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HOW MOBILE TECHNOLOGY IS RESHAPING THE GLOBAL LANDSCAPE

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Panelists:

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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 would like to welcome you to this forum on "How Mobile Technology is Reshaping the Global Landscape."

We are webcasting this event, so we're pleased to welcome viewers from around the world, and we have set up a Twitter hashtag at CTI Mobile for those who want to offer comments or pose questions. When we come to the audience Q&A a little later in this session, we will take questions both from our live audience here today as well as the virtual one.

Today, we are launching a new project on the mobile economy. It is a three-year effort designed to examine the impact of mobile technology on society, the economy, and governance. We're going to look at how smart phones and mobile devices affect education, health care, entrepreneurship, and economic development, among other topics, both in the United States as well as around the world.

We put out a paper today entitled, *Ten Facts About Mobile Broadband*, and it reviews the growth of installed smart phones and how they will surpass personal computers in 2012. Thirty-five percent of Americans currently own smart phones and 83 percent own a cell phone.

We are seeing rapid growth in mobile technology all around the world. For example, in Sub-Saharan Africa more than 60 percent of that population has mobile phone coverage. And the research shows that that is having a positive impact on agriculture in that part of the world, as well as labor market efficiency.

Mobile apps are reshaping education and health care, and they're altering how people engage politically. It's also helping to overcome digital disparities. In

the United States, for example, smart phone ownership actually is higher among Hispanics and African Americans, as opposed to whites. So, this is helping minority owners start businesses, and gain the full benefits of the technology revolution.

We are very grateful for the generous financial support provided by Qualcomm for this project. It will enable us to undertake research, public forums, and an annual mobile economy summit in this exciting sector. We need to understand what is going on in this sector, and what kind of impact it is having on various aspects of social and economic life around the world. We plan to bring together leaders from the private, public, and nonprofit sectors to address the dramatic expansion of mobile technology.

Today, we are pleased to welcome a number of distinguished speakers. For opening remarks, we are delighted to have Peggy Johnson with us from San Diego via video conference. Peggy is the executive vice president and president of global market development at Qualcomm. In that position, she is responsible for commercializing new business opportunities, incubating early-stage initiatives, and developing strategic relationships for the company.

Previously, she served as executive vice president of the Americans and India, where she played an instrumental role in the global development and adoption of 3G wireless broadband technology. She began her career at Qualcomm in 1989 as a software engineer, and has been a leader in the wireless industry.

After her remarks, we also will hear from two other distinguished individuals. Chris Dede is the Timothy Wirth professor in learning technologies at the Graduate School of Education at Harvard. He works in the area of emerging technologies, student engagement, and personalized learning and assessment. He is the author of several books. In 2005, he co-edited a book entitled, *Scaling Up Success: Lessons Learned from Technology-Based Educational*. In 2006, he edited a book,

Online Professional Development For Teachers, and his most recent book will come out next year and it is entitled, *Digital Teaching Platforms.* So, he'll have a lot of interesting things to say about the link between mobile technology and education in particular.

Our other speaker is Alan Friedman, who is a fellow in research director of our Center for Technology Innovation here at Brookings. His areas of expertise include new technologies, cyber security, and the economics of information security. He was a fellow at the Belfer Center for Science and International Affairs at Harvard, where he worked on the Minerva Project for Cyber International Relations. And he currently is writing a book on cyber security and the information economy.

So, to kick off our discussion we will have opening remarks from Peggy Johnson of Qualcomm. And so, we will lower the screen, and through the magic of technology Peggy will be with us.

MS. JOHNSON: Thank you, Darrell, for that kind introduction.

I'm sorry I couldn't join you in person today, but I'm very pleased to be participating from San Diego in the launch of the mobile economy project. And Darrell, I'd like to give a big congratulations to you and your team at the Brookings Center for Technology Innovation.

Qualcomm is excited to be supporting this project, really the first of its kind to document how the mobile revolution is impacting businesses, consumers, and the economies of both developed and developing countries. We are still a very young company ourselves, just 26 years old, and from Day 1 we've been driven by how our innovations can change the way people work, live, and learn. It's really what we're all about, and having put more than $18 billion into R&D over the past quarter century, we're committed to continuing to innovate and evolve the mobile experience.

We're very excited to work with the Brookings Institution as you document the

impact of the mobile revolution through a combination of programs, research, and engagement with leading thinkers from business, government, academia, and nonprofits.

So with that in mind, thanks for the opportunity with a few minutes of remarks, which gives me the chance to share Qualcomm's perspective on the opportunities that this mobile revolution is creating.

Qualcomm is a technology innovator and a leading supplier of chips for mobile phones. And in my role as president of global market development, it's my job to pursue new opportunities for the company by incubating and commercializing new segments, products, and services that will benefit our company and the mobile industry. And this role has allowed me to see firsthand how access to mobile technology can completely change the trajectory of people's lives.

Today, there are about 5.7 billion wireless subscriptions globally in a world with just 6.7 billion people, and with $1.3 trillion in annual industry revenue mobile phones have simply become the largest technology platform in history. And one year ago, we reached a significant tipping point; the number of mobile broadband Internet subscriptions passed the number of fixed subscriptions. So, the Internet itself is shifting from a desktop experience to an on-the-go experience, and that's really the case in both developed and developing nations. Mobile technology opens up the world to people who might never have had access to the Internet. It truly empowers individuals at all economic levels and in all corners of the world.

Currently, the growth rate of smart phones is about three times that of PCs, and that gap is even larger in developing countries, where mobile devices are proliferating in places that have little or no legacy PC market. So, why is this? It's because smart phones can deliver rich experiences, including full Web browsing and computing capabilities, high-def video, 3-D gaming, and much, much more.

The mobile economy project is going to take a deep dive into the impact that smart phones are having in communities around the world. And while we can see examples of positive impacts of smart phones around us, we don't believe there's ever been a study of this magnitude undertaken.

We look forward to learning more about all the ways smart phones are improving lives globally, and now I'd like to share just a handful of specific examples of the social and economic impact, and the potential of mobile technology.

First, mobile technology can make health care much more accessible and affordable, and it can improve access to health services. It can enhance self-care, address the rising costs, increase productivity, and help ease the demands of chronic diseases, which place such a grave economic burden on countries.

Qualcomm's CEO, Paul Jacobs, spoke just yesterday at the mHealth summit in Washington, and he introduced our new mobile health subsidiary, Qualcomm Life, and the launch of two new medical devices, the 2net platform and the 2net hub. Those devices transfer and store data from other medical devices, so that at the consumer's direction their data can be easily accessible at home as well as shared with their authorized health care provider.

For example, Intrahealth Systems announced this week it'll use the 2net hub and platform to connect a wireless blood glucose meter; allowing care providers to receive data that can be used to help patients better control their diabetes.

Mobile technology is also creating opportunities to change the way people learn. Smart phones are providing access to resources previously not available to students in the developing world, and they're transforming the ways we teach right here at home, enabling new methods designed to improve educational outcomes.

