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Speaker 1: The final keynote speaker of our conference, Seymour Papert is a mathematician and long-time innovator in educational computing. His background in the field of education reform stretches back to include several years of work with Jean Piaget at the University of Geneva in Switzerland. Dr. Papert is a co-founder of three organizations at the Massachusetts Institute of Technology that are important to research and development and educational technology: MIT's Media Laboratory, the Media Arts and Science Program, and the Artificial Intelligence Laboratory.

His invention of the widely used Logo computer language has opened many educators' eyes to the power of technology and education. Among his numerous acknowledgments is a 1993 award from the Software Publishers Association for Lifetime Achievement. Dr. Papert is the author of two widely read books in our field. One is *Mindstorms: Children, Computers, and Powerful Ideas*. The other, recently published, is *The Children's Machine: Rethinking School in the Age of the Computer*.

He's among the foremost, imaginative leaders in the field of educational technology. Please join me in welcoming Seymour Papert.

Seymour Papert: Thank you. I'm going to try to circle around the topic that was announced, what we have learned and what we have not learned from the past ten years or more of experience with computers in schools. I think that what I have most learned is really how hard it is. I've learned that to think about technology in schools, you have to be careful not to think too much about technology or for that matter about schools.

You've got to learn to think on a more systemic level about the nature of change and the nature of resistance to change and particularly with an arrow of focus. Inside school, we have to think about the learning process, about a learning environment that starts from the day of birth or not before in which the child lives outside school as well as inside school.

We've got somehow to put all these things together. We've got to see what we're doing with the technology as fitting in with systemic trends in this much larger whole. That's not easy. I find myself constantly torn schizophrenically between two modes of thinking. One mode of thinking: focus on the future and that future's not far away. It's very easy today to anticipate with pretty secure knowledge that in five or ten years, there

would be enormous changes and that in twenty years, unimaginable ones.

But if we look too much at these images of the future, we are filled with amazement and wonder and it's great fun but what does it tell us about what to do Monday when we come into a classroom full of students? On the other hand, if you focus too much on what to do Monday, you are without a rudder. You don't know where to go and I think that on the whole we see that without a vision of the future, the direction that the use of technology in schools pretty well inevitably takes is to reinforce, repair, strengthen old assumptions instead of opening up new vistas about how to think about where it's going to go.

I believe you listened yesterday or the day before to a talk on virtual reality. I'd like to spell out some aspects of what that movement can mean in the lives of children. I'd like to start doing it by telling a little story that in the last while has become for me almost emblematic of the central problem in thinking about school technology and change.

This little story about my three and a half year old grandson. I noticed him do something which amazed me and then I was amazed at my amazement and I want to say something about both sides of that. Little Ian walked over to a shelf where there are twenty or thirty videotapes. He selected one, loaded it into a VCR, started it, said some expletive, I forgot to rewind, rewound it and spent the next half hour watching this tape.

It seems a little amazing like it seems amazing the first time you see a child walk up to a Mac, turn it on, put in a disc, click on the right icon and get a program going. You think three and a half year children can't even read. How can they do these things? In fact, if you think about the complexity of what they're doing, it's no greater than knowing in which you draw your clothes at camp or your toys and getting them out. It's just that we didn't do that when we were children.

So, that's not amazing, not the complexity but the implications really are and I think that not enough attention is being paid the implication of this kind of little incident that I'm sure everyone of you has seen in your own families. That boy looking at a videotape for half an hour was doing something which I couldn't do when I was three and a half or even four or five.

The videotape happened to be about road construction ahead, I think, it's called. It's a wonderful tape about the way in which road-making machines are used to build roads. Every child, studies have shown, girls as much as boys like road-making machines. They're fascinating. If they're

boys they're more likely to want to play with toy ones. Everybody likes to see them.

Having a movie that shows them at work meant that something that is already important to this kid could get greater significance. He now knows much more about road-making than I ever will. Of course, not all his videotapes are about road-making. He loves the National Geographic animal series and he loves some that are just cartoons and fun.

