with both diagnostic and summit is. Think about those three E's. So in about 2000 2007, Tina, my colleague, have been doing her work and identities are complex causality, I have been to With virtual worlds, and we work with augmented realities and we had wanted to get it because I have done some work with teaching systems thinking in 80s and I have always been very interested in complex causality and had a healthy respect for Homer was to teach based on my experiences. So we decided to combine our forces, she had done some work on ecosystems that have hit a glass ceiling in terms of what students could learn within the myth of the classroom so I said, well maybe immersive interfaces. Of course, environment Thursday is very important, that environmental literacy is very important and something that students resonate with because it is part of everyday life and underdeveloped in the common Orient next generations find standards. Kids and adults don't often understand complex causality one of the reason that so many of our most resistant 21st-century problem keeping around and getting worse is because people do not understand the dream that underlies them and in ecosystems, you cannot do that is controlled experiments that might characterize the physical and biological sciences, little more like medicine or you have to be careful when you are experimenting on. And so, there is a different kind of epistemology that we want people to understand and of course, this is all fine but it takes a stance. Ecosystems science is about stewardship, not understanding the natural world, it is about being a steward of the natural world. And so there is a value dimension that is important and makes it more complex to teach so we thought this is a good challenge for us to take on, doing something in environmental education. Now of course, NSF has already done creative things in entering the litigation that to the kind of challenges that I have raised. So the global Forest Watch is an example of a project follows in a long string of citizen science projects were people locally collected and get involved and understand science but also the data is integrated in ways that help advance the scientific enterprise itself. So we knew that we wanted to build on things like that are -- also, you may know that there is a neon initiative NSF is leading her over four decades , all of the major biomes in the United States are going to have rich sensor networks embedded in them. So it will be a tremendous amount of sensor data and the public needs to be prepared to understand that if they are going to be able to make good decisions for citizens because as you know there is a lot of information and misinformation that the public wrestles with in terms of environmental science. So with that as a prelude, let's talk about virtual worlds in terms of their capabilities for immersive learning and let user Eco-Moves as an example. This was funded by the US Department of education Institute of educational sciences, a four-year project focused on middle school and three goals in terms of learning. Ecosystems, science concepts, inquiry as a collaborative process, and complex causality that underlies ecosystems. So we developed either a two-week or four-week ecosystems science curriculum, based on two digital ecosystems that were released under a pre-license from Harvard, used in a variety of places and you yourself can use it this afternoon or if you cannot come this afternoon and you pick up a copy of the handout, you can use it without having me around to support you because of course it is going to be practical to use in school, it has to be the kind of thing that people can use without a lot of support to do it. So on the left you see a pond called Blatts Nook him in near Harvard, we have a little environmental station some if you go to middle school in Cambridge, maybe once or twice during procedures, he will go for an afternoon out the pond, it is fun, interesting, it has very little impact on learning, unfortunately, because there is an isolated drop from the experience for most of the time you're just sort of mucking around and the teacher is trying to keep kids from falling into the pond and so on. But it is a great site and what we did

with the help of Amy, make sure our ecosystems science was authentic, to prepare not just a simulation of that particular pond, although we used it as an sample, but a rather generic simulation of a water-based ecosystem. Now in order to give you a feel for what this looks like, the easiest thing for me to do is show you a video clip, what it might be like to be a student using the pond ecosystem curriculum.

[Video]

This gives the students a respect for what you do not drink pond water.

[Indiscernible - low volume]

Back at the pond, the water measurement tools let us take series of measurements of the water in the pond, [Indiscernible] as well. The calendar tool tracks time in order to see how the pond is changing on different days. Here is training. When we walk into the water, you can see how cloudy the water is and can also take another measurement. The data but the CM compare data we have collected. The [Indiscernible]& See what has happened in the ecosystem overtime. We can see three atoms, carbon, phosphorus and oxygen. [Indiscernible - low volume] here we see and oxygen atom as part of a water molecule on the leaves of a tree. On the next digit -- visit, we see that through photosynthesis, the oxygen atoms are being released into the air as part of an O2 module. As kids explore different parts of the pond, we discover that on July 28, all of the large fish in the pond are dead. Through the inquiry-based curriculum, students work in teams to go and analyze data and see what killed off the fish. Once the students collected the data, they can use a drafting tool to compare different variables and create maps that explain why the fish died. During formation, Obama -- [Indiscernible - low volume] students developed a richer understanding of complex relationships and ecosystems.