In October, I had the opportunity to speak about mobile education at the Wireless

Ed Tech Conference, and we're beginning to see the benefit of providing 24/7 access to learning content and communities. And as a company founded by university professors, education has long been a priority for us. And as early as 2008, we were looking at the ways mobile might benefit students in grades K through 12. In fact, an initiative called Project Connect was launched that year to determine if smart phones with digital algebra content and 24/7 connectivity could improve educational outcomes of students who'd scored poorly in math.

For 3 years running now, Project Connect students continue to score at least 30 percent better on their end-of-course examples compared to students not in the program. And we believe the use of mobile technology in K through 12 can help drive student's interest in STEM degrees and careers. More than 50 percent of Connect students are now thinking about careers in math, so it's a terrific proof point.

And when we look at economic development and opportunities for entrepreneurship, we see how mobile is literally changing people's lives. Not long ago, I had the opportunity to visit Santa Cruz Cabralia, which is a tiny rural village in Brazil. It's this beautiful seaside community where the fishing industry is suffering from over fishing and lack of investment. As a result, the native people's incomes are down and their culture is at risk as family members leave in search of other jobs.

We launched a project there called Fishing with 3G Nets that provided fishermen with mobile phones and customized apps to help them get information on navigation and weather and connect with their local businesses who buy their product, all of which could be accessed while they're fishing at sea. The fishermen also learned how to catch other species which are more abundant and in higher demand.

So, I got to see directly the impact of this mobile technology on their lives. The project is designed to not only increase family incomes, but also to teach

people computer literacy skills and more environmentally-sustainable fishing techniques.

So at Qualcomm, we see a future where everything around us is intelligently connected, and people can easily exchange information using their mobile devices. It's our mission as a company to create new opportunities here and all over the world to unleash the impact of the mobile revolution. And in so doing, help create new and better ways to educate our kids, provide health care to our parents, improve public safety, and foster entrepreneurship and economic development across this country and around the world.

Thank you and best of success with the rest of today's program, and with the important work of the Mobile Economy Project moving forward.

MR. DEDE: Well, I really appreciate the opportunity to be able to share ideas with you today about mobile learning. I work in emerging technologies, and so over the decades I've looked at many different kinds of devices that might improve education, and I can tell you that few have developed with the speed that mobile learning has over the last few years.

So 35 years ago, shortly after I began working in learning technologies, a very powerful handheld device emerged at that time. The Little Professor from Texas Instruments. Some of you may remember that. One of the great tragedies of my life is that I now look like The Little Professor. (Laughter) I really never thought I would get this old. And of course, our handheld devices now are much more powerful on a whole variety of dimensions than The Little Professor was in the last 35 years.

What companies like Qualcomm are telling us is that in the next decade we're going to add as much power, again, on each of those dimensions as took place in the last 35 years. So from an educational perspective, imagine every child, including children in poverty, walking around with the equivalent of today's supercomputer in their

pocket. And then, think about what the opportunities for education might be.

And of course now, we tend to think about cell phones, but the ecology of mobile devices is broadening in very interesting ways. We're seeing eReaders, we're seeing tablets, we're shortly going to be seeing a wave of gaming devices based on augmented reality, which I'm going to talk about next. And so, the palette with which we can think about learning is broadening dramatically.

Now, that said, there's a long history in education of believing that a new device is somehow magic. I wish that learning technologies were like fire. Fire is a fabulous technology because just by standing near it, you get a benefit from it. And so I watch people put tablet computers now in classrooms and stand near them and expect knowledge and learning to radiate out into their minds. And of course, nothing happens because learning technologies are much more like clothes; you have to put them on, they have to be tailored to your needs. We don't want to believe that the device itself is the innovation. It's what the device catalyzes and makes possible that becomes the innovation: deeper content, better pedagogy, more valid assessment, links between the school and the world outside of the school, and so on.

So, the first thing that tends to happen with new devices is you put old wine in the new bottle. And we see a lot of that in mobile learning now and there's nothing wrong with old wine. Old wine can be very fabulous, as a matter of fact, and it is very exciting that each of us anywhere we are can surf the Internet or we can reach out to people that we know and share things with them; we can capture data from the world, and so on. And so, there's a lot that we can do with the old wine.

But in my field, I tend to think more for each technology about the new wine. What does the new bottle enable? And in this case, I think the biggest single thing that mobile learning enables is called augmented reality. This is a shot from Hong Kong.

I, unfortunately, do not read Chinese. When you travel to an airport like this it's very disconcerting to come across this kind of a sign, unless of course you hold up your mobile device to it and the mobile device recognizes what it's seeing and translates that for you. That is a very simple example of augmented reality, and you can think of it as a little like the Terminator. When I first saw the *Terminator* movies I was really impressed with the magic eyes that the Terminator had, being able to see the real world and then seeing different kinds of overlays on top of the real world. The Terminator then did some very uncool things, and I kind of lost my affiliation with the robot, but I still envied those eyes and those eyes are potentially really powerful in terms of learning.

So, to illustrate that, in a minute I'm going to show you a video. This is from a series that the Verizon Foundation sponsors called, Thinkfinity, and I was one of the speakers in the series. They put some interviews together. It's a little silly for me to show you an interview of myself when I'm standing right here, but what I want you to focus on is not so much the fact that I'm being interviewed as the kind of visual overlay that's being shown, which is a project that we have called EcoMOBILE, which is co-funded by Qualcomm and the National Science Foundation, and which has started just four months ago.

(Video played)

SPEAKER: Augmented reality is the one where you're actually in the real world. You don't have to have an avatar and you have devices that add to what you're experiencing. Can you walk us through what that's like if you are in augmented reality?

MR. DEDE: Sure. One of the projects that we're starting is called EcoMOBILE. And in the EcoMOBILE you go to a real ecosystem -- maybe a pond, maybe a forest -- and you start walking through the ecosystem. And of course, you're

appreciating, you know, the sunlight, the birds, and all the things that you're seeing around you. But if you hold out your mobile device in an augmented ecosystem, you might learn the names of some of the birds or some of the plants that you're seeing. You might be able to see a simulated individual atom and watch as that atom appears in different places throughout the ecosystem, giving you a sense of the flow of matter through what's happening. You might be able to hold your device over a pond and see data about what the pond is doing at the moment. You might meet a virtual person on the edge of the pond who would tell you about something that was happening that would help you to understand the pond more deeply.

So there's quite a menu of different kinds of things that can happen, just as there are in virtual worlds. And what we're doing is designing environments that we think are going to be powerful for learning, and then testing them to see whether or not that's true.

SPEAKER: And how do you know what works? Have you done research to see that kids learn better when using these technologies versus not using them?

MR. DEDE: We have done research and about five years ago we did some very early research in augmented reality, really to the bleeding edge of the technology at that time. We didn't have wonderful things like smart phones, and we found it was very engaging for kids. They really enjoyed being out in the real world and yet having these experiences as part of it. And we compared it to a control curriculum. It was like a board game, so it was an engaging form of classroom instruction. And we found that the kids learned just as much as in the board game, plus they have this whole sort of real-world outdoor experience.

Other researchers have done work in augmented reality; they're also finding that it

has considerable promise. But this is a technology that's moving (inaudible). And so even as we speak, it's evolving capabilities and we're trying to understand which of them might be useful.

(Video ends)

MR. DEDE: So, there's more to that video, but it is just interview with me. And since I'm here, we don't have to go through that part of it. We can talk directly.

