**SEYMOUR PAPERT**

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(Transcribed by Heather Phillips, edited by Anne McDougall, Monash University)

I will talk about AI and related things. Why am I talking about AI at NECC? And especially why am I talking about connectionism and neural nets? You could take that in a number of different ways. Why am I talking about neural nets at NECC, rather than other things? I think that thinking about neural nets raises some important questions about thinking about education. Why am I talking about it? In a different community, where people maybe haven't even heard about LOGO, I am seen as a kind of villain who with Marvin Minsky wrote a book, about 1972, which is widely read as proving that neural nets are a wrong approach to AI and that we need some other approach. Well I don't want to go into the subtleties of that. It is a more complicated picture, but what I am going to do today is take the opposite point of view and just say why neural nets as an approach to AI really deserves attention. Of course in a short time I can only give some hints, some ideas of what sort of thing you might keep your eyes open for.

Well to put in a little background... If one thinks historically about the idea of artificial intelligence, that is making computers think, there really are two separate origins. One is rooted in biology, in the ideas of people like Norbert Weiner who tried to understand mechanisms of physiology in mechanical terms in the early 40s, and of Warren McCulloch, people making nets of artificial neurons imitating the brain. The set of ideas started with biology. If you want to make an intelligent machine, let's start having something like a neuron and connect a lot of them together and do something.

The other approach came from logic rather than biology. And the approach that came from logic said we will start with things like propositions and relationships, like implication and deduction and out of that grew ideas like planning and setting goals, and sub-goals, and programs, and expert systems, etc. etc. There have been these two lines and over time there has always been a tension between them and sometimes one and sometimes the other has been dominant. When I first knew the field, in the later 50s and 60s, the biological approach was definitely dominant. The other had hardly been thought of. In the 60s the logic, programmed approach became absolutely dominant and in the 70s it spread and became very much popularized through robotics and expert systems. But in the 80s we have seen a swing the other way and in the last 4 or 5 years under names like neural nets and connectionism there has been a powerful trend in the opposite direction. Why, and what's it got to do with us interested in education? I would like to touch on some of these themes today.

I would like to mention four reasons first why we as educators, and educators interested in how computers might fit into education, might be very interested in AI. The first is I think a bad reason. A lot of people have suggested that you could have better CAI by attaching AI to it and making something called ACAI, expert tutorial systems and so on. Maybe in 20 years time computers will be intelligent enough to attach them to a system that might guide the thinking of a child. For the moment I think their intelligence is pretty rudimentary, and the name for just rudimentary parts of intelligence is stupidity. I think the last thing you want is to have a still stupid instructor in charge of a student's thinking, and that is my opinion about intelligent CAI - keep them away from my kid anyway.

The other two reasons are more serious. Number two is that artificial intelligence has had a profound theoretical effect on thinking about thinking. In fact cognitive science as it grew up in the late 70s and 80s essentially was based on ideas derived from artificial intelligence. A whole

set of psychological ideas that originate from AI have had a very pervasive and powerful effect on contemporary psychology, and that includes educational psychology. So, if you recognize that, the fate of these ideas in AI should be pretty interesting to you. And if the AI people are now giving up those ideas you might find it worth examining whether they have some good reasons for giving them up; if they are being challenged very seriously in the place where they started we should consider whether they shouldn't be challenged in other places too - like their application to education.

But I think even more important perhaps is the third reason. The third reason is that the idea of an intelligent computer, the idea about artificial intelligence has become part of the popular culture. I think it affects the way everybody thinks. The idea of program for example has permeated into everybody's thinking and it influences people. As educators we must be aware of the cultural background against which we are talking. The old AI was centred on such ideas as program, and programming. These new ways of thinking in AI are centred on ideas like emergence, chaos, interactivity, self organization, and I think you would recognize that these are ideas that are very much in the air. Kids in school know about them, teachers know about them. If what you are going to say to kids is meaningful, if what they are going to see when they interact with computers or anything else in the classroom is meaningful to them, it must resonate with what they hear in the rest of their lives. I think that is the most powerful of the reasons.

The fourth reason is that I think these new waves in AI are related to new approaches to computation in general, thinking of computation not as one step after the other, but thinking of computation as parallel processes, as distributed process. This leads to very different ideas about what a computer can do, ideas that have scarcely, if at all penetrated yet into the school world where computer literacy and computer studies - even advanced computer studies - still means single process programs, whether it is Basic, or Logo or Pascal or Lisp for that matter. As long

as it is a single process from this point of view, it is all in the same basket and it all belongs to a stone age. So I think we ought to pay a lot of attention, if we are interested in what children would be learning about computers and what their experience and use of the computer is, to these trends in fundamental computing.