All right, so I'm going to pause there. And go back to this. Now, I'm not the 20 -- I'm not going to go deeply into discussing this because getting down in the example is not the point. This is a container, virtual worlds are a good into which many kinds of things can go. It can sit in a classroom in Massachusetts in the middle of the winter or city name must remain Arizona where there is not a pond for any considerable distance and they can be immersed as ecosystems scientists in a pond trying to figure out what is going on. That is the fundamental point. This is based on the jigsaw pedagogy, so there are teams of four, each person on the team is about a quarter of wedding ecosystem scientist would do, and then have to combine their data to understand what is going on, so that helped to develop some of these interpersonal guilt and interpersonal -- intrapersonal skills that we were describing, and over time, students can trade roles so that the gradually wonderful skill set of an environmental scientist, it also helps teachers because if you got the student has difficulty reading, and they are dyslexic or an English language learner, you can give them my role initially that does not involve that they can still play a really useful role on the team and build their self-efficacy that have the same with people that are reading survey are seeing the value of being able to do reading. Not everything that happens happens inside of the virtual world. This is an example of the food web tool. The whole parts of magic that happens in the world, shrinking down the submarine, the-tracker, things like food web toolbar designed around these middle school kids typically have about ecosystems and complex causalities. So, the submarine is a way of showing them that are invisible, that in fact, the causality, the atom tracker shows the flow of matter which typically would not be visible. This is a way of showing that energy flows through the system which typically would not be visible so we are trying to build a mental model in their mind of all of the different ways that complex causality works. And you saw the end of the video, this collaborative construction of concept maps. The end of the unit, testing for participate in a little scientific conference with the get up and present findings to the class and even more important, they produce evidence behind the findings to their glass. So the teacher is able to judge not only what they understood and did not understand about the complex causality, but also what they did and did not understand about inquiry and making evidence-based arguments. And of course the teacher can see a little bit about their collaborative abilities, self-efficacy, how engaged they need to be in some other dimensions we were just driving. But that is not the only form of assessment and fax, -- in fact, one of the advantages of immersive interfaces is enable new methods of assessment beyond what may be typical for project-based learning and beyond the repost of the books was an short answer instruments that researchers use. This is really important because we can't really get things like virtual worlds for augmented realities into the curriculum unless we can assess the true value which means being able to assess along all