We're very pleased with the work that's happening in EcoMOBILE. Amy Camarinen, who was the adult you saw in the video, is in fact an ecosystem scientist, so we're being very careful about the authenticity of our immersive simulations and augmented reality and the quality of the science that's going on. And we're impressed by the early data that we're collecting.

Now, I get asked well, okay, that's science. Is that really what augmented reality is for? No, I think that's the tip of the iceberg. You can go to a mall and we can imagine doing indoor augmented reality where kids learn something about economics by making visible things that are invisible now, like the flow of money or the flow of goods or the flow of people through the mall. You can go to a cemetery and you can imagine augmenting that for history.

And what's particularly interesting to me about augmented reality as a form of new wine is that unlike virtual worlds, which I also study and which are also very powerful and immersive, they're pretty -- the technical part of augmented realities is fairly easy to create. The instructional design is still complicated, creating something that's powerful for learning still requires a lot of very careful thought, but authoring that and making it happen on a mobile device is not that time consuming and not that expensive.

And so towards the end of this NSF-funded project, we're going to be looking at having teachers author their own augmented realities. And better still, having

kids author their own augmented realities. And certainly one interesting place to start is the neighborhood, where you can look at history, where you can look at energy, where you can look at a lot of different aspects of the neighborhood that potentially are quite powerful. So, the new wine is very interesting new wine.

Part of why it's interesting is not simply that the kids are having this experience, but we're also collecting an audit trail. So in virtual worlds, we have a project funded by the Institute of Education Sciences, where we're designing new forms of assessments because the virtual world collects second-by-second what the student is doing, and then we can try to aggregate and filter and cluster and interpret this to come out with some sense of what they know and don't know based on their behaviors. Mobile phones do not collect as rich an audit trail, but they collect a very valuable audit trail. And if we couple that, perhaps, with students wearing little headsets and we capture what they're talking to their teammates about, it's a very powerful environment for research and it's a powerful environment for interpreting what students know and don't know based on how they're acting and what they're doing.

So, the most interesting part of this to me, though, is not the old wine and it's not the new wine. It's saying, what happens if the bottle disappears?

Since Socrates we have been saying if you want to learn, you've got to get away from the world. You've got to come to the forum or you've got to come to the campus or you've got to come to the school. Because the world is noisy, the world is confusing, the world is chaotic, and you need to be somewhere away from it where you can reflect and interpret and be guided. That is all true, but if we can compliment that now with standing right in the middle of the world and having a device that knows who you are and how you like to learn, where you are and what around you has been augmented for learning, and who you like to learn with and how to reach them, that's a

very interesting vision. That's a very interesting compliment.

And so, I think the next stage of mobile learning beyond the old wine and then beyond the new wine is going to be, let's make the bottle disappear and let's see what happens when we compliment schooling in its many forms with things outside of the school.

This fit into larger policy initiatives that are taking place. I was one of 15 people on the technical working group for the 2010 National Education Technology Plan commissioned by Congress, conducted by the U.S. Department of Education. That plan looks at what a 21st century educational system might be, and what kinds of research investments, changes in practice, and initiatives and policy would be needed to create that. I hope that you will go and take a look at that document.

And one of the graphics in the learning chapter captures this concept of learning everywhere, anyplace, anytime in contrast to the place-based, time-based industrial-era school. Or in Harvard's case, medieval-era university, and the school and the university and the classroom are still there, but they're about 10:00, 10:30 in that diagram. And there's a whole bunch of stuff outside of that sector that now has potentially opened up and made powerful by mobile devices.

So when we ask what's the biggest difference between a 20th century educational system for an industrial-era national economy and a potential 21st century educational system for a global, knowledge-based innovation-centered economy? This graphic may capture the biggest single difference, and mobile learning is essential to make that vision work.

So, I want to close with an optical illusion. This is a classic optical illusion. If you look at it carefully, you can see two women, an old woman and a young woman. One way to interpret what I said is to say, wow, mobile learning can really

enhance schooling as we know it now. And in schools people can use these for one-to-one access; outside of school people can use them to do their homework more effectively. It's a great enhancement. It's a kind of frosting on the cake of classroom-based learning. That's the old person. And we know pretty well what we can get with the old person, and mobile learning is going to add something to that but it's not going to perform any miracles.

We don't know the young person as well. Her face is turned away, but this young person is this 21st century model where you say the cake is actually active learning throughout life, in classrooms and out, and the frosting is all this presentational material that we've build up in the lecture-based method, the assimilative method. And now we can infuse that into the active learning model so that when you're stuck, there are resources that you can go to, be they printed resources, be they people, be they lectures or videos, that make that possible.

And one of the most interesting tensions, I think, with mobile learning is between automating what we do in schools and disruptively transforming towards 21st century education with this no bottle model.

Thank you very much. (Applause)

MR. FRIEDMAN: So, taking a step back from the application of education to the broader question of how does mobile change computing? And I'm going to -- just as once we've developed sort of networked computing, there was a fundamental shift in how we look at information. Similarly, as we move to a mobile environment, the way that we process information and use information is going to change fundamentally, which is going to lead to new ways of organization economically, socially, et cetera.

So first, mobile must be networked. And again, I want to be careful about defining things. In technology policy, you get very caught up in the definitions.

You spend a very long time arguing in committees, you come up with a very long document, and you haven't really made any progress. So rather than defining things, we're just going to talk about some properties.

So, networking in the mobile environment is a little different because it has to happen through spectrum, usually. That's what we're talking about today. And we can talk later about licensed versus unlicensed spectrum, but spectrum has certain features and the different types of features and the different types of spectrum have different capacities and drawbacks.

There is the question of what kind of data we're getting. Mobile allows real-time data, both directly to where you are no matter where you are, and also going up and out and sharing from you wherever you are. The sensors that we have are now richer than we've ever had. Usually when people talk about sensors in some kind of context they're thinking about fairly small scale-er data. What's the temperature? As opposed to very detailed information, location. The camera is incredibly powerful and can be used in many different contexts. The idea that you get the value that you -- you can value the data that you're looking for at any given time, and you can get the data that you really want. This opportunism in both use and sharing of information.

Now, this has some downside as well. On the privacy side, information that I may not feel is terribly private now may later in the day, same type of data, all of a sudden become something that I value a lot.

One of the more interesting components is this idea of context awareness. The idea that my device can learn about the context it's in and then engage in the surroundings. Professor Dede talked about that a little bit, but I think the idea is that you can now both learn about what other devices are out there, where am I, what physical conditions are going on? Can it talk to other things to realize that I'm at a

meeting and automatically turn off my phone? That would be a useful thing to have sometimes. (Laughter)

There are some constraints in the mobile platform as well. Variable connectivity is usually one of the things people bring up. It's not always certain how you're going to be connecting, what kind of access you'll have to data. Or you're on a plane, in which case all of those nice little applications that you have that depend on real-time data, you suddenly lose the ability to access. Or, alternatively, we have the challenge of this device is less powerful than some of the other devices we're used to using.

There is constrained resources, not just in terms of the chip. The chips are getting better and better each day, but this is a finite real estate. There's only so much information I, as a human, can glean from this small space.

