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EDUCATION TECHNOLOGY: THE NEXT GENERATION

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P R O C E E D I N G S

MR. WEST: Good afternoon. I'm Darrell West, Vice President of Governance Studies and Director of the Center for Technology Innovation at the Brookings Institution, and I'd like to welcome you to our forum today on education technology. I'd also like to welcome those who are viewing our event via a live webcast. We've set up a Twitter feed with the hashtag #TechCTI. That's #TechCTI for those of you interested in posting questions or asking questions during the event.

Advances in education technology have enabled dramatic changes in content delivery and accessibility. They are widely recognized as helping to reshape the American educational system. Today's technology utilizes massive online courses, video games, computerized testing, and in some places even robots. So we're seeing one of the most dramatic periods of innovation in education history.

This afternoon we are putting out a paper entitled "Education Technology Success Stories." This work is funded by the Gates Foundation, and it looks at how education technology is helping students and teachers promote learning. My co-author, Josh Bleiberg, and I highlight five success stories. These are examples of innovations that have improved efficiency and effectiveness in the classroom.

We argue that we need policy changes to encourage additional innovation. We urge greater flexibility in terms of school finance, school operations, and classroom rules in order to take maximum advantage of these new tools. And I will refer you to the paper for additional details. If you were not able to get one on the way in, you can pick up a copy out in the hallway after the event.

Today we have a number of distinguished experts to help us analyze recent advances in education technology. Marcia Lin is Professor of Development and Cognition in the Graduate School of Education at the University of California Berkeley.

She specializes in math, science, and technology education. She directs the NSF funded Technology Enhanced Learning in Science Community, and previously she served as Chair of the AAAS Education Section, and is President of the International Society of the Learning Sciences.

She's the author of a number of books, including *Computers, Teachers, and Peers*, *Internet Environments for Science Education*, *Designing Coherent Science Education*, *Why Science?* And her most recent is *Science Teaching and Learning: Taking Advantage of Technology to Promote Knowledge Integration*.

Anthony Kim is the CEO and Founder of Education Elements, a blended learning technology company that he founded in 2010. He also founded and led Provost Systems, a provider of software and services for operating online schools, and he worked with K-12 post-secondary and the Department of Defense institutions to support innovation in instructional delivery.

Val Shute is the Mack and Effie Campbell Tyner Endowed Professor in Education the Department of Educational Psychology and Learning Systems at Florida State University. Prior to joining Florida State, she was the principle research scientist at the Educational Testing Service, where she was involved with basic and applied research projects related to assessment, cognitive diagnosis, and learning from advanced instructional systems. Her general research centers around the design, development, and evaluation of systems to support learning, particularly related to 21st century competency.

Her 2010 book was co-edited with Betsy Becker and is entitled *Innovative Assessment for the 21st Century*.

Philip Piety is a national expert on education data and is the author of the forthcoming book, *Accessing the Educational Data Movement*. His book is due out in

April.

He began his career in organizational technology, working with many large government and commercial organizations to develop data systems. He was the first student at the Michigan School of Education to use cross-disciplinary degree options to develop his study on the learning sciences. And in his forthcoming book, he analyzes the need for the understanding educational practices both in terms of what they have been and what they can be when blended with personalized learning models.

So I'd like to start with Marcia. How should we use new technologies for student learning, especially in the sciences? What do we know from research that would help designers of electronic textbooks, and other new approaches to online instruction?

MARCIA LINN: Well, thank you. I'm delighted to be here. It's such a great opportunity to discuss these important issues, and I know these colleagues here can bring many useful perspectives to this discussion.

Over the past 25 years, we've been trying to figure out how we can really leverage technology. And as you know, this has been a win and lose situation. Technology, you know, is like a pencil. I mean, you can use it well. You can use it poorly. And we've been really looking at science and what are the advantages that we have with technology over traditional approaches to teaching.

One of the best ways, I think, is really to bring to life or make visible things that you can't see. So how do chemicals really interact? What does the solar system look like? Could I tweak it and see if it did something different? These kinds of things that aren't really possible to observe directly are great for science teaching.

And we've been building wonderful, I think, visualizations of these topics and helping students figure out and teachers how to use them. And that has been both exciting and challenging. Sometimes in other research people have argued that we really

don't need these dynamic visualizations, having molecules moving around, or we have an air bag simulation where, you know, we have a driver in a car and the air bag blows up, et cetera. And it would be better to use static pictures.

So one of the research themes that we've followed is, sort of, what are the ways to use these visualizations so they are better than static pictures. And we've found is that there's really important guidance that students need in order to make sense of these visualizations. For one thing, students are so used to them, you know. If you read starting when you're very young, you learn how to make sense of the textbook or the pictures on the page, making sense of these dynamic visualizations, designing good experiments to tweak the system and get feedback. This is a new skill, so we need to help students learn how to use it effectively.

And I think that we've made tremendous progress in understanding that. Just recently one of our post-docs, Kelly Rue, did a really interesting study of photosynthesis where she had static pictures of the photosynthesis process, and then she also had dynamic visualizations. In both cases, students could navigate as they wanted to, tweak them, et cetera. And in the end, what she found is those students in the dynamic condition made considerably more progress in understanding photosynthesis than those in the static condition.

She did a number of things to make these visualizations effective, but she did the same things for the static pictures, and they weren't as effective as the visualizations.

Another thing that really is exciting for making these kinds of materials effective is sort of creating a good interaction between what's on the computer and what the teacher is doing. And often teachers also aren't really sure how best to use these visualizations. So we've been designing online guidance and seeing if we can diagnose

what students are thinking, and then provide them with good hints or clues about how to proceed.

And we're finding that we don't need to tell students the answer at all. We need to just help them think about what to do next, how to tweak the system in a new way and get some new evidence, and then build their own understanding. And what we found, interestingly, is that the teachers are starting to tell us, you know, watching how your guidance system works, I have a better idea about how to guide students when I'm working with them in the classroom. So this has been very gratifying, kind of an interesting reverse engineering it on the computer and then the teacher finds a way to emulate and extend it.

The teachers also tell us that if we can provide this kind of clue-based or hint-based guidance so their students are actually thinking harder, then when students do get stuck, they have time to really work with that individual student to help them think about how they can proceed.

I think what this does is that it kind of changes the goals for science education so it's not just learning the facts. It's really trying to understand a complex system. And furthermore, it involves really becoming more independent in thinking about how to advance your own understanding so students are learning through these kind of hints the kinds of strategies that they might use to make sense of the next visualization or perhaps solve a problem that's personally relevant to them, like selecting a good treatment for some kind of health problem, or possibly making energy-efficient decisions about home heating or whatever. So I think that what we're doing is we're helping students become better autonomists or independent learners as a result of working with these systems.

The web-based inquiry science environment that has these units in it is

now free and available. It's open source. We have over 6,000 teachers and over 50,000 students using it currently, and people have set up instances of it across the United States and around the world. So it's very much a growing opportunity, and I encourage any of you who are interested to access it. It's free, and you can start tomorrow. It's wise.berkeley.edu.

One of the things that we're really excited about is that when teachers use WISE to help their students make sense of complex science, they're also introducing student who might not have computers at home. We work primarily in schools that are really very low-income, have lots of students that are receiving free or reduced price lunches. And often these students have not been using computers at all, or have only used them infrequently, and then not for anything too exciting, although I think they might think that PONG is exciting.