O.K. those are reasons. Of course I could do a series of lectures on each of them, so I can only give hints. I am going to try and give a few hints by taking some particular situations that provide images of the kind of concepts.

Let me say something about concept. I talked about program versus emergence. I think that one of the effects of the cognitive science of the 70s and 80s was a salutary effect to say that knowledge is not just in propositions. It is not just declarative knowledge, it is also procedural knowledge. The idea that procedural knowledge is also knowledge had a very good effect on thinking about education in the last decade. However, from the point of view of the new AI, declarative and procedural are all thrown together in the same bag. That is it is declarative and procedural versus - let me call it emergent, though the terminology hasn't really settled in. I'm going to give an example of emergence in a minute. I'd like to mention one other conceptual - there's a pun in that - distinction that is an important part of the contribution of cognitive science, which just said, "Don't just teach facts, teach concepts".

Now as with the distinction, declarative versus procedural, both sides are lumped together and seen as rather primitive by the new AI, so fact and concept are lumped together in the same way. The important point of the new AI trend is a profound critique of the concept of concept. That very concept of concept is rigidified. Let me give you an example of what I mean by that. My examples are insufficient, simplistic, but they might convey the idea.

Let's think of a situation that is actually being studied by one of our graduate students, Mitchel Resnick, in some detail and as an educational area, and that is the behaviour of social insects. Think of ants. You have all seen a line of ants between the nest and the place where the food is. Those ants are in a line. How did they get to be in that line? Simplistically the approach of classical AI to how could you make an ant that would line up in a line is this. We have first got to think of what is the representation of the concept of line, and somehow we have program the concept of line into the ant and we have to build some sort of goal/sub-goal system so the ant would say, measure how far away from a line it is or go through a loop that says that I'm in the line, I'm not in the line, if I am not in the line what can I do? It would be something like that. But in fact the ants do not have any concept of line. There is nothing in the ant's nervous system, however hard you look there, that in any way could be described as the concept of line. Line is not represented in that ant's program. It is emergent from something very different that's represented in the ant's program. The excitement of this branch of AI is how something emerges that was not put there. The critique of the previous round of AI is that what you see the machines do is what you program into them. Now, with these new ideas, you still program the machines but something else emerges. And we are trying to understand the concept of emergence.

The behaviour of ants emerges. Now how does it emerge? This is not fully understood but the kind of thinking goes something like this. The ants aren't thinking about lines at all. They aren't even thinking about the food. If you want to understand the behaviour of ants you have to understand first of all that there is a certain randomness, that they wander off at random. And by the way notice that randomness is in this context a powerful, useful thing, as opposed to the way it is usually taught as some sort of noise in the system. And that is a big conceptual change that we could bring to kids very profitably too. So the ants wander around and then there has to be some sort of recruitment process. It works something like this. When an ant is carrying food it is leaves a chemical trail. Other ants can smell this chemical trail and just tend to cluster, to go

around in the direction to where they smell this substance. And this is enough to produce the emergence of the line provided some things have to be right - the details aren't fully understood. But it is really an interesting project which children can do. For example Mitchel Resnick has made a Logo system that runs on a machine, called a connection machine that enables him to have 1,000 turtles. So with 1,000 turtles each one can be an ant, or a lot of them are ants and others are food particles. You give it this extremely simple program, extremely simple behaviour patterns, and from that emerges the lines to the food. So it is a kind of interesting process for children. It is as challenging as any other sort of program. It is much more varied and, much more than traditional programming, it leads to opening your eyes to things you might see around you in the real world, like nature. So that was my fourth reason, that that kind of programming, that kind of use of the computer should be part of children's technological fluency, what they should learn to do, to become familiar with, as part of getting a sense of what is most modern with computers. It is what is most modern with computers in a historic, correct way because it allows one to understand what is going on in the world in ways which we couldn't before with more narrowly restricted concepts of computation.

Not that the others were not very powerful. I am not going back on anything that I thought about that. Logo still is an extremely powerful way to understand a lot of phenomena. But there are still other phenomena, and many more interesting ones, which you can only get to with these more powerful computational concepts. And you can only get to those with the kind of more powerful computers which at last we are beginning to see in the real world of education. For example, on an Apple IIFX we managed to get about a 100 turtles, rather than 1,000 which works on the connection machine, running well enough to be able to demonstrate that kind of phenomenon. That was just out of the question in the days of the 128K memory barrier.