So, what we end up with sometimes is sort of this Swiss Army approach where we try to take all these different applications and cram them into a small thing, and just as the Swiss Army knife has lots of different features but none of them are superlative, that's often a direction we're going to head if we don't do some careful engineering.

So, one approach is the idea of sharing information between us and the cloud, right? We've talked a little bit about the cloud at the Center for Technology Innovation, but this idea -- I think it pairs very well with the idea of mobile that I treat my mobile device as a wallet and interface. Now, a wallet -- these days, people don't have too much cash in their wallet. Instead, you have a whole bunch of tokens that allow you to access the things you really want that are kept in large computers somewhere else. It's a great way of thinking about the mobile platform.

Another interesting dynamic created by this concept of, you know,

distributed computing is sensor nets. This idea of a bunch of different devices distributed throughout some environment that can help us learn things. People have proposed doing this and have in fact implemented models for this in everything from gaining battlefield intelligence to studying environmental changes over time, to learning how crowds behave. There's been some fantastic data of people just learning how populations in cities mix and don't mix, simply by tracking where the taxis are going on Saturday nights in New York and San Francisco. You can learn a great deal about the social patterns.

Sensor networks can be used in sort of an ad hoc system. Instead of having to set up your entire network ahead of time to discuss the whole protocol, design things -- that means that you have to have an engineer on your staff -- you can have small devices that are capable of building their own networks and communicating across pieces as you go.

People have even suggested this and the idea of a mesh network, the idea of using local connectivity entirely from ad hoc networks, and they don't even need to be automatic. You can have these on your mobile devices. Deborah Estrin at UCLA has done some excellent work in this idea of human sensor networks measuring everything from political data in terms of how people are reacting, measuring potholes and sending, you know, traffic conditions, what are the optimal bike paths in Los Angeles? All just from putting some application data running on a smart phone that people carry around with them all the time.

The solutions don't even have to be all that high-tech. So, we heard before about fisherman in Brazil. A former colleague of mine at the Kennedy School, Robert Jansen, had the fortune of studying the price of fish on the coast of India a few years ago while they were setting up mobile networks along the coast. He found that in

fact the fish market was wildly inefficient because everyone would go out, fish, and then they'd come back, but no one knew exactly where to take their fish to sell it. So, the spot price was highly variable. Some days, one market would get no fish, people were hungry, and the next town over the fish had to rot because there wasn't local refrigeration.

Cell phone network, which you can use far enough off the coast to deviate your destination without wasting too much fuel, you now have the ability to find out where the fish is and what the prices are. And so all of a sudden you have a magical, efficient market. The spot price went from shaking violently every day to smooth and even, varied only by season.

Similarly, we can use these platforms to say, listen, we can now crowdsource and gather data from people who actually know about it. What are the local blood supplies in small towns in rural Australia? Well, if you don't have a way of immediately contacting these people, you can just have the local nurse send an SMS and say, we're low. You can have that go directly into a computer. You don't need constant connectivity. You don't need to have very advanced systems, you just need enough people who are willing to engage and send small data, and the system allows recompense. Many countries in the developing world use mobile minutes as a form of currency, so now you can trade this in.

So the challenge in understanding how we're going to move forward in terms of exploiting this mobile connectivity is really just what we choose to make of it. And a large part of that is going to be on one, the power to have good computation and share information on the networks, but also allowing open innovation, open systems, and a creativity model that allows people to share new ideas and develop new business platforms, new social models. (Applause)

MR. WEST: Okay, so we have heard from several speakers. We have heard from Peggy Johnson, telling us about new applications that are coming online. Chris Dede just talked about some of the exciting education and M-Learning things that are made possible by mobile technology. And then, Allan had some comments about how mobile changes computing.

So, Chris, if I could start with you. You were focusing on education. What are the exciting new education applications that you're seeing? How common are they? Who is adopting these applications? Are there particular examples of especially innovative applications that are taking place in the education area?

MR. DEDE: There's a number of very interesting shifts that are rapidly taking place in education. Peggy Johnson mentioned the wireless tech conference that Qualcomm sponsors here in Washington every October. I co-host that conference for Qualcomm.

And it was held about six weeks ago and early in the conference we had four superintendents -- Baltimore, D.C., Fairfax County, and Onslow County, which is the rural county in North Carolina where Project Connect took place -- come up to this stage. And I asked the superintendents to talk about their plans for the use of mobile learning in their district.

Now, if I had done that the year before in 2010, I suspect that at least two and probably three of those superintendents would have said we're very concerned about mobile devices in schools, we have policies that highly restrict their use, we are worried about them as a distraction, as a means of cheating, we're worried about sexting, et cetera, et cetera, et cetera.

One year later, those superintendents said, can't you move faster with this technology? We got rid of all those policies. We know that we need one-to-one and

we can't afford one-to-one laptops, so we're looking at mobile devices and beyond that, we're looking at bring your own technology where schools bring in whatever device, where students bring in whatever mobile device they have and put that into classrooms. And that's difficult. It's difficult for the teacher, it's difficult technologically, but it does give us a kind of one-to-one that's not affordable anymore through other means, and we know that we need the technology infrastructure to help us customize and personalize and motivate learning. So, that's one big sea change that's taking place in technology, is a growing willingness for better or for worse to see mobile devices as being very powerful.

And I say for worse not because I don't believe they have enormous potential but because business being what it is, sometimes schools are sold a bill of goods. They're sold netbooks as if those were just like a laptop. Well, once you have that device in the school, you find there's all sorts of stuff that you might want to do that that low-end tablet or that netbook is not going to support, and now you've precluded a bunch of things, including the kinds of things that I build and study, that you can't use on the low-end device.

So again, the device is not magic. There are good ways of doing one-to-one with mobile, there are not so good ways of doing one-to-one with mobile, but it's a big sea change that's taking place.

I think more and more teachers are looking at social networking. And for kids, the device for social networking is mobile. It's not a laptop, it's not a workstation. So to the extent teachers are using social networking in very innovative ways -- blogging to help teach writing, academic bookmarking to learn information strategies for finding things on the Internet and judging their quality, wikis for collaboration -- mobile devices are where kids center those activities.

There's exciting things happening, as I said, with linking learning in and

out of school, getting parents involved. And in the informal learning area, you're standing in the grocery line, your three-year-old is raising hell, you pull down an app from Sesame Street or PBS, now they're not only engaged but they're actually learning something.

So, lots of things happening, lots to sort out, and lots to coordinate and orchestrate.

MR. WEST: Thank you. Allan, you mentioned several possibilities for civic engagement through mobile technology. I think you mentioned citizens monitoring government performance through potholes. You talked about crowdsourcing as a way to harness the collective knowledge and experience in energy that is out there.

So I was just wondering if you could talk a little bit more about that civic engagement piece in terms of what are the possibilities, what is taking place now, and what are the constraints in this area as well?

MR. FRIEDMAN: So, at the moment we're still in the phase of research and pilot programs. But some of them have been quite successful, so the idea of saying it used to be you had to, you know, call up someone in City Hall fairly low down and say there's a pothole on my street. A number of cities have set up what's started off as sort of an e-Government phase. An e-Government portal has now translated into a mobile portal.