But the opportunity to introduce computers in a serious way and to make a computer more equitably useful to all the students in these schools I think is a great thing. And it's great to do it with science, to bring students into using computers to learn science so that they're developing their computer skills. They're developing ways to search for relevant information.

They're also learning how to be critical consumers. There's lots of great science material out there that's actually not accurate. And so they're learning to be critics of the science material that they might encounter. So I think that that's sort of another great advantage of technology is really enabling a larger group of students to become competent in technology, and ultimately to be on the path towards being more productive citizens of our society.

MR. WEST: Okay, thank you very much.

Anthony, you've been on the front lines of innovation through your

blended learning work. So can you describe what Education Elements does and how it works to improve the learning experience?

MR. KIM: Yeah. I think frontline is appropriate. I have a lot of scar tissue from trying to help K-12 schools across the country implement blended learning or innovative schools models. And so it's a hard road. One, you know, we're dealing with only one-third of the schools across the country having proper bandwidth.

Historically, technology being implemented at schools and it collecting dust in many ways from beige computers still collect dust with Windows 95 and old versions of Internet Explorer that aren't supported, to a situation where I was actually trying to load a presentation on a computer at a school district in Florida, and it literally took us 25 minutes to load this presentation on a computer because two people had to come in and unlock the computer.

And so when technology is that hard for us to utilize, we tend to put it away, especially as a teacher. If you have 55 minutes to teach your class and you need 20 minutes to support a classroom or a technology issue, then it's just impossible for you to get through all the content and material.

So what we do is we'll come into a school and help them think about what new school models might look like in the future. And one way we do this is we talk to superintendents and say you just got awarded these major bond dollars. Let's make sure that you don't design buildings and classrooms of the past, and let's make sure that we have kind of open classrooms and abilities for students to work in small groups.

So one way we do this is by going through a design thinking exercise. So we'll give each teacher and principal a profile of a student and say, design a classroom for this type of student, and we'll give them a piece of butcher paper. And it turns out that all of these teachers actually design classrooms that have small group

areas, quiet reading areas, collaboration areas. And they all realize that these don't look like classrooms that they have today.

And so, you know, if the notion of how people learn is around different types of modalities, like independent, there are times when you want to collaborate. There are times where you want to work independently. There are times when you need to practice. But most of the classrooms are actually designed just like the rooms were in today, rows and columns of seats. And so it's not very interactive.

And so then we try to figure out, okay, how would technology support this type of design? So if you were to have small group stations, highly differentiated, you're personalizing, you know, how can a teacher do that? And it's really hard without technology. But if you had technology and data, you can do that a lot better.

And so then we're trying to insert technology into that and explain to teachers the role of technology. The role of technology in online coursework, for example, isn't to replace the job of a teacher. It's really to supplement the role of the teacher and really focus the teacher not on delivering the content and the basic skills that students need to participate, but really have the teacher focus on kind of the higher level -- what we call the higher levels of Bloom's Taxonomy, which are, you know, applying, evaluating, creating. How do we create situations for that in every classroom across the country?

And it's really by leveraging technology to help students develop an introduction to topics, fluency development, practice. All of these things can be done by computers pretty well today, right? You know, Kline Academy is an example of this, but other products are as well.

MR. WEST: Okay, thank you.

Val, your current research relates to developing stealth assessments that

are embedded in video games. So these games are used to measure a range of competencies, such as creativity, problem-solving, and content knowledge. So what do you see as the problems with traditional assessment, and how can performance-based measures provide a good alternative?

MS. SHUTE: Good question. I'd like to start by saying I'm happy to be here. Are there any gamers in the audience? Good.

So I'm going to start with a quote that I just found real recently, and I think it relates to today's comments. And it was by Plato, and it is "You can discover more about a person in an hour of play than in a year of conversation," right?

So a bunch of problems in education today,. One that I'm currently grappling with has to do with this idea that education really needs to embrace additional kinds of competencies. A hundred years ago, if you acquired your three Rs, you were considered to be sufficiently literate. But today's kids really need a new, fresh set of skills in order to be successful citizens in today's complex and very interconnected world.

For example, if, you know, when any of us are confronted with a hard problem, we really need to be able to think creatively, and critically, and systemically, and we have to persist in the face of failure, and we have to communicate well. So these are some of the competencies that I'm looking at in my research.

Another big problem that I'm grappling with in my research has to do with old school assessments. So the old school assessments that I'm thinking about, you know, multiple choice kinds of formats, and fill in the blank, and self-report surveys. And all of these are really woefully inadequate for assessing the kinds of complex skills that are really important, as Anthony mentioned, you know, kind of the higher order in Bloom's Taxonomy kinds of skills.

So what I've been doing is with regard to stealth assessment, I've been

embedding these, what I'm calling stealth assessments, directly into well-designed and very engaging games. And then they're pulling out information as a person is engaged in game play, and then using that information as the basis on which to make inferences back to a set of targeted competencies and their associated facets.

Excuse me.

MR. WEST: Is this a Marco Rubio moment here?

MS. SHUTE: Oh, my god.

MR. WEST: So you did it much better than he did, let me tell you.

MS. SHUTE: How funny, yeah.

MR. WEST: And you are from Florida. Maybe this is a Florida thing, I don't know.

MS. SHUTE: It is. We're so dehydrated down there.

MS. SHUTE: So there's three main features that I want to get out with regard to stealth assessment. The first has to do with stealth assessments are intended to be seamless and ubiquitous. So by "seamless," I meant that they're woven directly into the fabric of the learning or the gaming environment. You can think of it in terms of the DNA. It's right there in the code. And "ubiquitous" means that it's operating at any and all times, so it's not just one static snapshot of a person at this point in time and using that for all sorts of high stakes purposes. Rather, it's ongoing and cumulative.

The second feature of stealth assessments is that it's for formative purposes, so it's intended to help support learning. And that's primarily for the students, but also in support of teachers knowing about their individual students as well as the classroom at large.

And the third feature of stealth assessment has to do with its ability to create valid models of student learning, what they know, what they don't know, and to

what degree at any point in time. And this is made possible because the machinery in the underlying models are built on something called evidence-centered design, which I can talk about at length later on if anybody is interested in it.

So to make this whole thing concrete, I just finished a study several weeks ago, collected data from about 168 middle school students on this game that we developed in line with all the stuff I'm talking about. It had three different stealth assessments running concurrently within it for creativity, conscientiousness, and conceptual physics understanding.

So people are playing the game. They're totally engrossed. I'm sorry. The game is called "Newton's Playground." And to frame the game, it's helpful to think of, you know, remember when you were in high school physics and, you know, you were introduced to the concept of force equals mass times acceleration, F=MA, Newton's second law. So you remember that, you know, for as long as, you know, until the test, and then you use in the test, and then, you know, most people don't really remember it much beyond that. What does it even mean? And what would it be like if you could actually experience it?

So we built Newton's Playground so kids could actually experience physics. So it's a two-dimensional physics game with simulations for gravity, and mass, and potential, and kinetic energy, and transfer of momentum.