I will give you another example. The ants do not have the concept of line. You take another example which may seem far-fetched. This is in physics. A difference between Newton and Kepler is that Kepler thought of the concept of the ellipse. And he thought of the planets in terms of the ellipse and how much space is swept out; think of the Kepler law. Kepler was wrong in this sense. (And every scientist in wrong in many sense and right in many senses.) One of the senses in which Kepler is wrong is that planets do not have the concept of ellipse. What they do have is the concept of gravity, or the concept of gravitational force. And Newton's breakthrough was to understand that this concept of ellipse had to be seen not as something that is there in nature but as something that emerges from something else. Well one of the slogans of the new movements in AI is that really interesting things happen not on a conceptual level but on what they call a preconceptual level. It is what lies behind the concepts and makes them emerge that is interesting and important. The ant's smelling of the chemical is preconceptual to the concept of line and Newton is preconceptual to the concept of ellipse. Of course you might say that it is just a matter of finding the right concept; the difference between Newton and Kepler wasn't that Kepler was conceptual and Newton was preconceptual, but that Newton had the concept at the right level and Kepler didn't. But I think that misses an important point, because learning is the passage from Kepler to Newton. It is going behind the concept to see how it can be generated from something that is really not a process of combining concepts together by logic, but by a different kind of process of emergence. Although Newton was a singular and historic event, the new AI projects a kind of learning theory that would see similar things happening all the time in all learning, the connecting of many different things.

Well I am going to switch onto a different register and tell you a more personal story. People use the phrase "learning disability" as if there are some people who have learning disabilities and some people, lucky ones like all of us, don't. I think that is a wrong way of thinking. I think that everyone is mostly learning disabled. I just came back from Japan. It is so frustrating to

walk around the streets and not be able to read those signs and not be able to guess what they mean. If you were in Europe somewhere you might not understand them but you can spell it out. If only I could learn Japanese in a week. Well that's a learning disability. We all would like to learn much better. Well you say that doesn't count. That is just fantasy - nobody can learn Japanese in a week. Well I think we all have learning disabilities that are more down to earth. One of mine until recently was I couldn't remember the names of flowers. I think everybody has some pockets of things like that. Of course I knew a rose and a daffodil, though I never could get straight daffodil and narcissus and jonquil - all this was a vague confusion. From time to time I would go into a phase and buy a book so I could learn flower names. I would walk into florists and say what is that called, what's that called, what's that called? And for a while I would pick up a few names and then I would forget them. And it was exactly like kids always have. I mean kids are meant to have learning disabilities about number or spelling or reading. The disability about those things is called a learning disability and they send you to a psychologist to do to you what I tried to do to myself. It doesn't work. I really was trying to do to myself what I think shouldn't be done to people who have what are called "learning disabilities" in school. This shows how hard it is for any of us to break away from these ideas that so impregnate the culture we live in. Well, anyway it didn't work, until about 2 years ago I had an interesting event happen. The event was that I was with some people in Maine and everybody was saying how wonderful the lupins were this year. Lupins, lupins - I had heard the word often and I couldn't remember which flowers were lupins and I felt rather silly. So I tried to see how I could find out without exposing my silliness. Much better would have been to expose my silliness, but again it is hard to throw off these conditionings. So I tried to use a little bit if intelligence and said, "Why do you think they are called Lupins? It is such a funny name". Well it actually worked because somebody said, "Oh it must mean wolf. Lupin is wolf". "So it is like the wolf's tail," somebody said. Bushy tail, if you know what lupins are. They look sort of bushy flowers on big spikes. I won't ask you to indicate how many of you know what lupins are. Almost everybody