What I'd like to emphasize is that this child is able from his own decision without relying on an adult to begin to explore a piece of the world that went beyond what every baby explores in a spontaneous, wonderful way by direct touch, feel, smell, taste. Children always explored and got to know the world immediately around them through direct exploration, motivated from within, on their own agenda.

When it came to looking beyond the animals in Africa, how those machines really work, how roads were built, what happened in Ancient Greece, what might be beyond our galaxy, they were dependent on adults, and so I see in orders, even in the simple use of the videotape, a new kind of relationship to knowledge with the child in charge.

It's not stemming from any theory of education, it's stemming from the way life is moving. I think that this might be a more serious matter than I know how to deal with. I don't know whether it's a good thing or a bad thing. I don't know whether the children becoming more independent in their exploration of the world is going to raise problems about their psychological development, about their relationships in families. I don't know anything about how to answer those questions but I do know that they are grave and serious questions and that we ought to be paying much more attention to them than anybody is.

In particular let me, in a spirit of slightly teasing school people, point to one aspect of this change in relationship to knowledge that you might think I'm exaggerating and maybe I am but I think it deserves a lot of attention. This question is, what is the role of reading and literacy in our lives? Until very recently or even until today, literacy, being able to read, is the primary mode of access to knowledge that goes beyond one's immediate experience.

It is true you can look at television but it's obvious that if you do so, you are dependent on what other people choose to pour out at you. It is only by being able to read books, go and look in encyclopedias, choose what you read that you are able to gain access to the broad vista of human knowledge.

At school, we consequently put a great emphasis on reading and we become very upset when a child of normal reading age fails to learn to read. We create a lot of anxiety about it and a lot of tension. We bring in specialists and remedial people. Why? Because we know that the failure to learn to read is going to keep that child off from sources of knowledge and so impede the intellectual development.

I think that argument is unraveling. I think that if you look just a little bit into the future, it's not true anymore that reading will be the most effective certainly not the only access to knowledge under your free control. I think that you're choosing your videotape when you're three and a half gives a glimpse but in two or three year's time, many, many children in this country and in ten year's time, most children in all developed countries will be able to choose between tens of thousands of programs obtainable on information highways or some other channels yet unimagined.

Not only will they be able to choose between what programs to look at, the programs will be different. They'll be interactive. They will even be more in the spirit of the virtual reality that you had glimpses of yesterday than just looking at the videotape. The videotape is enough to make the point that we have to rethink what the role of, say, reading is in the intellectual development of individuals.

I'm not saying it should go away. Obviously, it won't. I'm not saying it would be a good thing or a bad thing for it to go away. I am saying that the arguments and the reasons that we've had in the past are going to become inoperative in a very near future and as educators we have to think very seriously about how we are going to deal with that situation. What will we put in their place? If we don't want them to go away, what are we going to do to keep them with us?

Those are the kinds of thoughts that come up when one looks into the science fiction future. What about looking right now at present? Imagining a day when perhaps reading will have a different role in the intellectual development and so in our concepts of education for our children, it doesn't tell us what to do tomorrow because we still are in an age where most of the knowledge to be had is still in the form of books and we certainly can't do away with that.

I think that what we can do is look at our decisions that we make from day to day inside our schools, what computers will you buy, where will you put them, with what attitude will you introduce them, what sort of preparation will the teachers have, what sort of opportunity will you give

the teachers to rethink their professional role as teachers and to rethink the learning process. All these are questions that do come up right now, tomorrow, today, and there are basically two ways you can answer them.

You can answer them in terms of immediate short-term returns. What will it do this year to your test scores? This is like the disastrous policy of a business that is forced to make all the decisions on the basis of the next quarterly report. Being confined to what will pay off in the very short term means that tomorrow will always be prisoner to the primitivity of yesterday.

A totally different way of thinking is to judge your technology to make your decisions not in terms of how much of these children in front of you now are going to learn next month but in terms of what their role will be in the evolution of the structure of the school, of the professional role of the teachers, of how we think about the role of school, of how we think about its basic concepts like curriculum, like grades, like our general sense of the philosophy and methodology of learning.