And what kids are doing in the game, there are 75 games across seven different playgrounds. So kids are drawing. They're creating objects on the screen using their mouse to create objects to solve problems. The problems are always the same. Get the green ball over to the red balloon. And they increase in difficulty in terms of the positioning of the balloon relative to the ball and obstacles and so forth.

So kids are creating objects. And what they're inventing are simple

machines. So they're creating levers, and springboards, and pendulums to solve the problem. So if they make a pendulum, for instance -- this is a pin right here, and the bob at the end of this arm right here is too small, or it lacks density. It'll just exert minimal force if they big a big fat highly dense bob, it'll exert too much. So by playing in the environment, they're actually experiencing some of the concepts.

So in terms of the three research questions that I asked -- am I at about five minutes?

MR. WEST: No, you're fine.

MS. SHUTE: Okay. Yeah, the three research questions were, are these computer-generated estimates of competencies, these stealth assessment measures. Are they valid? That was the most important question of all, are these valid measures, you know, of what they're purporting to measure.

Number two is, when kids are just playing the game, realize there's no instruction right now in the game. It's just pure play. Are the kids after four hours of game play learning any conceptual physics at all? And the third question is, are any of these models portable to other environments because developing these competency and statistical models and everything else takes a lot of time for creativity and conscientiousness. So it's imperative that these can be ported into other environments to be, you know, worthwhile.

So the answers to those questions are, yes, yes, and yes. We are finding right now -- again, this is all fresh data, but we are finding that there are significant correlations between the end game measures, the stealth assessment measures, and external measures of the same thing. Like for creativity, we have the uses test, which is divergent thinking. And we have a number of different external measures for all the different things, and we are finding significant correlations.

In terms of any learnings simply as a function of game play, after four hours playing, it turns out there is a significant improvement from pre-test to post-test as far as conceptual physics understanding. And as far as portability into other models, the answer is yes. We've taken the conscientiousness model and have plugged it into a number of different environments. And it works very well.

For instance, with persistence, to give you a flavor of what these end game measures are, it all has to do with how long you spend on difficult problems, right? So if you come to a hard problem and you go, oh, I'm out of here and you go off to another problem, and you flitter around like that, versus somebody who stays there and they try all these things and they fail, and they try and they fail.

So we have accumulation of all the time on difficult and unsolved problem data, which is accumulated to give an indicator of persistence. And another indicator of persistence is information about how many revisits. So if you go and you try a problem and you don't succeed, and you go off and you try somewhere, and then you come back to it, that's a good indicator of persistence. And this is in stark contrast to self-report measures which is the most popular way of measuring persistence, which has questions like on a scale of 1 to 5, agree or disagree, I always finish jobs that I start. I enjoy good challenges. Well, we all agree on those things, right? So there's problems with self-report measures that these behavioral kind of indicators can handle and take care of.

That's it.

MR. WEST: Okay. Thank you very much.

Phil, how does the growth in education data analytics compare with other fields, and what can we expect in the coming years?

MR. PIETY: Thank you, Darrell. I just have to say as somebody who

grew up in this area, it's great to be at Brookings. The Brookings name is one that is associated with deep thought and hard problems, and it's great to be here with all of the panelists.

And it's also great to be part of a panel that's convened about the Center for Technology and Innovation because technology and innovation create some real challenges to understanding what's possible. Researchers develop ways of assessing the world as they know it, and technologies can change the world in important ways.

So the lens that I bring to this area, this question of analytics and data and even media is a sociotechnical lens. I look at not just a technology and how it's used in a particular context, but the broad sets of technologies that are used together and help to change practice.

If we go all the way to the printing press, we see that, yes, there was that innovation and it was disruptive, but there was a whole host of ways of doing things, whole sets of changes in different professions that were related to that technology. And it didn't just happen overnight. It was a process that occurred over a longer period of time.

And in education now, I think we're at a very interesting point because there are two socio-technical trends that are converging. And we've seen evidence of that convergence in these three panelists and a lot of other work that's going on right now. One of those trends is in the area of media and its accessibility, and the other one is in data and analytics.

If we think back 10, 15 years ago, there were a lot of questions about whether or not the Internet would change the way people read and wrote. What we found is not that reading has changed so much, but the textual practices have changed, the way we go and get information out of which sources have changed dramatically.

And that's one of the lessons of sociotechnical revolutions, which is

where I believe we are in education right now, in that they change the ways we do things, maybe not necessarily our cognition, but in the ways that we organize, the ways that we approach certain tasks.

In the area of data, we've seen in education in the last decade or so a real push for the collection and the use of data and information. In many ways, this is a process that parallels what's happened in other fields. And there are some who say, well, these are, you know, ideas from business and they don't belong in education. What we can see is that there are parallels between what began in other fields, sometimes 40 or 50 years ago, and what began in education 10 or 20 years ago, whereby information was analog and manual was collected in computer systems, was developed in reporting systems, was made available for analytics.

But in the case of education, we're starting late, and we're dealing with a set of social practices that are very different from other fields, even from health care. The multi-layered social nature of education means that the data that we have, the information that we have, is of a different kind. It's not that the ideas don't sense in education. It's that the information that we have is marked in ways by the fundamental challenges in measuring learning, the unusual political structure which we have in education with 17,000 districts.

So educational information is often difficult to compare. It's often spotty. And there's a persistent quality problems. But we are seeing now the ability to analyze it and get important insights, not to say we're at the level we are with Amazon or other types of fields, but there are important insights coming out of educational data. And I think we're going to see even more in the coming years.

I think that if we look at a company like Amazon as an example of something that we see today, everyone can take out a personal device and purchase a

piece of media and access it from their device. And that's important, and that's a marker of our change. We weren't able to do that 20 years ago.

We can also go to that same device and order something today that they didn't have yesterday, and they will have it shipped to us tomorrow. And the way that they're able to do that is not just because they have a web front end or something that works on a personal device, but because of all of these infrastructures that they've built behind the scenes to allow them to work with other organizations that have also built compatible infrastructures. And in education, we're not quite there yet, but we are moving in the direction of having these broader relationships based on that information.

I'm optimistic, but I would say that the process in education is probably going to be hard, and it's going to involve a lot of challenges. But I think what we're seeing is the ability to do things in different ways. And if we look at the kinds of examples that we're seeing of real progress, whether it's blended learning where it's not just the addition of technology to schools, but it's also -- or classrooms, it's the re-architecture of schools. We're seeing people now looking at the kind of data that we've been collecting for 10 years and saying, this is not sufficient. It doesn't help teachers. It doesn't tell us things about students.

And going further, like Professor Lin's work that looks not only at what students know, but how they work together in groups, how they ask questions, how they create explanations. Or Professor Shute's work where collecting important, in many ways, psychometrically valid information, but not having to interrupt instruction to do it.

So I'm optimistic, but I think it's going to be a very challenging and important next decade or so.

MR. WEST: Okay, thank you.

So I want to throw out a couple of questions for the whole panel, and any

of you can jump in.

So Phil was talking about the technology revolution. Each of you has described kind of a range of different types of innovations. The question is: what do each of you see as the policy barriers to education innovation, and what are your suggestions on ways we can overcome those barriers? Anybody who wants to can jump in.