from New England knows what lupins are. So once they said it was like a wolf's tail I could identify it. In this situation, this situated knowledge, I could see from the flowers that were around only one looked like a wolf's tail, and that was a lupin. Now I knew what a lupin was for a while, but on my usual pattern I would have forgotten it the next week or certainly the next year. However, it connected with something else and it is this connection that I would like to emphasize. Well what it connected with was that I was so pleased and gloating with myself about my cleverness that at least I remembered it long enough when I got home to look up to see if this really was the origin of lupin. Now I happen to be interested in the etymology of words and I am particularly interested in certain paradoxes. I will mention one in a minute. I found out it does come from lupus, it does come from wolf, but it doesn't come from the tail, according to the etymologists anyway. It comes from wolf because people used to think that a lupin wolfed the nutrients in the soil, and that they were very bad plants because if you planted them they would wolf all the nutrients and they would impoverish the soil. Apparently this isn't true. Modern horticulturalists think, on the contrary, if you grow lupins and let them go through their natural cycle they are very good at enriching the soil. Anyway there is a connection with something which is exciting for me, this paradox, because the word's origin was based on a misconception and really the truth is the opposite of what it was. I happen to like that little kind of historical twist. And because of that lupin got stuck in my head permanently - can never get out. But not just lupin. I began to wonder about other flowers - maybe there were some others. I wasn't even thinking of learning about flowers but I found some other funny things, like anemone which you think comes from wind but it doesn't according to these books, it comes from namen which is a name for a ??? That story is also paradoxical.

So I got into a few flower names like this. And then something interesting happened. Once you make that kind of connection it is sort of as if a part of your brain starts becoming active. This becomes a sort of a hot area instead of a cold area, and you start finding connections all over the

place and it gets into a kind of critical mass. And once you get to a critical mass you start generating more and more things and it grows and makes connections with all sorts of stuff, so much so that in the last week when I was in Japan I went to the Botanical Garden in Kyoto, and I hunted around Japanese bookstores for books on flowers.

One other connection. Once I started thinking about the names of flowers and I started looking at them more, connecting with nature more and being more interested in the parts of flowers - there is a part of the flower called the anther. Anthos is Greek for flower. And then there are a whole lot of flower names that come from it, like dianthos. It doesn't mean two flowers, it means flower of the gods, because di also stands for god. What about anthology? Anth actually means flower. Anthology meant a bunch of flowers or a collection of flowers. An ancient analogy, way, way back, to a collection of flowers, it got to meaning a collection of poems, or stories, or anything else you might collect. What about logos? I happen to be very involved with the word logos, like biology and Logo. I have always thought of that word as in biology - the scientific study. Does anthology mean the study of flowers or poems? Not at all. Like Trilogy. Trilogy is not the study of three, it is collections of three things. That same stem, logos, means "collection" as well as "study of", and so now anthology has a different meaning for me. So something very important to me like Logo has a different sort of resonance.

What I am trying to say is that I think I am pretty cured of that particular learning disability. I find now that I know a lot of names of flowers. It has changed my relationship to people, to flowers, and way off beyond flowers. It cured my learning disability and I learnt a lot about the stuff as well, so walking through the streets I am more alive and my eyes are picking up more things. So that's a model of learning.

I would like to think about this from a number of points of view. First of all the serendipitous saga. We all know that good things happen serendipitously. Nevertheless, even though we know that, we try to do a different thing of directing the learning. When we go into schools we write computer programs. But surely we know that is nonsense. We need a different approach to a different kind of learning theory. It is not that I learnt a new concept, or new facts. It is that a different set of connections got established between things, and these connections get established by some sort of natural emergence process. Nobody could program this into me. And what has emerged in my mind is like the line of ants. We have got to look for the kind of situations that can facilitate this emergence.

Well what could facilitate it? I will tell you another story. Let me just say, before I tell you another story, what I think a good theory might look like. A good theory of learning wouldn't be a set of propositions but maybe it would be a collection of stories, of learning stories, stories about how learning happens. And teachers and pupils should exchange such stories, and children should discuss them, and maybe this leads to a whole different approach to how to theorise learning and how to propagate the theory of learning to facilitate it.

My next story is about a 3-year-old who knew I grew up in Africa. And this child said, "Did you ever see a giraffe?" and I said, "Yes." "Not in the zoo?" I have seen a giraffe in nature. Well, she said, she had been wondering, "How does a giraffe sleep?" Her problem was that it has such a long neck, and, she explained, when she sleeps she likes to cuddle her head and she noticed that her puppy-dog does as well. What about the giraffe whose head is such a long way up? And where does it put it anyway? And what does it use for a pillow? A couple of other kids had gathered around, and we had a very good discussion about this, which I have continued with some other kids. I've found kids pick up the story - they don't think it is nonsense or who cares? and I have collected quite a number of nice little theories, like the giraffe finds a tree with a fork and