People ask me questions often like, "Well, that sounds very interesting but what will the teaching of third grade math look like in twenty year's time?" Personally, I think there wouldn't be no such thing as third grade math being taught in twenty year's time because I think that the very idea of separating math from the rest of knowledge, of separating the third grade from the rest of life and of separating teaching from learning, all these might disappear. I hope they will.

I want to give some images of ways in which I think they will disappear. Let me first give some greater respect to the people who made our school system. I think if one is going to criticize something that had such a long past built by so many dedicated and intelligent people, one can't just say they were stupid. Were they evil? One's got to understand why they did what they did.

I think that why they did what they did is best seen by focusing on mathematics as a particular subject. What I say about mathematics applies to everything else but mathematics in particular shows us one of the limitations of the dissemination of knowledge before there was the proper technology to do it.

Society for good reasons, I think, came to the decision consciously or not but by social movement. It became clear that certain knowledge was necessary for the people to exist as adults in productive work as in that society. This knowledge included certain mathematics.

Now, from the beginning of time, critics of school and philosophers of education and learning have known perfectly well that the best way to learn is by doing. The best way to learn a language is by living in the country or growing up in the country where it's spoken. The worst way to learn is to learn it like a dead language in a classroom where you learn it through exercises fed out on somebody else's agenda.

However, there was no place where you could learn mathematics that way. There was no math land where you could learn mathematics like learning French in France would be. The only way to teach it, the only way to disseminate this knowledge was to cut it up into little bits and dish it out.

From that, a lot of other things flowed. The idea of the curriculum, the idea of testing people on the curriculum, the idea of the teacher's lesson plan, the idea even of cutting up the day into periods, life into grades, and knowledge into separate subjects. All that followed from the fact that we couldn't use that knowledge. We couldn't learn it like a living language. We had to learn it like a dead language.

To mock this difference in point of view, I'd like to use these contrasts. I'd like to talk about instructionism and constructionism as two ways of thinking about educational change. Instructionism says as if it were obvious that if kids don't learn as well as they might, we should give them better instruction. Let's teach them better and teach them more. Constructionism says the way to innovate is to make better things for them to do so that they can acquire knowledge in the course of doing things that are meaningful, authentic projects of their own.

This doesn't mean that no instruction should be there. It doesn't mean children have to rediscover everything. It means that construction should be directed at putting the child in a position of maximally being able to construct, to do things. What you want to do is to maximize the ratio of learning to teaching. I'd like to give you some examples of how technology can be used to do that.

I'd like to make it very clear that this is a polemical statement that I am opposing in this what I think is the standard use of the technology which is used to reinforce the teaching of the third grade curriculum in mathematics bit by bit. I don't care whether the child can individualized the order in which you do little exercise in numbers, they are still little exercises in numbers.

I think that the whole movement towards so-called ILS systems is a part of the reflex of the traditional school system like any other living organism. When a foreign body comes that didn't quite fit into, its response is to mobilize an immune system and isolate that.

To make the point more concretely now, I'm going to show you some glimpses of a kind of experience that we've been trying to give to children in all ages. The examples I'm going to show you are like fourth, fifth grade levels but we're doing the same sort of thing, more sophisticated at higher levels and even in pre-school.

I'm going to show you some examples of something that probably worries you about the influence of technology in the world and that's the spread of the culture of video games. Looking at video games as an educator, I think like every other educator, one looks at the energy these children are pouring into that and the amount of learning that happens.

In fact, I've tried to tabulate everything you have to know to be a real expert, say, at Super Mario and I believe you have to know more than anybody would dare put in a fourth grade curriculum in any subject. Yet the kids learn that rapidly and well.