Just take a picture of the pothole and show that it's big and painful, and that somehow drives attention a little more, and it also helps the crew sort of say, this is what we need to go out and do this.

On the research side we've seen some work on the challenge of get out the vote. So now, you can do everything from, you know, on the day of the election get lots of reminders. Hey, vote. And organizations that believe that their members will vote the same way can engage in this through SMS, through app. You can track the behavior of

people doing get out the vote approach.

In terms of transparency, this allows a lot better control for workforce management. Can you actually see, you know, this police officer said they were not anywhere there when there was a local complaint against them? What can we learn about that from all the technology, all the mobile devices they have on their person?

So, on the social network component, again this can sometimes work against the civic engagement side, allowing people to vent their anger very quickly. This has led to some high-profile tweets that shouldn't have been tweeted, and also leads to a shift in dynamic of how people engage their representatives.

MR. WEST: Okay. For each of you, let me ask the following question. Then after that, we'll move to our audience for some questions.

What constrains adoption in this area? And what do we need to do in order to facilitate innovation? Chris, perhaps you can focus on the education area and Allan, you could focus on some other areas.

MR. DEDE: Sure. There are two big issues with adoption of not just mobile devices, but any learning technology. One of them is concerns about privacy, safety, security that the federal government mandates, although the federal government is much more flexible about how that mandate is achieved than often school districts interpret.

And mobile devices pose very interesting challenges along those lines, as Allan discussed. So, there are issues with how you make sure that students' privacy and security and safety is protected. And one of the strategies that school districts are developing is to root the mobile device inside of the school through the WiFi, and then it can go through the same kind of filters and controls that laptops and workstations go through.

Another strategy is to monitor what's happening on the mobile device for the first couple weeks, and students that are using it in inappropriate ways when they're find out they're being watched, that behavior rapidly gets suppressed. And then as they get involved, it tends not to be so much of an issue.

The more profound issue and the longer-term issue is that for these to really be powerful in learning, we need to change the model of pedagogy from learning by listening with a mobile device to help you to learning by doing with a mobile device to help you, guided learning by doing. And a shift in pedagogy is a much bigger change for teachers than simply a shift in whether or not students are using a cell phone to help them. And that has been a foundering point for many learning technologies over the years, and it will be a foundering point for mobile learning as well, unless we're very creative about our professional development and unless we as a society place an emphasis on moving beyond simply automating schools and universities as they are.

MR. FRIEDMAN: I wish privacy and security were more of an impediment in adopting mobile technology. It would give us time to solve a lot of the problems that we haven't. Unfortunately, it doesn't seem that for the most part, these are big impediments. For example, corporations and large organizations for a while just had a no mobile device approach. They said, we have our way of doing information management and we can't support all these devices, so we're not going to support them. And they've just had to give up on that approach because people want mobile devices.

I think from the perspective of innovation, the largest challenge is interoperability and interactivity. So we talk about context awareness and the challenge is how can my device know what your device can do? What we can do together, how do we negotiate that kind of transfer? How do we create a room where this can all interact and do so in a robust, reliable fashion? And there are sort of two general approaches to

that. One is you do vertical integration. Everything is in one platform, you know, you have everything through a single controlled centralized network with a single vendor. And the other approach is completely open, where you have to have standardized interfaces because that's the only way that you'll have engagement, which is the open source model.

The problem is, we're in-between those two options. We have a lot of control over what happens on the network, and some of that's good and some of that kind of inhibits evolution. And, some aspects of the mobile platform are tightly regulated or are closed ecosystems. But it's not a large enough span that we can really have the engagement and the generativity to build novel ways of combining new capacity.

MR. WEST: Okay, why don't we move to the audience for your questions? And those of you who are watching the webcast, again we have a Twitter hashtag at CTI Mobile. That's CTI Mobile. So, if there are particular questions you would like to ask, just submit that question to that Twitter hashtag. And we have someone where who is monitoring them and will pose the question here in the room.

So, those of you in the audience -- actually, Christine has a Twitter question from our audience.

CHRISTINE: Sure. I've got one from S.K. Shahk, who is a tech professional here in D.C. And he wanted to know about the impact of nanotechnology on computing and a lot of the issues that -- the themes and issues that you've been brining up thus far.

MR. DEDE: Nanotechnology is a way of miniaturizing computing, and in the long-run it's going to be important because Moore's Law, which is what has led to doubling different aspects of power in the computing industry, is going to run out for using the kinds of architecture that we use. And so, the hope is that there will be

breakthroughs in nanotechnology that enable a whole new kind of computing, more powerful kind of computing comparable to, say, getting fusion power in the energy industry.

In practice, that isn't really going to affect many of the things that we're discussing because while the speed of computers opens up new possibilities, it doesn't change the fundamental kinds of policy issues or human issues or opportunities for improvement beyond expanding the menu somewhat.

MR. GALSTON: So, to follow up on that, Moore's Law predicts that we will sort of double power in a number of different dimensions with some frequency. The notable exception to that is battery life, power storage. And I think Chris talked about the challenge of, you know, expanding potential. I think that's one of the new fundamental areas that research is going to bring down to us is some better way of storing power that doesn't rely on rare earth minerals quite as much.

Miniaturization that comes with, you know, particularly carbon structure is going to be very useful for some approaches. This idea of micro-miniaturization. There are teams that are working on smart insect-like robots that you can sort of release in a large cluster. And there we have the technology to do the networking; we have the technology to do some of the processing. What we don't have is the technology to actually make things small enough that can fly and carry all the stuff we need them to carry. So, that's an advantage there.

MR. WEST: Okay, questions from the audience. We have a question here. And if we can ask you to give your name and your organization.

MR. ALTMAN: Hi, I'm Fred Altman. And my question is on the downside of all the mobile technology. Can it be like the tourist that goes on a trip and doesn't see anything because he's so busy taking pictures all the time? If you're paying attention to

your mobile device, are you missing the environment?

MR. DEDE: There certainly is a real risk of that happening without good design. So for example, if you were to do something like our EcoMOBILE project and you just packed the mobile device with information and with links to web pages and with streaming videos that you could watch, pretty soon you might as well be sitting in your seat at the school compared to standing out in an ecosystem because the focus would be totally on the device. It would not be on the world around you.

And that's why I think this opportunity of overlay is so important. You still don't want to be looking at the world through the device all the time. You don't really want to have glasses that create overlay all the time. You want to see the real world as it is, if only for transfer as well as for the beauty and the natural appreciation.

So, the design is to create things that are there but they're there only some of the time. They fade over time as your knowledge expands and you don't need the supports anymore of having the visualizations or the information. It's an art that we're learning how to do in design, and what's important about research is understanding where we succeed and where we fail, and what the limits are of the technologies as well as the strengths.

MR. FRIEDMAN: The challenge is going to be making sure the advertisements don't distract. (Laughter)

MR. WEST: Other questions? Yes, back on the aisle.

MS. OXTON: I'm Alison Oxton from Microsoft. I have a question for Chris. With the augmented reality, you brought up the idea of active learning and I think of that in the context of sort of students creating something new. But I watched the thumb clip, and I see the kids in the ecosystem, and they're definitely personalizing, they're choosing who they're learning with, they're learning about their reality, but what

part of the design do you envision -- paint a picture of then what does the kid do that's actually active learning or creating?