keeps its head in that. Now mostly children can't do much about this. They can fantasize and think, that is good. But there is a big difference between the relationship that children develop with a piece of knowledge like a question like giraffes sleeping and say, any knowledge about physical ??? Everything they find they play with, they put in their mouths, they bite, they eat, they touch, whatever. If it is in range, children develop an exploratory and intimate relationship with it. But when it is out of range their only way is through asking an adult maybe. And very seldom does the adult either have the time to pay attention or have enough sympathy - who knows - you can't really find things out by asking people anyway. You get a lead but you need to explore and touch. So what could the child do? What I could do with the giraffe business is this. I could go home. I'm lucky, I can read and I've got a lot of books at home. I've got telephones and I can call people. There are a network of people I know so I could follow up on this how do giraffes sleep business. My encyclopedia had a very interesting article on the giraffe and - I learnt this during the middle eastern crisis so that it is significant to me - it is an arabic word, and once you hear that it has that sort of resonance. The most amazing thing for me and the giraffe was that with its long neck it has the same number of cervical vertebrae (bones in the neck) as I have with my tiny little neck. That seemed like an amazing fact which I will never forget, and which has enriched my understanding of the skeleton and so on. I found out all sorts of stuff about giraffes. I did not find out by reading how a giraffe sleeps. To do that we had to go through a more circuitous route. In fact it was found out by the secretary in our group, who spontaneously picked this up when she heard us talking about it and found somebody at a zoo who could tell her. It sleeps standing up and it is related to its big bones. These big bones are so solid that they can lock together and hold the giraffe's neck up there. O.K.

Now what I would like to say, the point about this giraffe story, is it just like the flower story. It is more concrete in a certain way. It leads to a certain image of how one might think of new technologies coming into the lives of children and radically changing their relationship to

knowledge. Because that three-year-old child can't in any way do what I did - now. But in the year 3,000 or I don't know which year, sometime in the future, that child is surely going to be able to access an information system and - I don't know how it'll work - speak to it, poke on screens, gestures, walk into an artificial, a virtual reality - I don't know what it will do then, I don't try and guess the details of the future. The point is that that child will be able to explore a question like how does a giraffe sleep. And wander around, not just to get an answer but in the course of looking for the answer, like I did, establish these connections, activate areas of knowledge, areas of the brain, make connections. And it is this making of connections that creates this new AI kind of theory that is the essence of learning and certainly is an important part of learning and something that one day would be radically changed. Let us think through what the consequences might be. Imagine this child who from the beginning of life has been living and searching in information worlds. C age seven, send her to first grade school. Come on, you have got to be kidding! You can't imagine that kid being sent into anything that would look even slightly like what you see in first grade schools anywhere in the world today. The kid is used to something infinitely more sophisticated, more self controlled, more active, more associational in all sorts of ways.

I think that the value of speculating, of imagining such scenarios I think is to stir up in our heads questions about how we think about education. Do we think of education in the future as like it is today but a little bit better. A little bit improved? Shall we improve the second grade or first grade curriculum? Or are we imagining a world that is going to be radically different? I think we have to spend some time on that second sort of activity.

Now don't get me wrong. I am not saying we should run off and write a proposal to the National Science Foundation to make a program that has a knowledge base about giraffes. That is exactly not the point. It is an accident - that child thought of a giraffe and I thought of a lupin as

the starting points of an important learning process. In order for the child to have this different experience, whatever the child thinks of, whether it is a giraffe, or flower or bee or a dragon, what ever it is, there has to be some chance of not finding the answer to the question. That is neither necessary nor even desirable. We don't want the children to find answers to questions that could lead to little mindedness. We want them to do the exploration and surely they would do. But it has got to be a rich, huge information base, and such a thing cannot be made by anybody overnight even if we had the technology, or even a decade. It is something that has to grow as part of a cultural social cross. Many, many people will contribute to it in the same way as many, many people contributed to the existence of the book, or the cinema, or painting. It wasn't Caxton or Gutenberg who made the book, the printed book. People who made the technology for printing it seeded the process and it took Shakespeare, and Jane Austen, and this whole social evolution of these art forms and cultural forms. So this is the way we have to see the evolution I think, through these new technologies, of a radically different learning environment. These are not better ways of doing the old thing but something sort of fundamentally different.

Well, that has gotten a little bit away from AI, or has it? Let's go back to these theoretical questions of what kind of, what is your image of learning? If you think of learning as acquiring a definite set of facts, or for that matter, a definite set of contacts, or any definite set of anything, it leads you to think, well, just step by step we will add them in and it adds to one image. The idea of shaking that up is, I think, most important in the modern, current AI. As a matter of fact I think the current AI ideas are not very much more powerful than the old AI and I predict that in five years time we will see another pendulum swing in the opposite direction. But I think that what is very valuable is not that you can pick up the technical detail, but inherent in it is a critique of certain ways of thinking. But what is being critique is the very concept of concept. Aren't I contradicting myself by using the word concept to describe it? Well yes, I am. And that is the way that knowledge grows by. We can only think in terms of the ways of thinking that we

possess. And we can play with the contradictions and the place where they break down and you can make those contradictions something wonderful.