Educators looking at these games say, "If only we could mobilize that learning in a direction that would be more educational, be more school-like." I think that's true. I'd like too but if you look at how people think of doing it, they instructionist versus constructionist dichotomy comes out very clearly. The instructionist's approach is, it says children like playing games. We want them to learn, say, math fact. Let's put math fact in games and use the game to instruct the child. Good luck. The children aren't dopes.

I take a different approach. The constructionist's approach says since children see video games as an important thing, they care about them. Maybe they would like to make their own. Maybe the real way to empower them is to put them in a position of being producers as well as consumers of these things and maybe there will be fallout from there too. They'll be more critical of the tricks being played on them by the makers of the games.

We've done this. We've begun. We have a long way to go still but we've gone to develop context in which children can seriously make their video games using modern forms of the Logo language. The version I'm going to show you is a form of Logo called "micro worlds". There's a booth here. You can get some visions of it but I'm not going to worry about details. I

just want to give you some glimpses of what the children do and I want to emphasize that it's not just technology that makes this possible.

What also makes it possible is the whole culture, the encouragement of children to take their own learning into their own hands to feel that they can learn by doing something that they see is important in their lives. Of course, for children, it's not the supermarket that's important. It's the video game.

Here's an example. This is Brian Silverman who's going to demonstrate. If they can turn the computers on to the screen, please. This is really wonderful technology. There it comes. This is a game of the kind that we've now accumulated an enormous amount of experience of children being able to make games like this. I'd like to emphasize that this is not something that the child does in half an hour sharing a computer with another child in a computer lab.

These children we're talking about work maybe an hour a day for maybe three or four months or they have a total immersion experience of a whole week full-time to be able to make these games because they learned a lot in them and part of what they're learning is the experience of carrying out a project that goes over time, that involves running into many, many problems. Your own problems that come from your own project, your own situation that you created, overcoming this project's problems, knowing what it's like to carry out a complex project.

This game as you see, there is this little spaceship which can be steered by clicking on north, south, east, west down there. If it gets on to a black square, you get a ... It's supposed to be a despondent noise and you see the number in the score box decreasing. Now, if you get on to the gold star, you hear a different kind of music. You see the number in the score box increased and you see the gold star moved somewhere else to another randomly chosen position.

Why is it worthwhile doing this? I'd like to mention a couple of reasons. I mentioned one already that spending a long time at a difficult project enables an approach in mathematics that's more like what we've known for a long time works in social studies or history. Let the kid go out and do a research project that will produce a product that can be individually owned.

This makes it possible for something with a mathematical content to be used in this way. Specifically, in order to do this, the program has to run into a lot of mathematical ideas. In this case, X and Y coordinates were used. The idea of randomness and probability was used in order to decide



where to put the star next. If you I ask Brian to run it into the black a few times, you'll notice that if you keep on subtracting points from the score, it goes down to thirty and then it all go down to zero.

What will happen? It just falls out, that it goes down to that mysterious thing, negative thirty so that idea of a negative number came up in a natural way out of this experience and the child might never have met a negative number before and this is the right way to meet a new concept in a situation where it happened. In this case, serendipitously.

Let's look. I'd like to show you next some just a vision of how easy it is for the child to get into this. Brian's going to show us an example of what programming is like in this system. I think in a parenthesis here, I'd like to say that the concept of programming has in some ways gotten a bad name in some school technology circles partly because I think we were so successful in the early '80s introducing Logo as a way of programming that lots of people got involved in it.

Although, prematurely, in the sense that the computers they had and the limitations of what they could do and the limitations of time, also, its effect has made it very hard for them to do a lot of things with the programming. They became disillusioned but the idea of programming has changed radically; so much so that you really ought to rethink very thoroughly all opinions whether they follow against about the role of programming if they based on what happened to the 1980's.

Brian's set up a little bird there and I think he's made the bird fly. How the bird flies, let's leave that. That's every first grade child we've ever worked with can do that within the first period. There's nothing hard about that. I'd like to show you a new feature in this and that incorporates into it elements of what's become part of children's culture. Paint programs, for example, that they might have got through Kid Pix or elsewhere is really as much a part of a child's culture as reading a book or playing the video games.