MS. SHUTE: I have an issue that I'll bring up. I don't have any answers because this is something that I'm actively thinking about right now, and this has to do with once we get into big data mining efforts and, you know, say, stealth assessment and so forth, there's a very real question that we have to address at some point, and that has to do with the ownership of the data. And that brings up security issues and so forth.

So who owns the data? Ideally it would be lovely if I owned my own learning data, but then to be able to offer it to others, you know, teachers, parents, or whomever for a small price.

MR. WEST: We wouldn't offer it to parents.

MARCIA LINN: I agree with you. I think that is really a huge issue right now is thinking about privacy. It's not limited to education by any means. Privacy is an enormous problem and challenge and opportunity for us all. And on the other hand, what I see in schools is that we don't even have, you know, really a good enough infrastructure the information that we might want to use. As both you and Phil have indicated, it would be possible.

In the schools that we work in, when students work on our activities, we gather a tremendous amount of information that allows the teacher and us to essentially develop a very detailed understanding of what they know, and then they go on -- the only data the school ever collects is some standardized tests where they bubble a few things. Like they might study, you know, chemical reactions in our unit, and in the course of

maybe a week or 10 days, we would know a tremendous amount about the depth of their understanding, their ability to make sense of new chemical reactions, their understanding of how the supplies to global climate change and other problems of significance.

When they get the test in that particular grade, sixth grade, there are 65 topics, and there's only 50 items on the test that they take. So, you know, there might be one item on chemical reactions. And, you know, that's really tragic because then we don't really have a very good indication of what students learn, how they learned well. And we aren't telling the next teacher anything about how to build on the knowledge that the students already have. And I think that really this is a tremendous impediment to effective cumulative and powerful learning in our country.

So my feeling is that, you know, the biggest obstacle is really thinking about how to allocate funds to schools so that -- I mean, they're at least as good as the worst industry. I mean,would you start an industry and not allow your people working there to have computers, or Internet connectivity, or, you know, actually send e-mail messages to each other? I mean, this is really pretty basic. I think it would be rare, but yet we start schools with none of those features.

When I go into schools, I often have to bring the computers to the school because they don't have any that would run anything -- I mean, they think 286 machines are computers. You know, your phone is a lot more powerful. So it's really sort of scary.

And, you know, then the Internet is a big challenge as well when we get to these schools because they're often -- they don't have the connectivity appropriate to, you know, run the kind of thing that you run every day in most of your lives.

So to me, that is a huge problem and one that actually has economically -- I think economic benefits. I think we can run models to show that making these kinds of technologies more accessible and useful will increase the efficiency and effectiveness

of our schools. They can really improve the power of the teacher because a teacher has all this information.

When our teachers look at the information, you know, that their students have generated, they plan the next lesson to build on what the students already know, not just the next lesson that's in the book. They do an opener where they have flagged student work while the students were studying that they show. And they say, you know, here's the range of answers that students gave. Now, you know, let's break into small groups and talk about which of these answers makes the most sense and, you know, come back. And those kinds of activities are tremendously effective for students to learn the material.

But I think we're hampering our ability to give good education by not having enough infrastructure to use these technologies. And so I think that's a really important next step for education.

MR. WEST: Okay. Anthony, what do you see as the policy barriers and ways to overcome it?

MR. KIM: Yeah. So, you know, I grew up fitting the typical Asian immigrant stereotype. I was really good at math, played the violin. In high school I ended up taking three years of calculus because they had nothing else to offer me. And I begged and pleaded to go to community colleges and stuff. They said no way. And what I experienced was the same jokes, the same teacher, year over year different kids beating me up and, you know, stuff like that.

And when I designed the first elementary school in South Central L.A. where we did a blended learning model, what we did was we took math for kindergarten kids. We took kindergarten, first, and second grade math, made it kindergarten math, and we gave it to the kid. And literally all the kids finished up to second grade in

kindergarten.

And so when the students aren't bound by kind of the notion of daily scope and sequence and Basil's context, they can actually do much more than what we're allowing them to do today. And then if you could differentiate that in ways where students aren't plateauing. And if you look at sets of Conn Academy data, there's like these massive plateaus that kids land on, right? If we can shorten that feedback so that they can get feedback quicker where they're not plateauing for so long, then we can actually increase instructional time during a normal school year, which is pretty incredible, right?

What we looked at was if you shorten the feedback loop to students where they're plateauing, you could create 20 to 30 percent more instructional time during the school day. So if we can look at an approach to delivering instruction with quicker feedback loops, we could actually deliver better services to our students.

And so, you know, in terms of a policy, I think where we can get to a competency-based instructional program would be great. Where we can get rid of kind of seat time, but allow the notion of what students have learned and testing for those more on demand instead of having to wait for a particular time of the year to test for them would be of high benefit.

MR. WEST: Okay. Phil, your thoughts on the policy barriers.

MR. PIETY: Well, I think that there are very few issues as important as privacy and governance. At the state level, governance involves the districts that own their own data by law, and in some cases, that can be hundreds of districts in the State, and then each state has its own ownership of their data systems.

We're seeing some improvements in terms of several states getting together to be able to develop memorandums of understanding to share data. The

Department of Education there's now National Chief Privacy Officer and there's a Privacy Technical Assistance Center. And they're getting information out there about how to use information ethically, what are the rules around the FERPA, Federal Education Rights Privacy Act.

But there's still a long way to go. And what we have as a reality is a student can sign on to some online environment. Their data can be collected, and who knows where it's going to go. And that data can be collected across multiple contexts. So matching students from formal to informal or in school to out of school has a lot of challenges.

We're seeing some innovation. We're seeing some response from the Department of Education. But I think there's still a long way to go in terms of allowing people to use the data that can have tremendous insights about learning processes that we haven't seen before in certain ways, and data about which types of innovations are working in which types of settings that we haven't had before, but to be able to do it in an ethical way. And so I think we have some more work to do in that area.

Okay. I'd like to open the floor to questions from the audience. And those of you watching the webcast, you can post questions at the Twitter hashtag TechCTI. That's TechCTI. And we will integrate some of your questions as well. So if you have a question, raise your hand, and we'd ask you to give us your name and your organization.

Up front we have a question. There's somebody coming with a microphone for you.

MR. HIRSHON: Okay. I'm Bob Hirshon. I'm the Program Director for Technology and Learning at the American Association for the Advancement of Science. And, you know, it always helps to have an exemplar to look at when you're doing yoga or

something and you say, oh, look at Joe do that and look at Sue, that's the way you do it. And we've heard a lot about how a lot of places are doing it wrong.

Are there are some exemplars or one exemplar we can look at and say, they're using technology effectively. They're assessing appropriately. They're taking what they learned from the assessments and building it back into what they do so, you know, we have some positive examples?

MR. WEST: Great question. Panelists, who are the exemplars? And, Anthony, you can't say yourself.

MR. KIM: You know, roughly there are 80 to 100 schools that are implementing blended learning in K-12 today that are of high fidelity. So it's not just Smartboards and computers sitting in a classroom with one-on-one. There are a lot of schools that have tablets and iTouches in the classroom, and it's an incredibly poor example of implementing technology. It has a actually negative impact because the teachers actually step away from teaching and look at just providing tech support.