dimensions in a footprint that I described earlier, not just the narrow dimension that you've assessed with traditional measures. Also, if you use only the tradition measures of these new concept media don't look that different in terms of their instructional outcomes, whereas if you are able to use a broader spectrum assessment, you get to see what they are really accomplishing and in particular because of the server, Eco-Moves and all other virtual worlds give you this incredible second by second information about which each student is doing, where they go, who they talk to, what they say, what they hear, with activity and do not activate, with a shared notebook with their teammates the data they collect, etc. Now this creates a huge problem because the files are intellectually indigestible and so a lot of work and learning analytics is going on for all parts of cyber infrastructure, not just virtual worlds and immersive interfaces, trying to understand how to digest the data. We have done some work on that and River City project and another project funded by NSF that I'm not going to talk today about called virtual performance assessment were we develop a rubric for analyzing the kind of rich data that came out of that. But even without advancing learning analytics completely, there is a lot that we can do now with diagnostic assessment that are formatted for learning. So they are happening near real-time and really shaping instruction and learning, rather than waiting for this summit is assessment and science conference at the end and repost measures that are used to judge the effectiveness of Eco-Move has an out, because that is too late for students and teachers. One of the things that we did with friends or that we are now doing with Eco-Move is we collect data and we displayed for student being trained for their paths, both individually and as a team, exploring each time they went back in time machine. And when we show them expert panels and just without feedback, all of the teachers spending time explaining what was gone, we saw dramatic improvements in one students were doing and another barred from games to use heat maps which not only capture the path, but also show how long somebody stays at a particular point and in this particular heat map, we took the students who were high-performing in terms of inquiry skills and the students who were low performing in terms of inquiry skills, the high-performing was green, low performing was being, and you can see that if you superimpose the two, a lot is depending on where they spend their time. This was another kind of feedback that we can provide to students and teachers that turned out to be pretty effective. We don't enter visual wise guidance into River City, something that we have not yet done with Eco-Move but me with new grant we have to extend the environment. Of course the beyond providing support for students, the hint system lets you know whether students need a hint and how deep into the tree they are going. That is the kind of diagnostic information that can be helpful with the teacher knowing who is struggling and what they are struggling with. Something that we did in River City, but this is an example of this, is animated pedagogy, you can meet computer-controlled agents of the kind that you saw in the Eco-Move video who will interact with you and tell you things. This is an example of one of my dogs roll students who did a lot of work with NASA and was part of the education program where they took NASA scientists and they would adopt an elementary school classroom so that the kids could interact with the scientists, increase their interest and knowledge. And she wanted to do her dissertation on this and I said, well, yes, but it is not scalable. You run out of NASA scientists long before you run out of elementary school customs, ethnicity something that is scalable. I showed her a couple of options and she showed this one, and she designed Doctor C, a pedagogy agent , now this is not artificial intelligence or some elaborate natural language recognition expert system, this is a very crude Wizard of Oz kind of interface for the exact keywords and has a big frequently asked questions database and asked the frequently asked questions and feedback some of the time it says, I did not understand, please repeat, some of the time it does, give us an answer, the answer is off target. But it is very easy to create and what the research showed not presently listed. To a real NASA scientist to his highly engaged and knew how to talk to kids, this was inferior compared to a real NASA scientist who was not highly engaged or compared to a real NASA scientist who did not know how to talk to kids, this was superior. Of course this is eminently scalable so there's a lot that can be done in virtual worlds with embedding agents that can be both educational and diagnostic in terms of what is asked of them and what kind of answers you give to them in these do not get out of flow when they are in the world because they are part of the storyline, rather than the teacher coming over and saying, what are you doing and why, or some other kind of voice of God intervention that tends to make us dislike what is going on. I briefly mentioned the virtual performance assessment. One of the ways that we can try to measure transfer is to put students in a different world. So we have a forest ecosystem and one of the ways we can measure transfer, although we have not been candid studies of this at this point is to have them do the pond and then move them over into the forest and see what is particularly inquiry strategies but also ecosystem science knowledge they can transfer into a different environment that has a different and complex causality associated with it. Building on gains, another thing we have done in terms of feedback, if

you can obtain powers through your punishment and experiences, but we did not want the powers to be something like flying because then you're just using extrinsic motivation, I'm related to learning. In River City we designed the spooky house, you can only get into different parts of the house. If you pump enough within your role in River City, and then access special things but they let you go back in time or that you have superpowers that we see an aura people who were going to get sick, so it was geared around intrinsic engagement. The point I want to make is in the long run, one of the biggest powers for learning of these interfaces are going to be these embedded diagnostic assessments that don't interfere with learning, network and self-assessment of Val Schute would say, but provide diagnostic information for students and teachers to understand through learning analytics the big data. These are all interesting way to think about that, but if you step back for a moment to where I started, this is somehow trying to get at this issue of real-world learning when you can't do real-world learning, these are all of the kinds of proxies and a mentor might use in the real world. If somebody was an apprentice and you are watching what you were doing, we are trying to figure out how we were learning your -- we were learning.