MR. DEDE: Sure. And some of what I'm struggling with is giving the 10-minute version of the 1-hour talk about this area.

So, EcoMOBILE is actually built on a project called EcoMOVE, which is a one-month middle school science curriculum in which we built two immersive digital ecosystems that you actually use inside of classrooms. And this is the point at which ecosystem scientists get really angry if you begin your talk with that sentence, because their motto is, no child left indoors. (Laughter)

And so, the idea that some bozo at Harvard is building digital ecosystems so kids don't have to go outside, they get very upset and we say, no, no, no. The whole point is to make that field trip really powerful because now you've got your experience in this simulated ecosystem to help you understand what's really happening below the surface.

We're building on what came out of that EcoMOVE work, which turned out to be very powerful for learning in designing EcoMOBILE. And what we're actually creating now is blended curricula that are part EcoMOVE and part EcoMOBILE, where we look at how these two kinds of immersion could potentially compliment one another.

And in the pond ecosystem in EcoMOVE there's a mystery. You can go backward and forward in time for about six weeks, visiting this simulated pond, and about one month into that simulation all the large fish die overnight. And then, students in teams of four, where each person in the team has a different role and there's a jigsaw pedagogy, so the team can't succeed unless each student collects the data that only they have access to and synthesizes that together. The students work together to solve that mystery of why did all the large fish die.

Narrative is very important to active learning and to inquiry. And so, now what we're asking ourselves is, you can't just take the virtual world and put it into augmented reality. That doesn't work; it's a different medium with different strengths. But what stories can we tell so that teams of students might find themselves exploring the pond where the pond is made more interesting, if you will, by superimposing a narrative and some simulations that show something happening at the pond that's dramatic, that's intriguing, that leads the students into knowing how to figure that out?

We're not at that point yet. We hope to be at that point in about a year.

MR. WEST: Yes, back there on the aisle. Yeah, right there.

MR. GRYSKIEWICZ: Stan Gryskiewicz, Center for Creative Leadership, senior fellow there.

The marker for me, the incredible one, is the learning paradigm has moved away from the $99 laptop to the whatever mobile device. And that's a great framework to take looking forward into executive education.

Thank you.

MR. FRIEDMAN: So at the risk of pushing back a little bit, I think one of the challenges -- especially focused on something like STEM education -- one of the beautiful things about OLPC program is it was built around the idea that students had to learn about the device. They had to be -- and ultimately, be able to take it apart and play with it from a software perspective.

It is harder to do that in a mobile environment.

MR. WEST: Well, you could take it apart but you can't put it back together. At least in my case, so. (Laughter)

Over here is a question?

MR. SANG: James Sang. Today's *Washington Post* points out that a

town like D.C. is very inhomogeneous. This was in particular in the case of educational attainment, how it divided between social economic groups.

Do we in fact know how 10-year-olds from different social economic groups interact with their mobiles? You know, expectations and what they see when they look at it and play with it?

MR. DEDE: We know somewhat what students do with their mobiles, even in terms of different demographic characteristics, because of surveys like the Pew Internet studies that have been going on for quite a while and that have expanded to extend to mobile devices. We even know what college students tend to do with their technology through groups like EDUCAUSE that have similar surveys. And longitudinally, we see changes over time towards things like increased use of social media, for example.

What we don't know is, if I am out at a pond and I am on a team with two boys and a girl, trying to learn STEM, what gender dynamics may be there and how can I get past some gender dynamics that might be unfortunate in terms of what's taking place? If I am an urban student, who has never really been in any kind of natural ecosystem, and now I'm in a virtual world ecosystem or I go on some kind of special field trip to an augmented reality, how much of that is overwhelming and how much of that is helpful?

So, there's a tremendous amount of research that needs to be done to understand developmental levels, to understand cultural backgrounds, to understand the influence of stereotypes from society, particularly in STEM learning. And, we're -- the hope is that these audit trails that I talked about will give us richer ways of collecting detailed information that we can then try to interpret and understand in terms of how to help with educational opportunity and educational success for many, many different kinds

of learners.

MR. WEST: Larry?

LARRY: This is a bit of a follow-up and building on the question that was just asked. Susan Crawford used to be the White House technology advisor, wrote an op-ed in Sunday's *New York Times* in which she made the premise -- and I'm going to butcher her premise. But part of her premise was that African Americans and Latinos use mobile devices, but they're on a thin bicycle lane where as young white kids who are using laptops and are on broadband networks in their home have the full Information Superhighway. And we're creating a new digital divide by saying it's sufficient for children of color to have mobile devices where white children have laptops.

I have fought that with Burkeman and Susan and others, but I'm curious as to -- because I actually believe it's wrong. But I'm curious as to where you come down on that argument that mobile devices are not sufficient for children to have a full learning experience.

MR. DEDE: There's no question that mobile devices today are not sufficient for children to have a full learning experience. That's absolutely true. The virtual worlds that we build -- while they were designed to work in schools that have even low-end workstations or laptops, will not run on any but high-end mobile devices. And even those mobile devices, because they have relatively small screens, don't convey the same sense of immersion.

So, yes, mobile technology is limited. It's going to continue to expand in its power, but its form factor is going to continue to be small. And laptops and workstations are going to continue to expand in their power.

So, on the one hand, yes, it would be very dangerous to say this one group in society -- this kind of technology is good enough, but this other group needs

more. That's a huge mistake.

It is part of the dynamics of technology development, though, that we keep coming up against that in many different forms. And it's a little like telephone service. Telephone service, when it was originally available, gave the rich an advantage. Universal telephone service leveled the playing field. So, I think with a lot of these emerging devices, the real challenge is to say how fast can we move through that period of inequality and establish much greater types of equality to all kinds of technologies?

But the other side and the more subtle side is not focusing only on the device, but saying what does the device give you access to? If it only gives you access to English, what does that do for our English language learners? If it only gives you access to highly visual environments, what does that do for the visually impaired? And so, universal design for learning is also a really important theme because it gets at the sort of back end issue of what's the material that you're able to interact with? And what are the experiences you're able to have once you have that powerful device or that less-powerful device?

MR. WEST: Christine has another question from our web audience.

CHRISTINE: Sure. Ken wrote in, here in Washington, wants to know how will mobile learning change how we learn at the university level?

MR. DEDE: It's very difficult to change things at the university level, that's the first thing I would say. I don't know what I did in a past life to have led me to become a university professor, but I must have done something pretty bad. (Laughter) If you're a university professor that deals in innovation.

Someone once said that it's easier to move a cemetery than to change a university, even though the two involve similar skills. (Laughter)

So, it is difficult in universities because we see professors valiantly

continuing to attempt to lecture at a time when there's much more us of flipped classrooms and K-12 education, and at a time when students are busy, you know, using their mobile devices or their laptops to be a million miles away mentally from whatever is happening in the classroom.

I think that the big change at the university level is going to come in part through innovation from nonstandard universities, like the University of Phoenix. I think part of the other change is going to be driven by students themselves. I find that my colleagues come to me and say, my students are complaining that I'm not doing this semester what you did last semester. Can you tell me how to do it?