Rocketship is a good example or Carpe Diem schools. Reynoldsburg Public School in Columbus, Ohio is another good example. We helped launch 14 schools in Pennsylvania that are all doing kind of integrated -- they're bringing some of the digital content as part of core curriculum and integrating it into the school day, and then using that data as part of kind of the instructional practice. So there are examples of this.

And going to sites like Blend My Learning, Blended Learning Now, Digital Learning Now, Getting Smart, all of these sites have kind of the same examples of schools.

MARCIA LINN: And I think we're working with schools that have embraced using visualizations and virtual experiments and other techniques to improve

science understanding. And we actually have a community of principals. And I think an example of why that is a success is that these principals now when they interview new science teachers, they ask them how they plan to use technology and whether they would be willing to continue to use these techniques of interactive science learning that promote knowledge integration. And they say, well, we just don't hire teachers that don't agree with that philosophy.

And so what we're seeing in those schools is that the teachers are not giving the right or wrong answers to students. They're not focusing on just whether you know the facts. They're really asking students to be able to develop an argument, to explain their reasoning about the scientific phenomenon.

And looking cumulatively over middle school -- sixth, seventh, and eighth grade -- we're seeing that the students who are engaging in this kind of science learning for three years have much firmer ability to use and develop arguments for new science topics. So I think that's sort of the kind of evidence that I'd like to look for. I think there's a lot of -- you know, the blended learning model is going to give us a different kind of evidence.

And I think one of the advantages of bringing these various kinds of models together is that we do now have a way to gather enough information to try to make comparisons and say, you know, under what circumstances would this work, or if you do a blended learning model, how would you build in these more complex science topics where students are engaged in really sustained reasoning over a period of time, and trying to develop a coherent understanding and ability to apply the knowledge that they have to new personally relevant problems.

To me, this is so key because, especially in science, you know, you learn science often and never -- I mean, how many of you think you never use the science you

learn ever again? Whereas, you know, if you learn to read or you learn math, occasionally you use those skills in your everyday life. So one of the challenges I think, you know, is to develop all of our instructions so that people make it a life-long task of using that information.

And so we don't want short-term goals. We really want long-terms goals in looking at the effectiveness of these innovations.

MR. KIM: I would add that I think the bigger problem is that aren't enough exemplary examples where schools feel like there is something that's similar to them. There are examples, but every school feels like they're different. And this is a real systemic problem because the school that has upper middle class students that are at grade level, they need a certain model. There are a lot of schools that are using technology well that are higher free and reduced lunch, and they think that that's not them. A school in Massachusetts thinks they're different than a school in Florida.

All of these things, everyone feels that they're really different, so we're getting to this point where we need almost examples of every demographic and type of school -- rural, large, rich, poor -- in each state in order to make it an exemplary example for a state.

MARCIA LINN: Well, and I think that brings up the issue that you can really customize instruction quite easily with technology. So if you move into a new school, you know, and the students are starting at a different level, then you can emphasize that aspect of the online materials and spend more time or augment it with additional activities, whereas if you want -- if your students are way ahead of that, then you can start with more sophisticated activities. And I think that's one of the real strengths of online innovative materials where students work independently or in small groups.

MR. WEST: Phil, you wanted to jump in

MR. PIETY: And I think that's a great point, Marcia, that technology does have an ability to be customized, and sometimes we think about, you know, what are the best ways, the exemplary ways to take a particular type of innovation and not always think about the variation and circumstances that really does exist across a hundred thousand schools or whatever the number is. It's a lot.

And so in some schools there's new staff. In some schools there's older staff. And those staffing situations are going to present challenges in addition to the type of students, the demographics, the language issues. Maybe those aren't excuses for why a school can adopt a technology, but I do think it's important to realize that in schools they're often trying to solve very specific community problems, and they're trying to teach students that come from very different circumstances.

And so where we can use the ability to customize and to give the school leaders tools that they can use in their setting and pick the features that make the most sense for their circumstance I think is a real benefit.

MR. WEST: Okay. Christine has a question from our webcast audience.

UNIDENTIFIED SPEAKER: Yes, I have one from a teacher from Burgundy Farm Country Day School in Alexandria. He wants to know how much screen time is appropriate and at what age?

MR. WEST: Great question. Val, do you want to take that one?

MS. SHUTE: No.

MR. WEST: Anyone else on our panel?

MARCIA LINN: It's a really big challenge. I certainly do not have an answer, but I have seen literally six-month olds when they're given a screen try to swipe it to see if they can make it do something fun, so clearly children at very young ages are

becoming tech savvy in certain ways that would be shocking in the past.

But, I mean, I remember with Apple II computers that we had this wonderful picture of Allen Kaye's young child holding on to one of those huge brick-like mouses, with the baby's hand. It was like just barely there and moving it around to make a picture on the screen.

So I think that it's not screen time, but what the quality of that time is, how the technology is used that's really the crucial thing. We all know adults who get addicted to some online game, and have to, you know, basically break their computer and lock it up in a vault in order to break their habit.

So, I mean, it's not the time, but it is the usage that's a real challenge, and I think we don't know the answers, especially for very young children, as to what are the best technologies. But I must say that, you know, when people ask me, I usually recommend expressive technologies where you can draw things and invert them.

I mean, there are some really absolutely fabulous ways that kids can learn to visualize shapes and colors and symmetries, et cetera, when they're quite young.

MR. WEST: This gentleman over here has a question. We have a microphone that's coming over to you.

MR. MCGHEE: Thank you. Ray McGhee, SRI International. My question is addressed to the entire panel. With the advent of the common core standards, the next generation science standards that are going to be implemented, and the assessment consortia that are working to develop assessments for those particular standards, I'm wondering, what are the implications for the use of technology now that these standards are now being put into place?

There's a lot of concern about the implementation of those standards, but I'm curious to hear from you all and hear your perspectives on what types of challenges

you expect to see or what kinds of positive things you hope to see as a result of these standards? These standards purport to focus more on deeper learning and helping to promote post-secondary success for students.

Please talk about the implications of using technology to address these standards.

MARCIA LINN: I'm really excited about the standards. I think that they're really moving in the right direction. Emphasizing deeper understanding is something that we've been promoting, and showing the benefit of. As students gain deeper understanding of a few topics, then it amplifies their opportunity to learn other topics even if they don't have the opportunity to do those in as great depth.

I mean, I think it's still a challenge there are still far too much information in those standards. And to do deeper learning of all those topics is not going to be feasible. So what's going to happen is a big question.

Another issue that I think the standards really address well is expression, articulation of your ideas, developing of arguments. And extending that to math and science is a fabulous idea because we find that when students write about their math and science understanding, first of all, we eliminate gender differences. We have zero gender differences in all of our science materials and everything that we've tested, and I really think that's because there are many media that you can use to express your ideas and to explore your ideas.

In addition, I think that the standards' emphasis on engineering, which is a big point for the math and science standards, will be extremely valuable, bring to life topics that are more accessible and more relevant to students than the topics that have been in the science and even in the math standards in the past. So I see that as a real plus. The language standards I think are fabulous. I mean, it's really asking people to be

very effective in explaining their ideas.

Obviously we're going to see an enormous challenge in trying to provide feedback and guidance for students who are doing these expressive activities. Already I see class sizes going up to 40, teachers teaching six 40-student classes at a time. Two hundred and forty students are not going to get a lot of feedback from one individual.