Now, Eco-Move is a model, so it is as authentic as we could make but it is also inauthentic because any post of vice things. So there are private things that are good for learning ecosystem science and other things like collecting data that are deceptive about what is involved in ecosystems science. This is like a flight simulator, if you're learning to fly an airplane there are advantages to a flight simulator but it is definitely not the same as flying a plane and we wanted to understand both transfer, so when you really master the model, does that mean that you are transferring this and looking at the world, and we also wanted to understand how this might relate to augmented realities and whether it made sense for us to bring in the second immersive interface. We did a lot of kinds of research on Eco-Move including comparing it to a project based learning curriculum that did not use immersive interfaces, which I'm not going to talk about today, but I am going to talk about this one these -- one piece of research that looked at Eco-Move and getting people into the real world through field trips. As part of our initial research, we have buses use Eco-Move, then go on the field trip and wanted to see if everything the transfer from Eco-Move to make a field trip more effective, standard, ordinary field trip. What we found is that in fact, we did see things from students from inquiry if they did Eco-Move first before they went on the field trip. We identified three aspects that we thought Eco-Move might be effective on, making observations, using the data collection tools and using evidence-based reasoning, we did find gains in terms of operations -- observations, the slides are available so I will not wonder on them we did not find, at least in that design tool use was enhanced, so we needed to think about that more. We did find the explanations improved, and so that helped get the feeling that we are on the right track in terms of moving toward the go mobile. So the vehicle movements like mine craft, Eagle mobile is like neon or the global network of sensors and how do you put your people for that? What makes all of this possible, this new kind of interface is handheld devices. Some of you may remember 30 years ago the first powerful handheld device, that help you later from Texas Instruments, one of the great tragedies like my life is I now look like the little professor. I never thought I would get this old, never. And of course, in 2014, or handheld devices are much more artful than that was, and so we took the same pond, Blatts Nook, and is, why do we augment around the pond and have different stations that kids can go to and see what we can learn beyond a standard field trip where we are trying to augment the field trip, and also that have been used [Indiscernible] and when real data because we want to overcome misconceptions that the simulator might create about how easy it is to collect data handheld variable just how variable data is. So, we are at the end of a four-year funded project, it is complementary to Eco-Move but our primary emphasis is Eco-Mobile , and it integrates a lot of research on augmented realities that different groups have done before hand. So, you've got this pond that we have augmented, you will see in a video in a minute that we have ways of using mobile devices to help provide assistance for students in understanding, like simulations, we can also called students attention to things that they might ignore, but this [Indiscernible] that is in the pond environment that if you weren't looking for it as an ecosystem scientist would, you would not see what is involved. So this is an example of location is augmented reality, here is a video about Eco-Mobile.

[Indiscernible - low volume]

Helps them connect with real world experience Obama -- [Indiscernible - low volume] explore a virtual ones the virtual pond now we have developed Eco-Mobile to allow students to take some of the things they are learning in the classroom and learn more about them in the real world. We developed and augmented

reality game that students can play on smart phones using their wireless networks at the pond. So as students move around the real environment, they encounter hotspots with information to connect with what they were learning in the classroom. Things like [Indiscernible - low volume] or allow them to take measurements of the and test water quality. And the students coming out in the pond environment, they go on a field trip and using trend, track their experiences in the classroom.

[Indiscernible - low volume]

The kids have been excited to use the smartphone devices and it is amazing to see how prickly they can pick it up and use it, it took a very short introduction for the kids to be able to navigate with the device and be able to access the hotspots. They were figuring things out and troubleshooting together and it was really fun to see them work together to solve problems they were countering and one thing they might not quite understand how something works and others were there to help them figure it out. One of the programs they are using are very similar to what real-time [Indiscernible - low volume] ecosystems and they are getting experiences that rival what real scientists can do and they realize that and see things about water quality start to understand what the -- it means for, we have had a lot of rain in the past few days and they are connected and the fact that [Indiscernible - low volume] to understand things that happened in the world are affecting close to home.

The higher, the morgue body in the lower, the less cloudy.

I agree.

All right. I was a good production. Let's see if you are right.

[Indiscernible - low volume]

If we did not have the phones, the students would not have a way to access some of the initial information that connects them to the classroom. Their experiences in the real world when we have gone on field trips before have been on, snapshot that these that when they go back to the classroom it is hard to remember what they did or why it mattered but now that we have the phone to connect them to their experiences in the classroom with the real world, we can take the phones back and use them to help connect the learning.

It was awesome.

We get to learn about the oxygen in this case and are answering questions and can test the water and, yeah, it is awesome. Much better than using a textbook because you are in it and you can see everything. And the questions are related to what you can physically do instead of just what you know from knowledge.