Anything we do in school should be rooted in this culture that exist outside there. We have a Paint program here. Brian's going to draw a purple ring around the bird but before he drew the purple ring, he's going to let the bird go and, wow, the bird didn't cross the purple ring. Why not? Because Brian told it not to. This is how he told it not to. He gave this color a property and associated with the color is the property that some certain class of things which we called "turtles" will turn around if they get on to that color.

Very easily and very concretely, a new kind of programming is possible. We can produce action by making color into a living thing instead of just a dead thing on the screen. Color can talk to the bird. Now, that's how the game works. The black color and gold color of the star and the square were based on exactly the same sort of easy to get at kind of programming that starts with what we call a low threshold.

Every child should be able to get into it but once in, we want a high ceiling. It should not be limited and that's a thought of almost all the otherwise very excellent beginning software that we have for small children that many times you can get into it but after a while you've run out of intellectual content.

I'd like to just give you one more example of another game to make a more subtle point maybe about the mathematical content of this kind of experience. A lot of jumping game and let's have the next page and do the jumping first. This is a game more in the Mario style. This figure ... Can you get the next page, Brian? Click on try.

This little figure runs along and when he hits the black ... What we can do about it. Now, this was built up gradually. First, the figure just ran. It was just animation. Then this obstacle was put in its way and that seems funny but now the obstacle ... Try again. This time, if we click on leap, oops, he went over that. That's enough. The point about this is that constructing the game that got much more complicated afterwards involved thinking about jumping.

I don't know you've thought much about jumping but if you have it leads into a lot of interesting mathematics and physics. Now, let's go back to the previous and when we say we'd like to make something jump, when we jump physically with our bodies, we don't have to think about the physics or the mathematics. When you make something jump on the computer, you do have to think about such things.

What's jumping? Here, you see a number of ways you can jump. There's one kind of jump. You go up, across, and down. Bang. In a discussion group with children doing this, there was a consensus that that's not an interesting kind of jump. It doesn't look like a real jump besides it makes the game too easy because you just know how to get over it. Let's think of some other kinds of jump. Here, they're playing with a number of different kinds of jump. There's a circular jump. They also can play with some that's easy to do in this programming system using those sliders to vary this force and the speed and play with different functions of different variables.

This mathematical investigation into the nature of jump comes directly out of the wanting to build this game. It leads directly to mathematics which you've seen here, which I think really belongs to elementary school mathematics but the children when satisfied with any of those jumps and to get a satisfactory jump, the one that you saw in the actual piece of game that I showed you, another concept was necessary.

It was a concept that normally one does not dare teach, certainly not in an elementary school, scarcely in high school, and usually it's for physics, math, and for college majors in physics and mathematics. This is a concept that's called "Decomposition of Velocities" that the way that you think of this thing moving is that it has two velocities, two speeds simultaneously. One in this direction, one in that direction.

The way you make it run is to give it a velocity non-zero in this direction and the way you make it jump is to add on to that a velocity in the vertical direction. If you did that, it would just take off up into the sky and that's the first thing that happened in the evolution of this game. What can you do about that? Then somebody said, "Hey, it's gravity. We need gravity."

They had to think about how to bring gravity into it. What is gravity anyway? It holds us on the earth but what does it really do? What gravity really does was captured very accurately and concretely by a conversation of children that I've seen repeated three or four times. I'm sure many, many more times if I had a chance.

This is the picture and this isn't quite the children's language but gravity is something that when something is moving up, it eats away at the velocity, at the vertical velocity. Gravity is represented as an agent, as an object, as a sort of dynamic living thing and what its function is to know anything is up off the ground and just eat away at its vertical velocity.

If the thing starts over at the vertical velocity of ten going up fast, it will get eaten away. It'll be nine, eight, seven, six, and now the rise is slowing and eventually it's zero and then it gets negative and the thing starts coming down. The child runs into an important concept in physics, an important concept in mathematics. A different way of thinking about a parabola and all this came out of a real, concrete living experience that made it authentic for that child.