So, it won't be so much top-down as it's going to be through competitive forces and through consumer forces, I think, that we'll eventually start to see changes in universities.

MR. WEST: Right there is a question.

MR. CONKLING: Yeah, James Conkling. If I can take this in a slightly different direction and talk about mobile technology in the developing world? And particularly, you know, looking at something like mobile banking and M-PACE in Africa or the use of mobile technology in Haiti to chart the immediate effects of the earthquake on Port-au-Prince.

MR. FRIEDMAN: I think certainly when you look at any natural disaster, whether it's here or in the developing world, you know the first thing that gets knocked out is all the landlines and personal computers and those types of things. And so, the communications device of choice almost always -- at least, in the early days -- comes down to some wireless device. So we saw that in Haiti, we've seen that in Hurricane Katrina and other types of things.

So, I think there is tremendous potential there, especially in the developing world

because in many of those countries they skip several of the lines of transition that we have gone through, you know? Just in my lifetime, you know, we went from mainframes to desktops to laptops to tablets to, now, smart phones. Many of the developing countries basically skipped several of those intermediate stages and have gone straight to mobile devices. And so, they are building a lot of different applications -- mobile banking, which you mentioned -- and otherwise. And so, that's where the real growth potential I think is taking place in those countries.

MR. WEST: So I think following up on this, the challenge of getting a mobile environment deployed is still -- it's not easy, but it now is the sort of thing that you can airlift in in a couple of trailers. And I see in the back of the room, there's John Pejo who has done some work on this.

In terms of once you have a network up, this idea of crisis mapping -- Ushahidi was used in the Haitian earthquake, but it's now been spread -- is an incredibly powerful tool that combines -- so, crisis mapping is the idea of taking GIS information, just location information, and visualizing it. You distribute the responsibility of collecting information and you can now put things together.

In Haiti, it allowed teams of ex-pat Haitians in Boston to work together with computer scientists at Tufts University to get text messages from people who were trapped in the earthquake. Those were routed through this computer system that was very quickly deployed, to volunteers who knew Haitian Creole, which is a fairly small subset of global population, and then returned that information very quickly to the rescue personnel on the ground. What made that system very powerful is the ability of, one, sort of small social and financial entrepreneurs to put something together very quickly. And two, having open interfaces throughout the system.

On the idea of using mobile as payment, I think that's an incredibly

powerful tool. You know, you can pay your taxi driver in Nairobi with your phone, and you don't even need a very advanced phone.

The challenge Darrell mentioned -- this idea of leapfrogging to mobile technology. One of the reasons for that power was the local telcos were very entrenched monopoly that was built into the existing power structure. It meant that phones were very, very expensive and hard to get in large swaths of the world. Private sector comes in on the mobile market, and now you have a much more flexible dynamic marketplace.

In the financial sector, we're now bumping back into that idea of you have an entrenched bureaucracy, which in some cases is performing valid consumer protection services but is not eager to surrender control of the financial system. The question of do you want a financial system that's completely a currency that can fluctuate with the open market or with a carrier, a much longer discussion.

MR. WEST: Okay, right there.

MR. GRINDSTAFF: Hugh Grindstaff. With the mobile technology you have a case like Estonia, where everything's mobile. And you had the attack; they lost something like $70 million of business that day. So, that's an example of where mobile cash doesn't always -- you have to prepare for some -- a drastic hacking or a cyber attack.

MR. FRIEDMAN: And the question of security is a very long discussion, but bringing up the idea that we're tying the infrastructure into another set of components. So, no longer just something about a phone network. Now you have the power system, you have all the back-haul data, which is going to run in many different cases. In some countries, it'll probably leave the country. And just the dependency on many more systems as you move data into clouds. It's a symptom of how we're centralizing and making things more efficient in IT, not just mobile.

MR. WEST: Right there is a question.

MR. CATALANO: Mike Catalano with PreClarity, and also senior advisor for social innovations at Mercy Corps. PreClarity does advanced analytics for mobile operators, where we look at the basic market demographics. But my question really is -- I think we touched on this and it's a build-on two other questions that were asked.

You know, what do we really need to -- what type of platforms does the education industry need to do that basic research on these new dynamics? I mean, what is bullying in this social networking world? Is it different? What do kids think about in terms of credits and incentives? Is it -- are they trading Facebook friends? Who has the most friends? Do we really understand the basic dynamics of what's going on in a child's brain based on -- using these new learning tools? And, what type of platforms are you thinking about that the education industry needs for that basic research in terms of analytics?

Second, I do a lot of work in the mobile payment space. In Haiti, we did the food security program, the $40 per month out to beneficiaries for 9 months, where they were receiving $40 of mobile money value and using that to purchase commodities locally.

In the mobile financial services space, there's a lot more care and a lot more potential for systemic risk. Estonia, although you guys are fantastic on the mobile front, there's a small company called NOW! Innovations in Estonia that enabled civic engagement. The largest population of mobile voting users in the world happen in Estonia. So, that's a positive thing. Yet, in a place like Zimbabwe that has lost their currency, what does mobile money mean as a proxy currency in an environment where there is no currency?

So, you have to look at those factors, and I think there's a lot more systemic risk

issues with mobile financial services in certain market contexts.

MR. WEST: Maybe I'll address just the cyber bullying part of it, and if you guys want to jump in on other aspects.

I mean, there's no question technology kind of enables a wide variety of bad behaviors and certainly doesn't do much to stop any of those. But the one thing that technology does is, it provides greater accountability. Because when people engage in bad behavior through technology, they leave digital fingerprints. And so, thereafter it actually becomes easier to prosecute the case, to penalize individuals, or otherwise kind of keep track of what's going on.

MR. FRIEDMAN: Predictive analytics is an interesting challenge and opportunity for education. And it depends on the type of behavior that you're trying to predict.

So, we're moving now for a variety of reasons to large-scale student information systems that collect all kinds of data. And there's some interesting opportunities there, for which we know how to do predictive analytics pretty well. So, let's say that we've got a statewide information system that's integrated, that's collecting all sorts of stuff. Guidance counselor comes in to her office one morning in the high school, and there's a red light flashing on her dashboard. Turns out that in the last six weeks, Johnny's attendance has gotten significantly worse, he's dropped off the football team, and his grades -- his interim grades are going down. So, that's, you know, a nice form of predictive analytics that we can use to combine data and say, maybe I'd better see Johnny, try to figure out what's going on.

The much harder kind of predictive analytics is where we do our research, and that is to say Fred has been doing this kind of math intervention for about 10 minutes and just seems to be floundering. Is it because he doesn't understand the

mathematics? Is it because he doesn't like math and is unengaged? Is it because he likes math and understands it but he doesn't feel that he can do it and so he's got self-efficacy issues? Is it because he didn't get any sleep last night because he was up watching the Red Sox in the World Series? It's much, much more difficult to do small-scale predictive analytics on learning, and that's where we need some very careful research and some breakthroughs, frankly, in our predictive analytics models.

Both are very valuable things to be pursuing in education, and both come off of mobile devices just as they come off of other kinds of computing devices.

MR. WEST: Chris, I was with you until you gave that Red Sox example.