And so what I am about to end on is what attitude.....end of tape!

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The following meaning she wanted to use the word to deutero second learning.... to draw attention to the fact, as he said it, whenever you learn something you learn two things. You learn something about geography or math or whatever it is and you learn something about learning. But the learning experience is always a model for other learning experiences, and for the next learning experience you are going to have. So in the spirit of deuterolearning I think of children in school and I think of what model of learning we are giving these children. What is the deutero learning that is happening there? Are we encouraging them to think by making connections, as happened to me with the flower, or explorations as might happen to this child with the giraffe? Or are we encouraging them to - well we have given up memorising facts but still - grasp this concept and then move onto the next concept. Get it right. Be consistent. Be logical. Or are all these concepts of concepts of logical, of consistent, etc., are these things really restrictions? Do they cramp the spirit of the working of the mind? Do they impede learning? Well I think we need an epistemology that can deal with that, and I do think there is a fundamental dilemma. I would like to leave you with this dilemma and ask you to take it very seriously.

You know Piaget taught some wonderful stories about - like the giraffe, how the giraffe sleeps and one of my favourites from Piaget is what makes the wind? Well we know what makes the wind. It is the rotation of the earth and it is the movement of air masses, etc. etc. But that is not what children think. Maybe a child might say that the trees makes the wind. Clouds makes the wind. God makes the wind. These are all kinds of answers. So whenever we hear that we sort

of purr with delight. Isn't it nice? I mean your child says the tree makes the.. and you enter into conversation. And the child says, well look I can make a little bit of wind like this, and if my hands were as big as the branch of the tree think how much wind I could make, and if there were a 1,000 of them think how much that would make, and that's how the big gale comes. And if all this goes on in the child's mind that child is making a wonderful theory. And when we listen to that child talking, we are excited, we are pleased and we purr with delight.

But if we are a teacher we find ourselves in a dilemma because isn't it our job to tell the child the truth. Shouldn't we tell the child how the wind really gets made? But if you do that are you going to be saying to the child, nice work Johnny, that's a wonderful theory but it is all wrong. And if you keep on doing that how long is it going to take before the child stops making up theories? And is that why when we get to be adults we occasionally have the wonderful experience of making a theory while children do it every day? Maybe we could go back and be children again if there was a different setting.

Well there is this dilemma. And how do we balance this dilemma? How do we show the child an approach to respect the theories made by others while we are respectful of the child's theory? And I think this is the real dilemma that faces education. It requires us to have a very different epistemology. You can't say logic is nonsense - throw it out you don't have to be logical. But we don't want logic to be a shackle that locks us down and prevents us from making the illogical association of connections. Yes we want logic, but logic should be on tap, not on top. It is a useful thing to be there when you need it, but it should not be allowed to dominate our thinking. And what applies to logic applies to conceptual thinking, conceptual structures and the kind of theories that have historically gotten established in science. But that is something you do on the right occasion, when it is useful. And on the other occasions you can do this other thing, which ought to be valued more. And I think that with our technologies, we can give children the

opportunities to to explore, and navigate through these vast areas of knowledge, to make microworlds, which we have always done with Logo. A while ago I was revealing some videotapes of children in Boston working with Lego Logo and there were three children who had decided that they wanted to make a snake out of Lego, and programmed this too. What a job! By a snake they really meant a sort of fantasy dragon. Here were children who did a remarkable thing. They brought together connection. Usually in schools science and technical things are very literal minded. There is very little room for fantasy. Fantasy is for creative writing class, poetry class. These children were expressing a fantasy through this technology and wanted to make the science. They were making connections. They were exploring, they were learning all sorts of stuff about gears, about ratios, about programming, through making this snake. I think this kind of connection is to be made. We need to break down those barriers that sees science and technology as related to truth and literal mindedness. It has got to be tight fantasy so that the mind can roam and make connections. I guess that is a simple enough idea that any poet didn't need modern AI to know that it was true. But I think probably modern AI is giving us permission, and maybe giving us a more precise way of thinking what poets have always known...and I guess that is time to stop.