We've been doing a little using a very interesting collaboration with ETS using their C-rater technology to diagnose student understanding and give adaptive guidance that encourages students to think harder, but also to do something that Valerie talked about, to revisit prior information that would help them strengthen their argument. And that kind of guidance we find, just as you did, is really important. And students who do revisit came up with a deeper understanding, even though the teacher didn't give the guidance. And our teachers are thrilled. They're saying, wow, if I could use some of this guidance and some of my own, it's a much better combination.

But I do see that we aren't thinking far enough ahead on these standards as to how are we going to give the students the kind of guidance that they need in order to achieve the accomplishments that I think we would all agree are important.

MR. WEST: Okay. There's a woman in the very back row who has her hand up with a question.

MS. BOURBON: I'm Contessa Bourbon from the *New York Times*. In terms of educational technology, how does the U.S. fare and compare with other countries or major economies in terms of progress and advancement in educational technology?

MR. WEST: Panelists? Don't be shy.

MR. KIM: I actually just read a research report that was done internally about China and comparing it to the U.S. So in China, the average family spends

another $1,500 a month for education outside of the school. Kids go to school until 10:00 at night. There's a shortage of English language teachers and a shortage of test prep for GD, TOEFL, GMAT. They'll drive two hours to find an English language tutor. I think we don't see as much of that in the U.S. Korea has the same thing -- $3,000 a month for after school programs.

But there is this movement of international students wanting to come to the U.S. for our higher education system, and why is that? And part of the reason is because the skills that you develop at a Stanford or a Harvard in this country are pretty phenomenal, like critical thinking, the analytical skills, the Socratic Method, and the discussion. These are all very creative skills that you develop that are useful in you becoming a career manager. And in these other countries, you're really being trained to take tests really well.

So I think if you think about what's benefiting kind of the higher education economy, there's this influx of kind of foreign and international students coming in here creating the -- desiring kind of the higher education system that we have.

MARCIA LINN: And I could really echo that. The web-based English and science environment is obviously inquiry oriented. And it's been adopted in China, Taiwan, and Japan, as well as a number of other countries. But in all of those three cases, the motivation is just the one you mentioned, that there was a feeling on the part of the people who are adopting it that it would increase emphasis on inquiry, and problem solving, and critical thinking that they felt was not represented as effectively in the curriculum. And indeed, we're collaborating with the University of Tokyo College of Engineering to use these activities for inquiry and English learning simultaneously.

So, I mean, I think that's a common theme. In fact, I've complained that, you know, why is it that here we don't have time to do inquiry, so teachers are always

pleading with me, can you please do that inquiry activity in two days instead of four, whereas in Taiwan, they're pleading with me, can we please your inquiry activities because our kids needs them.

So, I mean, I'm wondering if we're offshoring inquiry, and that's maybe not a good plan.

MR. WEST: Phil?

MR. PIETY: One of the things that I think about in terms of technology is how it is helping to change the boundaries that have existed. And certainly within this country from state to state, there's been tremendous variation in the standards for what students should know. And historically there's a really interesting relationship between standards and innovation. Standards, the right standards, can actually be drivers of innovation. The Internet is all based around standards of information exchange. Once they became universally accepted, people could develop products in one place that they knew would be broadly usable.

And we're seeing the same potential in education with the math, and the science, and the language arts standards where they're good standards. But what's also important about them is that they're broadly adopted, and that means innovators will be able to develop products and know that there's going to be a market that will be compatible with them.

MR. WEST: Okay. There's a woman there in the back with her hand up. Yeah, right there.

MS. CONRAD: Hi. I just wanted to underscore this situation with innovation and the skill sets that are very unique to this country. I'm Nancy Conrad of the Conrad Foundation.

Google asked me to go speak in Korea because we do a competition

asking kids -- high schoolers -- to create products using innovation and entrepreneurship as well as STEM education, commercially viable products. And so Korea wanted to know, well, now do we know how to innovate, and how can we understand how to do that, and what is entrepreneurship? I've done the same talk in Saudi Arabia.

So we do have a special sauce here if you will. And if we can integrate that sauce with technology, which is kind of the work that we focus on, we can get kids from all over the world working in this sector and, you know, kids can start working together. Education could end up becoming diplomacy. Peace could break out, you never know.

MR. WEST: I like your optimism there.

MS. CONRAD: And we've actually seen this happen. We've seen kids from different countries collaborate using technology on this crazy Internet that we live with now. So it's a tremendously valuable tool that can really transform cultures across the world.

So I just wanted to underscore that for you, your question back there.

MR. WEST: Okay, thank you. There's a gentleman right over there with his hand up.

MR. SCHIFFRIN: Hi, I'm Phillip Schiffrin. I'm a senior at St. John's College in Annapolis. And I had a question about students being motivated to actually learn the material. It seems like with new innovations like learning through video games, it's all very novel, and I think, you know, intuitively it seems like students are more interested than they would be reading out of a book or something. But eventually these technologies are going to become commonplace, right? All the schools will have them.

So my question is, is the common belief among the education technology community that implementing these new technologies are really going to change the way

students feel motivated about the material, or is it simply a better way to try to impart the material to them, and we're still going to have the same problems with trying to get students motivated once this becomes commonplace?

MR. WEST: Val, would you like to take that?

MS. SHUTE: Yeah. I think, number one, I've been playing video games since the very beginning, and I'm as thrilled and motivated, you know, now as I was, you know, 30 plus years ago. So I don't think it's a matter of, you know, it's a passing fad and, you know, the novelty will wear off and so forth.

But there are a number of issues. One is that there are obviously good video games and there are not good video games. And take a game like Portal II. Have you played -- yeah. It's one of my all-time favorite games. And every year there's a new game that comes out. I just downloaded Antichamber that promises to be my next most favorite game ever.

But what it does, all these games, is in the process of playing them, the way game designers -- really good game designers work is intuitively to set up -- somebody was alluding to the flow state earlier, which is this magical spot which is, you know, if something is too easy, you get bored. If something is too hard, you get frustrated, you know. So there's this kind of magical spot in the middle as you progress through a game which is right at the cusp or the balance of, you know, doability. So kind of at the outer edges. And then the success that you feel, the satisfaction and the great sense of, you know, ecstasy even when you succeed at a really hard level is unsurpassed. So the motivation is there.

For really good games, it's doesn't matter if you're a boy or a girl. So for really good games developed by really good game designer, I think that the motivation is just part and parcel of the game itself.

Now the downside is that game designers don't develop, you know, with assessment in mind. And educators or assessment people, bless their hearts, when they try to build a game, invariably those games are really not very good.

MR. KIM: They suck.

MS. SHUTE: What?

MR. KIM: They suck, right

MS. SHUTE: They suck big time. So in the last several years, a couple of years ago, Gates and MacArthur co-funded this get together between game designers and assessment experts and administrator types. And we all came together and we had heterogeneous groups of about eight. It was a wonderful phenomenon.

So, first of all, it was a two and a half day gig where we learned to speak each other's language, and then we had to come up with the end of the prototype, which would at the end assess some substantive competency with really fun game mechanics built into it. So each of these 10 different teams, you know, presented at the end. And it was awesome.