Now, I'd like to contrast this with the very idea of a curriculum and, I guess, we'll leave it at that. We can turn off the computers from the screen. It doesn't work. The idea of a curriculum boils down to this: that

because it's now the seventh of May in your fifth year, you will learn this operation on fractions because that's laid down in your curriculum.

That's very different in this situation. These children making these games all needed mathematical knowledge not on a particular day in a particular year but because they needed it right there and then, because it came out of something that they were doing and so we need a very different way to think about how to organize the handing out of knowledge or the access of knowledge to these children.

Here, I think that we see the implication for school and I'd like the restructuring of school and thinking about school which I will emphasize by bringing out just mentioning three different ways that I see that I'm very much involved with personally enabling children to get access to the knowledge when they need it, when they want it.

One of them is a new kind of organization of knowledge which my colleague, Mitchel Resnick, likes to call the "Constructopedia". A Constructopedia is like an encyclopedia except that you find the knowledge you want by reference to something you want to make or do rather than something that you want to just know about. Under jumping, you would find how tigers jump and how cats jump, how to think about jumping, what the records in the Olympic games, and the mathematics of jumping.

This needs a different organization of knowledge and, bit by bit, we're doing this but notice that it means rethinking very radically what mathematics is appropriate for children of different ages. Decomposition of Velocities, for example, is totally accessible to any child of any age in this context of really wanting it. It's extremely inaccessible because it becomes very formal to somebody who is just learning it because it's handed out on somebody else's agenda because it's now in the curriculum. It says you do it at this time.

We need a different structuring of access to knowledge but above all, rethinking what knowledge it is that we're going to give to children. Now, I don't think that things like encyclopedias in CD-ROMs and all those are the answer to how to get knowledge. People will always be the key to how to get knowledge. I want to talk here about two kinds of people although I hope in the end, eventually these two kinds will blur into one.

One kind of people is other children who have already done experiences like this. We find that when you have a group of children working in this kind of game-making studio as Yasmin Kafai, one of my former graduate students who did a thesis about this topic and will be publishing a book

next year on it, she has noticed, studied how in a studio of children working this way, they get to know one another and they get to know that different ones have different kinds of expertise. They can pick up an idea from somebody else. Picking up a mathematical idea from another kid is a wonderfully empowering experience and a wonderfully new approach to thinking of knowledge as out there, not from a central source but it's in the world for you to acquire. The children help one another.

Of course, the fact that they are split into grades of just one age level, limits the extent to which that can happen. I think this kind of approach to knowledge says we shouldn't do that. We should have children, people of all different degrees of expertise in contact with one another, looking at one another's work, collaborating, seeing how the other people do things so that they can get knowledge.

Our splitting of children in two, segregating them by age, and even if we put two or three grades together, we are still segregating them by age and expertise that doing this, however good the reasons might have been originally deprives us of the most potent source of teaching that could possibly exist, namely, every child is potentially a teacher of some other child. Just allowing that teaching potential to come out would multiply by with the factor of thirty or more, the teaching potential of the world.

We've tried to expand the possibility of children learning from one another by setting up electronic communications, by setting up an electronic bulletin board or information sent so that children who are working on projects like this can send questions in and these questions are posted up and children who know about topic, who've done it maybe last year or would have done something else related can answer these questions.

We're seeing across electronic networks, children helping one another to get knowledge which teachers might not have to give them or the teacher might not have time to do all these. New kinds of knowledge structures, new kinds of encyclopedias, new kinds of communication, the mobilization of the teacher power of children is part of what's going to happen or what has to happen.

I'd like to end by emphasizing the role of teachers, professionals in the art of helping people learn. There is a strong tendency in schools to turn teachers into technicians. The very idea of a curriculum of laying down the education objectives of this teaching plan that you have to lay down and carry out each day does tend to turn the teacher into a technician.