MR. DEDE: Oh, sorry. (Laughter) Wrong town to use that example.

MR. FRIEDMAN: So, on the question of systemic risk. I think that is sort of one of the defining themes of the networked era. The network effect creates strong power out of systems that everyone is using, and so you're putting more and more eggs in one basket. And as IT develops and evolves, we're seeing even more of that with the transition to cloud, et cetera.

One of the interesting things about the mobile space is it is possible to build networks that are more resilient than your classic centralized model. Those are expensive -- at the moment, they exist largely as toy projects to produce computer science Ph.Ds. and create lots of conferences, but that technology is there to create, say, mobile payments that don't require centralized servers, and to have a communication protocol that says, listen. Even if the towers in this environment go down, we can still as long as there's a density of people with cell phones, we can still get our text messages to people telling them that we're okay.

So, that capacity is there, it's just less efficient. And that's the challenge of saying IT investment is because of efficiency.

MR. WEST: Right there? There are two questions side-by-side. The two of you can fight it out over who goes first.

SPEAKER: Thank you. My name is (inaudible). I'm a student at the George Washington University. I'm doing my Ph.D. in economics.

My question is regarding the augmented reality that Professor talked about. It's extremely interesting, and I was curious to know if anybody is trying to work with it, in particular in agriculture sectors, about learning about, in particular, how to deal with risks, especially in the face of climate change and microclimates.

And my second question is that if not, what would be your advice for somebody who would be trying to look at this kind of a project? Thank you.

MR. DEDE: It's becoming very difficult to track everything happening in augmented reality because this is a field that's exploding right now. So, two years ago you could have put the total amount of augmented reality projects in the world into this room. Now, if you do a search on augmented reality on YouTube you come up with a huge amount of stuff, much of it of low-quality, some of it very creative and of high-quality.

My guess is that there are people doing the kind of work that you describe somewhere. But we need, as in many emerging fields, we need better ways of sharing what we're doing, we need better ways of convening people doing the same kind of work so that we're not reinventing the wheel. We need ways of transferring inside cross-sectors, so that somebody gets an insight in education and can transfer it to the kinds of agricultural applications that might be important.

So, it's an exploding area and a great area to get involved in at this point.

MR. FRIEDMAN: Just a compliment to that that might be useful to the applications you're looking at, is the quantified self movement. The idea of people

empowering themselves with sensors. And from a learning and collecting data about risk, especially in something like a microclimate approach, networks where people can get regular information of what's the CO2 in this neighborhood, what's the humidity in this part of the Andes versus a mile away? Empowering a bunch of people with small network devices that allow information transfer, information exchange, information collection could be very useful.

MR. WEST: Christine has another question from our Web audience, and then we'll come back to you over there.

CHRISTINE: Sure. Edwin Stepp, who is the director of development at Vision Media, he wanted to know how mobile technology changes the art of storytelling in education. Does it make it nonlinear versus linear? Two-way, one-way, more predictable, less?

MR. WEST: Great question.

MR. DEDE: It is a great question, and I will say that we're still in the middle of understanding how to do effective designs for narrative and storytelling in education.

I mentioned in my talk that we did some work about five, six years ago, very, very early in augmented reality. And at the time, we developed some learning applications that were pretty linear. And we found that they bogged down in a lot of respects, and that they also didn't teach the full range of higher order thinking skills that we were interested in accomplishing.

And so, in this latest second generation work that we've done in augmented reality we're creating more non-linear designs that are more complicated, frankly, to do, but that work a lot better both in terms of the skills that are learned and in terms of some of the practicalities of implementation.

So, it's interesting because there are fundamentals of every human activity that transfer across technologies. There's a lot about storytelling face-to-face that transfers into storytelling in a movie, or that transfers into storytelling in an interactive device where people are telling stories back and forth. But each medium, each situation also has its own rhetoric.

The spoken word is different than the written word is different than the mediated word in texting. And so what we're learning is the rhetoric of narrative now in these kinds of devices.

MR. WEST: And I think the big trend in technology is adding video and multimedia, and so if anything we actually may be returning to the aural storytelling narrative that used to be a dominant means, kind of then lost out as we moved to a text-based world, but we may be getting back to that.

Over here.

MS. HAAS: Hi, my name is Sheri Haas. I'm a researcher at the IRIS Center at the University of Maryland, and we've been doing a study on M-PESA in Kenya. And even in the most remote villages, I had a hard time finding households which didn't either have or have access to a cell phone. But, no one had a smart phone or access to the Internet.

And I was wondering: we've kind of talked mostly about mobile technology connected to the Internet. If you could talk specifically about possibilities for text-based and voice-based cell phone technology and their applications, and if that's being developed or if that's kind of being less innovation on that part for the developing world in favor of the Internet-based mobile technology.

MR. FRIEDMAN: So, one of the most popular fields in computer science in Africa and Latin America is mobile programming. This idea of, one, how can you take

some fairly basic phones that still have some programmability and do things with that? And also, how do you handle the back end of once you get an SMS, how do you translate that into your data and process it.

This has been used in some fairly creative directions, both entrepreneurially -- having people do small amounts of data processing. Sort of here's some random pieces of text; please summarize them or please find which is most important, you know, auditing and things like that. Anything that can be broken up into very, very small components you can then distribute.

But also, you can engage in actually using local knowledge, right? So as you said, everyone has a cell phone. What are some of the things you need to know about everyone or having, you know, information coming from every hectare in a country? And this could be climate data; this can be health data, education data, very powerful.

You can also have a social search, right? So, having people have a social network that is based on sort of geographic proximity of how many hops in a social network to find someone who is a doctor within 50 miles, or to find someone who has seen this strange phenomenon you're seeing on your livestock, what's going on there.

MR. DEDE: Mobile is a big tent, and there's a lot of things underneath it that qualify as mobile devices. So Paul Kim, who is in the School of Education at Stanford University, does a lot of work with handheld devices for marginalized populations within the developing world where they're marginalized within that particular country and have no access to any form of education. These are not even feature phones, these are very simple handheld devices where, say, the kids jump rope for an hour and then they take the handle and plug it into the handheld device and it gives them power for a while to access literacy learning experiences. And then when the power runs

down, they jump rope again for a while. I mean, it's very, very simple handheld technology. Then you go up to the feature phone, then you go up to the smart phone. And at every level, you gain something.

I did a webinar for a group in USAID and for DAV IV Ed, which my co-presenter was a fellow named Steve Vosloo from South Africa. And his topic was, what can you do with one mobile device per school? And the answer was, a lot. I mean, he had a fabulous list of things that he talked about that you could do with one mobile device per school. Not necessarily a fully-integrated Net-connected mobile device --

MR. WEST: Speaking of mobile devices --

MR. DEDE: Yes, speaking of mobile devices. So, it's a big tent, and there's a lot of different levels in understanding what you get at each level, I think, is very important in helping us move forward.

MR. WEST: Okay. We are out of time, but I want to thank Chris Dede and Allan Friedman for joining us, and Peggy Johnson for joining us via video conference. Thank you very much. We'll be doing these forums on a regular basis, be putting out research papers so those of you interested in mobile technology and the mobile economy will have lots of other things rolling out over the next year.

Thank you very much. (Applause)

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