But that's what it's going to take is this kind of interdisciplinary activity where, you know -- talk to me afterwards if you want to about Portal II because I'm actually working with Valve Corporation right now, and I have stealth assessments built into it for assessing problem-solving skills and spatial abilities and conscientiousness. And this is an off-the-shelf, excellent game that had no intention of being for -- but really in order to succeed in the game, you have to hone your spatial skills. You have to be very creative with your problem solving. I mean, you know, you learn how to use your portal guns one way, and then you can discover another use of the light bridge and so forth. So there's a lot of richness in these games that you could tap, you know, fully to inform all sorts of interesting competencies.

And back to the woman -- the Conrad person woman, Nancy, with regard to creativity, there are lots and lots of things in games that can be very good indicators in not only assessing, but also supporting the growth of creativity where you do get some feedback. And there have been some lovely instructional interventions that actually tell how to think in terms of -- I just read a paper, I can't remember the author right now. But basically it was a process that required deconstructing a problem like one of these insight problems where you have a candle, and you have a block of steel, and you've got to match. How do you put two metal bars together? And the answer ends up with you use the metal bar to hack off all the wax on the candle, and then you use the wick to tie the two things together. But it requires insight because you have to think of the candle in terms of its constituent parts.

MR. WEST: I can't believe you just gave the answer to that game. I've been working on that day for a day.

MARCIA LINN: Blow it away.

MS. SHUTE: I have many more where that came from.

MR. WEST: There's a man over there with his hand up. The microphone is coming up. Right here next to the window.

MR. BOUTELL: Alexander Boutell from Global Strategic Partners. I was wondering if you could talk about how to unleash the potential of computer engineering and computer science for these kind of critical thinking skills. I say that because CS is essentially a form of engineering, which is looking to find solutions rather than answers. And so it provides far more opportunities to independent thinking. But unlike physical engineering, you don't need to own a lathe to be able test out your solution. So how can we use that in education?

MARCIA LINN: Well, one of the big issues that we've been thinking

about in education recently is this computational thinking, which is essentially the combination of computer science kind of thinking and the other kinds of content that you might need to solve a problem. So how do you combine the computer science ideas and the scientific ideas, for example, to compute the human genome?

And I think this is an area that is really crucial for education, and kind of it's very difficult for especially a pre-college to bridge different disciplines, and even to include engineering concepts in the disciplines because they haven't been there traditionally and, you know, adding a new course to the pre-college curriculum. While it sounds like a good idea, it's often, you know, a policy nightmare.

So that's why I think the new standards are really exciting because they're emphasizing engineering. They're emphasizing computational thinking, this ability to use the principles of computer science in a variety of different disciplines. And they're really pushing longer-term projects, because the other thing that I find working both in computer science, and pre-college, and college is that in order to learn those principles, you really need to do bigger projects, you know.

The tiny little projects that we used to do in computer science, you know, three-line code, don't really teach you anything about the principles of computer science. And so, you know, you end up being a little bit frustrated. But bigger projects really raise a completely different kind of planning, and thinking, and coordination, and collaboration. And I think that we're really trying to figure out ways to make those more a part of the curriculum.

But, you know, that's where we really need more computers in the schools. I mean, I started with computer science in pre-college, and we figured out that, you know, kids were getting seven hours on the computer. You know, a family that had a computer at home, they were going to be better than the whole course. And that was a

long time ago. Now many more kids have that access, but it's still not everybody.

And there are some people that would really benefit tremendously if they just had a weekend on a computer where they could code up something bigger. And some of the languages now have very low VAR to get started. And then you can move on to a more complicated language. I mean, the other thing that we've learned is learning multiple languages is really an important way to become good computational thinkers.

So, you know, I think there's work there, but I think your question is well placed. How do we get that out of the laboratory and the research and into the schools?

MR. PIETY: And I think it's a great question also because we can think of computer science as one of a number of sciences that are design sciences -- architecture, engineering. And in those sciences, you're right, it's not about finding an answer, but solving a problem within constraints, and often doing it within a team, and often doing it for somebody who has a goal.

And so all of those skills really lead us to a broader understanding of education that the STEM disciplines are asking where it's not just about discreet pieces of knowledge, but being able to use that knowledge in action to solve a particular type of problem. And I think earlier in the curriculum, the better really.

MR. WEST: There's a woman here who has her hand up in the blue shirt.

MS. SHUTE: And to get girls into it, too.

MARCIA LINN: Absolutely.

MR. WEST: There's a microphone coming over to you right here.

MS. AMAN: Hi, Luzik Aman from (inaudible) International USA. Computers obviously are very expensive, which is why many schools and students don't

have them. And they also go out of date pretty rapidly, and programs won't work on old computers. So what is the cost effectiveness of implementing technology in education when you have to update the technology so frequently and when it progresses so fast?

MR. WEST: Panel?

MR. PIETY: Someone could take that one.

MR. KIM: It's been a big problem. It's not my area of expertise, but I think that we're seeing across the board the cost for computers coming down, the modularity going up. So I'm not going to say that problem is going to go away, but maybe it won't be as big an issue in the next five years as it has been in the last 20.

MARCIA LINN: I mean, I think it's also an issue of you know, looking to where schools are spending money on curriculum. There is a big move to think about, instead of having textbooks, having online interactive activities that would be maybe more effective. I'd like to see them to be more effective. The most scary thing is that you put the textbook on a PDF and that would be very terrible.

But there is the possibility that these would instead be really exciting interactive opportunities where students could work with virtual experiments or, you know, reconstruct poetry. And so then when you reconfigure the budget, you have funds from textbook purchases, which in California are pretty rigorously monitored, that would be available for other opportunities.

But as I said at the beginning, I think that we really haven't even tapped the ways that we could use technology to rethink schools and change the economic bases and the economic decision making in schools because of the many ways that they could be used to improve the situation.

But if you look at, you know, the testing budget and the textbook budget, there you have some opportunities. If you could eliminate those, you would be able to do

computers without trouble. And I think this continuous assessment, stealth assessment, you know, embedded assessment, is a far more valuable way to gather information about students and to monitor their progress. It doesn't allow as much screaming and yelling about which person did better -- which school did better than which other school, but it does a lot more for making individual student decision making and ensuring that individual kids are making progress on the goals that are appropriate for them.

MR. WEST: Okay. The person over here who had her hand up. Yes.

MS. WHITE: Thank you. My name is Taylor White. I'm from the Carnegie Foundation for the Advancement of Teaching. And my question is for everyone. We recently launched a project to rethink the Carnegie Unit, which has lots of implications for C time and blended learning, and all of the technologies you're discussing today.

In discussing the research with folks, they say, oh, so why has the Carnegie Foundation decided to revisit the Carnegie Unit now? And a big part of the answer that has sort of become a refrain is that technology is enabling schools and teachers to do all sorts of different things in classrooms to individualize learning, to personalize learning, to, you know, allow students to --- asynchronously.

But earlier this week, I stumbled on a paper written in 1964 by a fellow who was talking about all of the new advantages technology was bringing to schools and how curriculums would be truly individualized, and we could move away from C time, and things would be truly disrupted. And then I stumbled on another piece from 1987 yesterday and this morning 1996, where all sorts of researchers were hailing the promises of technology.