All right, so let me get myself back here. So, just as an interesting implement, and again, this is trying to address the issue of what we do to have virtually contact waste real world -- contextualized real-world experiences. We have done a variety of things to study the augmented realities and I don't have time to report on all of the outcomes. Augmented realities are much easier to create technically then a virtual world, but they are still tricky in terms of the and structural design and in particular what you don't want you to do is to be out in a real environment staring into a mobile device. It turns out it is quite challenging to figure out the right things to do to draw kids into the environment rather than out of it. So one of the things that we examine is the issue of how you go out and do authentic science and then come back into the classroom and make sense of it. And we did one set of augmented realities implementation where we contracted the highly structured augmented reality versus a free choice augmented reality to see whether trade-offs were between the two. Both were similar in many respects except for the autonomy that students have. So in the first case which was the highly structured one, we had a lot of activities that involved the students with data collection and those paths are different for different teams. So students on different teams would wander around, find things out about oxygen, they would these simulation in another place about oxygen, they would collect information about oxygen, in this particular pond, and then they would synthesize all of that. And what we found is that the teacher felt that this really helped compared to a regular field trip because in a regular field trip, all of the students are standing next to a teacher, the teacher

is shouting, some are engaged, some are not, here are the mobile devices to keep the student contract and Philip Roth the ecosystem and we were able to show significant learning gains compared to a regular field trip with the augmented field trip. The other was unstructured where we wanted to emphasize student autonomy have a virtual mentor, this is the Cambridge public school teacher who was at the field site for Blatts Nook, sort of an expert, the students went around to different hotspots at their discretion and one of the things we found that we should have anticipated as designers is no matter what advice we gave students, they always want to hotspots loosest. The natural conservation, but we did find a way around that and inadvertently, I was on an implementation last fall where there had been a tremendous amount of rain the day before and there was a part of the pond where it was treacherous and slippery and money and before the get started, we said stay away from that, it is dangerous and every single kid of course immediately went to the furthest part of the pond so they could do that. Now we know how to handle this issue, this version, hotspots. Notice the kids are collecting a lot of teams including a lot of the we would not have put into the augmented realities. They found them on their own. Now they are Cody signers of the augmented realities and then they come back to the class and constructing rich multimedia picture and of course, there are a lot of ways that could go. Beyond what we are doing in our experience. Again the teachers, kind of like this version as well, feeling structured version but also the unstructured version. There might be an interesting dynamic tension between the two were you want to do both. I want to wrap up for the start time for questions so let me say a couple of things. I don't want you to be fooled by the examples into thinking this is a talk about ecosystems science. This is a talk about containers. These are containers, virtual worlds and augmented realities that are part of cyber infrastructure. And they can have all sorts of stuff in them. You could have a virtual mall in which you make visible the flow of goods from the flow of people and money, and then the kids can go to the real mall and it would be augmented to help them understand economics. You can have them take their own city and do a historical virtual world that shows the city itself changing over time and then they can go around two houses in their own neighborhood and people can bring down all the photos and juvenile augmented reality about the history of their area. So, not just for STEM but broadly across the curriculum, there are interesting wings we can think about put into the containers and use with cyber infrastructure if we understand how to use them well for learning because it is easier to believe that virtual world for learning than a good one. It is easier to build that augmented realities been good ones. This is not about technology, this is about and structural design. The tech knowledge he does not meet the learning better or worse, it creates an environment with a three E's, debug this, engaging and evidence. Only if you take advantage of those do you get good learning. Ultimately of course, the bottom line is transferred, it does not matter if we build a wonderful virtual world or augmented realities, in this case for environmental science, and at the end of the day, kids go out into the real world and even exact same ways they would have without this. I think one of the things that will be important for the field is look at how you scaffold transferring both service and deep features of the media so that we get to give impact that we really would like to have. So with that I want to say I hope you find this as interesting as I do and we are going to continue for the next three years our work in both Eco-Move and Eco-Mobile and get further along in these issues and I want to thank the many people who have been involved in the project. Thank you for listening.

[Applause]

We've got some minutes for questions and anything you want to talk about including things I did not talk about it on the table.