The image of learning that I'm projecting through this example of making the video game needs a very different kind of attitude and knowledge and background and image of teachers. I would say far from being a technician, the teacher has to be more of a philosopher that questions like, "what is mathematics anyway?", have to be addressed by teachers. They didn't have to think about it much before because what is mathematics is what is laid down in the elementary books, in the textbooks, in the curriculum, what they learned at school.

As soon as we jumped in to this kind of world, new things come up and they have to be thought through and evaluated by the adults in the system and that means, the teachers. I think the most important thing that I have learned from the whole experience of working with technology in schools is this. We have to elevate to a higher intellectual level of respect and ability and breath of mind our concept of the teacher.

I didn't say the teacher. I think teachers in their real lives are often wonderfully visionary, broadly educated people but in school, they are confined to narrow technicians in a narrowly defined, technically defined function. Not all schools and, of course, I'm exaggerating. My exaggeration does points to something that's real as a tendency and something that needs to be combated and counted.

Two last little maybe wisecracks to round off that point. One is about the use of words. As a matter of fact, I think that bringing words into mathematics is something we wanted to do to make many more connections. For example, in Logo, in this kind of programming, children do a lot with angles because you have to make the thing move at a certain direction. I wonder who knows where the word "angle" comes from or why is an angler called angler? It's because the fish hook is at an angle that catch and that's what makes it work and so on.

We speak English because English comes from the word "the angles who are called angles because of the hook of Denmark" so English which is called d'Angleterre in French is really the land of angles. I think we would do well to make more of that kind of connection but coming back to this point here, one of the things that rises my blood level, blood pressure most is when I hear the word "teacher training" because then I feel like asking, "Really? You want to train the teachers to train the children?" Of course, everyone says, "No, no, no. Good God, we don't want to train children. We want to do something else called educate them".

Then why do we talk about training teachers? Especially in technology, there's a disastrous, almost suicidal tendency for school systems to think

that we'll spend our money on the computers because you can touch and feel that. We'll leave the "training of the teachers" to the vendors coming in and giving two-hour, little seminars. We must get away from that attitude.

Our teachers, especially our computer teachers have to adopt the role of the philosophers of learning and the philosophers of mathematics and the knowledge of epistemologists. To do that requires a lot more than training and a lot more than workshops in how to use computers. If we don't do that, I think there's not much future for school.

My final crack about the use of words is something I make a lot of in my recent book *Children's Machine*. There's a chapter called *A Word for Learning* and it notices that we have a lot of words for the art of teaching. Pedagogy is the art of being a good teacher or in some context you call it "theory of instruction". In Ed schools, they often call it "methods" and everybody knows that means methods of teaching. If you want to improve your art, the art of teaching, there are courses you can take, there are books you can read, lots of people are concerned with that.

What is the name for the art of learning? Where do you go to be a better learner, to learn how to do this? What books are there? There aren't. They're very few. There is no word for the art of learning that stands to learning like pedagogy stands to teaching. I think this reflect an old attitude built into our very language about the nature of education.

You teach something to somebody. The teacher teaches a child. The teachers, the active; agent, the child, the passive recipient and so we need, of course, for the teacher to be an expert in teaching and where the learner has to do what the teachers says. It's significant that even the books on active teaching on open education, on constructivist learning, they're all direct to the teacher.

They tell the teacher how to set up an environment where children will do this or that. They're not addressed to the learner. I think that's the big change that we're creating a new environment where we have to give up, we can break away from an old pattern with children who are born as learners. They learn from their own energy until they went to school. When they went to school, the first thing they had to learn was to stop learning and to begin being taught.

I think that's what we need to turn around and I think the technology which can go in both directions by making instructionism more dominant or by opening the doors to constructionism to making everybody a learner, teachers and children together and that's the vision that I get

from thinking ten years ahead or twenty years ahead of what's going to happen and applying that to what to do tomorrow. Thank you.

Speaker 1:

Professor Papert, thank you for sharing those stimulating ideas with us. We wish you all a safe trip home and look forward to seeing you next year at the 9th Annual Technology and Learning Conference. Good morning.