And I don't mean to be -- I know this is probably one of the last questions, so I hate to be playing devil's advocate this late in the show, but I'm wondering

what's different now. What do you think is different about today's technology that might truly prove to be disruptive? And is there reason to believe that changes are ahead, or will someone in my shoes 35 years from now be reading something I write laughing at me, like I'm laughing at these papers?

MR. WEST: Actually I'd like to answer that. The way I'd like to answer is, if we assume that it's only technology that needs to change that's going to produce some transformation, we're going to be disappointed, just as people in the 60s, 70s, and 80s, you know, had wild hopes that were dashed.

I think the key here on technology innovation is it's not just about changing the technology. It's also about changing the organization, the operations, and the culture within schools. If we get all of those levels kind of moving in the right direction, create the proper incentives, then today could very well be different from past time periods. But if we don't get that, then I see a lot of schools just imagining they could bring the technology in, but everything else stays the same. That's not going to be the answer.

MARCIA LINN: I agree. It's a systemic kind of solution.

MR. PIETY: I do as well, and I think that one of the things that is different now, and we've heard this argument for a long time. Thomas Edison invented the phonograph and said it could be a teaching machine. We've seen the teaching machine argument over and over and over again. We have a confluence of different types of technologies. It's not just presentational or assessment or reporting, but we're having innovation in all of those areas.

In a lot of cases, we don't yet have the right kind of tools, but as those get developed, I think we'll see the ability to reengineer a school with a lot of technology for both the teaching and the teachers working together to try to solve problems and the

management and the administration.

So I think -- my hope is that as these tools come together that we'll see a broader arrangement of technologies rather than just those for presentation and teaching, those for the whole school. But we're not there yet.

MR. KIM: One thing I would add is I was visiting a school in Puerto Rico recently, part of the United States. And the principal took me to a computer lab that had computers, and there were no kids in those computer labs. And I turned on the computer, and there were no programs on it. And what it reminded of was schools in the late 80s and 90s where they bought a bunch of hardware, put it in the classroom and said, we have technology.

And so I resonate with what the other panelists are talking about, you know, this isn't a technology discussion. It's really an instructional practice discussion as to what's the best way to educate our kids today. And part of that includes technology, right?

And so I think that the conversations that are happening today in most schools are very different than the conversations that were happening 10 years ago, which was, you know, we're going to put a computer in a room, and all of a sudden magically it's going to teach kids to do stuff, or by osmosis by looking at the school, you know, you're going to absorb it in your head. Like that kind of discussion isn't really happening anymore.

So now I think where we are worried is that there is still this notion that if you lump on technology into a classroom, that teachers are going to actually have time to deal with it, and they don't. So there has to be systemic change in order to make the technology. No one buys technology to make their lives more complicated. I don't carry two phones and a computer and an iPad because I want my life to be more complicated.

But it creates a different set of complexities, and in order for me to adopt those technologies, I need to have other things -- that's to create certain conveniences that don't exist for me without those technologies.

MR. WEST: Okay. I think we have time for one or two more questions. This gentleman right here has his hand up.

MR. KASNER: Thanks. My name is Phil Kasner. I'm in the research office of the American Alliance of Museums. And my other hat is that I'm trained as a historian. So I've got two questions, which I hope you'll actually tackle in reverse order.

One is I'd like to hear some examples of educational technology that don't involve STEM subject. I'd love to hear some example about stealth assessment of historical understanding and moral reasoning.

The second question, which I hope you do talk about, is how does this conversation change if we say that, in fact, it makes schools less important than ever, and potentially it's informal learning institutions, like museums, like libraries, like web-based non-centered places, that that's where the real opportunity is going to be. And this is actually a move potentially away from schools rather than remaking schools themselves.

MR. WEST: Interesting questions.

MS. SHUTE: Excellent, yeah. I can start up an answer to that. A little context. This happened in 2008 and then again real strongly in 2012, a phenomenon where I found myself going back to the 1700s and reading a number of books. I read *Cane River* by Lalita Tademy, and then I followed up with Red River, which was her father's lineage. She had traced her ancestors back to Louisiana. Long story short, they were stories about slaves and generations of slaves.

And then I read a book called *Kitchen House*. And long story short, in

the context of so much, I don't know any other word except for "crap," that we saw during the election cycles with regard to, you know, instances of, you know, all over the place. I'm not taking any sides or naming any names, but instances of bigotry and intolerance. And it just -- it really sickened me.

And so one thing that I have in mind, and this goes to your ethical decision making or moral reasoning kind of query, was, yes, in fact, we could have some kind of role playing games that would allow somebody to actually, you know, be able to walk a mile in somebody else's shoes, and, you know, have these immersive kinds of experiences. This is something that I would love to do, and this would be, you know, part of, you know, the informal out of school learning that I as a parent would very much like my kids to, you know, participate in.

But I don't want to see moral reasoning done in schools. I think that could go wrong really quickly.

MARCIA LINN: I think that your second question is particularly important, that, you know, if we can link the home, and the school, and the museum, and other informal learning opportunities together, we just amplify the effectiveness of instruction. And I'm seeing more and more ways that those connections are being built, and that individual families are being helped to recognize how they can make the connections.

And I think that museums are doing a fabulous job of linking their displays and activities more closely to everyday experience, to personally relevant problems that then are also the goal of many units in schools.

I would love to see more examples of history, and drama, and theater, and other things that take advantage of technology. I think the technologies are actually there. I think the difficulty is that there is such a shortage of access to the technologies in

schools that we're not seeing the big build up there because there's a belief that it's more crucial to do it for STEM.

But absolutely one of my favorite software programs was built by Friedlander at Stanford where you could block out the movement of actors in a production. And then he had this marvelous curriculum where you looked at five different depictions of a particular scene from a Shakespeare play and talked about what the director was thinking about in both the blocking and the emotions that the actors portrayed.

And, I mean, it was such a powerful unit. It was unbelievable. And I wish that these things were more common in the curriculum. But I agree with you that it's not as frequent as some of the other topic areas.

MR. KIM: I would add if you guys want some edu porn -- it's like porn for education -- look up on Google intel classroom of the future. And so to me, that's like edu porn where, like, you're collaborating via video Skype ad with another classroom, and you're doing a project-based learning thing, and there's a parent that's pulling a tablet out that's looking at your homework, and the teacher is walking around with a tablet knowing exactly how each kid is performing.

You know, that's the optimal state of what everybody envisions. And I think what we don't have is a clear pathway as to how we get there. And someone really needs to look at all the kind of steps and what is the blueprint for us to have that level of education.

MR. WEST: And we'll give Phil the last word here.

MR. PIETY: Thank you. If I could leave with one point, it would be that this period of change is a process where some of the decisions that are made have implications for what's possible, easy, convenient, and conceivable in the future. And

right now, a lot of our curriculum is dominated with math and literacy. In large part, that's been baked in because of No Child Left Behind.

And as we think about the reauthorization, when it will happen, it's important to think about these other areas that have been neglected, and to think about how we can build an infrastructure that will not have barriers to these other types of subject areas and these other ways of being students that in some ways I think we recognize may be more important than factual knowledge.

MR. WEST: Okay. I want to thank Marcia, Anthony, Val, and Phil for sharing your thoughts, and great questions from the audience. Thank you very much.

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