At this time we will begin the question and answer session. To ask a question, please press star one on your phone, unmute and record your first and last name when prompted. To withdraw your question, press star two.Again, to ask a question priest -- please press star one and record your first and last name.

Questions from people here? Or comments?

Obviously, one of the functions of the Eco-Mobile is structuring the abstract representations in the environment or understanding the conceptual [Indiscernible - low volume]. What have you found out about the structures [Indiscernible - low volume]?

In Eco-Mobile, we have teams of two and each has a mobile device, typically one has a graphing calculator and the other has a smart phone. Where we don't do the graphing targeted with appropriate where, one has a smart phone for taking notes using Ever Note, and the other has a smart phone with the AR software. So it is not me that's not me team of four, but it still teams of two, and get a jigsaw pedagogy, but you're not having a crisis event like a fish kill, you are not traveling back and forth in time, you are not the same kind of scientific convention were different teams are presenting evidence, you are more having a deconstructed session after the pond. One of the things we have done this is an interesting that we are starting to study is the last time the kids went out we put a GoPro on their head and there is a new camera with audio that has come out of adventure gaming, so you wear it and post your exploits on the Internet. We were staying -- amazed to find the audio and video quality from these mounts was excellent and we have been following the friend with the camera and of course that strains what they can do and also what they said, but whereas with the GoPro, they forget they are wearing it. The thing that has good research properties in terms of interpersonal and intrapersonal, but we think in terms of the sensors and capturing biomes turning kids loose on biomes that we want to document but also having AR and having them wear GoPros, putting them up on the Internet, there is a whole other level of citizen science that we think is possible coming out of something like that. Yes?

[Indiscernible - low volume]

Are you looking at ways to assist other communities to create their own, given their location?

One of the challenges with augmented realities is a Eco-Move -- online Eco-Move where you can download anywhere in the world , in augmented realities, you are augmenting a mobile reality and strength isn't actually the kids love that Eco-Move but they ascribe much higher relevance to their own ecosystem in their own backyard appropriate. In another year, we hope to release templates, so we've got a water-based ecosystems AR geared around a pond, but the template might say, do you have a marsh, stream, drainage ditch, anything with water in it? Here is a subset of the pond stuff that you can do, because again, technically programming this is much easier than a virtual world. There is a Google Earth interface you can look at a God's eye view of what you want to augment and pulled the ordinance right out of Google Earth, so that part is not that. It is getting the design right that is challenging. We are doing an experiment now with teachers creating their own augmented realities given a template, it is not straightforward yet, and the [Indiscernible] is not straightforward and mobile devices not straightforward, but it is a moving target. Cyber infrastructure. Stuff that is hard now we think in two or three years is going to be right in the sweet spot and we hope to have the kind of template that we can use.

Are you looking at partnering with companies that provide textbooks and [Indiscernible - low volume] for the school district?

This has been a considerable frustration on my part. 10 years of funding went into River City but River City as a curriculum was built on kind of an [Indiscernible] modem, and we could not find a publisher that was willing to take it on, almost more or less for free. And we could not get funding from any group to rewrite River City in a modern shell and release it for free. So, it is essentially gone weird -- it is essentially gone. Eco-Move, the technology was further along when we started so we built it in a strong offering shall and is released for free by Harvard and actually I am working at the moment to get a Chinese version of Eco-Move because I also study scale and would love to have 10 million Chinese students doing Eco-Move your --. So I am working on that. Our work with publishers has been a lull, publishers used to fire or forget things, they are not used to services that live on a server like virtual worlds were potentially augmented realities. But in the long run I think that industry will change as well.

You keep referring to the interfaces, immersive interfaces as opposed to immersive environments. And I wonder why you focus on the interfaces as opposed to the environments.

Well I guess that is probably due to my own role in this as a developer. Is that as a developer, I am always thinking about the offering shell itself, what it does and does not enable you to do, how you work around the limitations and how you work around limitations within the school. This is implemented. But you are

right from a users perspective, hopefully the interface is what you are focused on, the experience. I think I'm just having a role.

This is the operator, please continue to stand by.

[Music]

[Event concluded]
Actions