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# THINKING ABOUT LEARNING ABOUT THINKING: AN INTERVIEW WITH SEYMOUR PAPERT

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Seymour Papert began his career as a mathematician and subsequently became interested in theories of cognition. Shortly after receiving his Ph.D. in mathematics from Cambridge University, Professor Papert went to Geneva where, for five years, he worked with Jean Piaget studying cognitive development. Following this, he went to the Artificial Intelligence Laboratory at MIT, where he worked with Marvin Minsky on theories of machine intelligence. There, Professor Papert started the Logo Children's Learning Laboratory and became noted for his work on using computers to help children learn about mathematics and about the nature of their own thinking processes. His influential book, *Mindstorms: Children, Computers and Powerful Ideas,* articulates his views on the role that computers should play in the learning process.

What struck me when I first interacted with Seymour Papert was his sophisticated and interesting interpretation of Piagetian theory. His deep understanding of Piagetian theory, combined with his research in artificial intelligence, gives him a unique perspective on the nature of cognition and its development. Further, his work on utilizing the Logo computer language to teach children "powerful ideas" reflects his stimulating views on what is important for children to learn and on what types of environments facilitate this kind of learning.

It is these thoughts concerning "powerful ideas", how they could be acquired, and how they relate to Piagetian theory, that I wanted to draw out in this interview. In particular, the class of "powerful ideas" that I attempted to focus upon are what others might term "general reasoning skills". Papert has often argued that exposing children to carefully constructed computational environments would develop skills, such as decomposing problems into subproblems, that would be useful across a variety of domains. This is a controversial claim and my intent was to get him to articulate his views on this subject.

**BW:** I have a general outline in mind for the interview. We could start with the issue of whether or not there are such things as *general reasoning skills* and go on to a discussion of how the concept of a general reasoning skill relates to Piagetian theory. Then, given that you believe there are such skills, we could discuss what kinds of learning environments might foster their acquisition and how one could assess whether children are acquiring those skills.

To start out, do you believe that there are general reasoning skills that children can acquire and apply across a variety of domains?

*The interviewer would like to thank John Frederiksen for his help in editing this material.

**SP:** Well, I think the discussion of that sort of question is often distorted by the assumption that everybody reasons in the same way. When people ask, "Are there general reasoning skills?" they are usually asking about differences between reasoning in, say, mathematics and politics. Does one use the same reasoning in both of these domains? I think a much more important question is whether, when *you* do mathematics and *I* do mathematics, and when *you* do politics and *I* do politics, do we both go about it in the same way. Probably we don't. A lot of the work I have been doing in the last couple of years has been focused on finding whether there are deep differences in the way that different children go about working with Logo, both in programming and in thinking about the content of what they are programming.

**BW:** Well, I could ask my question in the context of a single individual: Can a person acquire general reasoning skills that will help him or her in a variety of different situations? Then, perhaps, we could move on to ask the second question: Do people share the same general reasoning skills?

**SP:** Ultimately, I say, "Yes, I think there are reasoning skills that are used across domains". And you say, "Well, what are they?" expecting to hear about skills that apply to everybody. However, I may not be able to give you those, because that may not be the way it works. For instance, the reasoning skills I use could be very specific to me. My learning experiences in any domain can make a difference in how I think and learn in a very unrelated domain. For example, it may be that something I met in a particular domain struck me so forcibly that I have come to use it as a model and have learnt to apply it in many other domains. So, for me, it has become general, although it is not general in itself.

**BW:** So, does this mean that you are rejecting the notion that there are some general, key ideas that all people can acquire and apply in a large number of situations, and that probably it is a good idea to teach people these key ideas?

**SP:** No, it doesn't. I think that this is also true. I think there are some powerful ideas that are widely applicable. For instance, the idea of a *counterexample* is a powerful idea. You can use it in many places. Everybody uses it to some extent or another. If you didn't have that idea, you would be somewhat worse off in almost any domain. So it is obvious that there are some ideas that can be used in many different domains.

**BW:** Would you contrast your viewpoint with the Piagetian viewpoint that there are certain, what you might call, powerful reasoning capabilities that children acquire at specific stages in their lives, and that all children acquire these capabilities in virtually the same order?

**SP:** I think, first of all, that Piaget focused on the part of intelligence which is most universal because that is what he was most interested in. So, again, one must not neglect the fact that there are some elements of intellectual functioning that are not very universal, The question is whether universal skills account for a large part of the reasoning process. Undoubtedly, there are some very widely applicable skills, but it still may be that a large part of the process has to be carried by something else. So, you can't create an artificial intelligence or create a new approach to education by only focusing on what is universal and relegating the rest to specific knowledge or information.

**BW:** Could you elaborate on your interpretation of Piaget's theory?

**SP:** Piaget focused on what is most universal. He chose the sort of ideas that appear in many domains, like the idea of conservation. I don't see how there can be any question that conservation is a phenomenon that crops up in many different domains. It is very important in the development of intelligence. You might question whether all the different conservations are related to one another developmentally, or does it just so happen that we develop conservation of number and conservation of quantity independently? That just doesn't seem plausible, although I don't think there is really any solid proof that they really build on one another.

**BW:** What about stage theory — the claim that these ideas are developed in a definite order?

**SP:** Well, I don't believe that. There is no doubt that there is a fair amount of evidence in Piaget's work suggesting that they come about in pretty much the same order. The question is, could that order be changed? Personally, I think it can, by making radical changes in the early environments of children. We have been trying to collect evidence for this by looking at children in environments with a high density of computers. We see isolated examples, but I don't think there is solid evidence yet that we can change the order.

**BW:** Why do you think that working with computers will introduce such fundamental changes into a child's environment that it will cause a change in the developmental sequence?

**SP:** Well, because I think that if you look at the particular behaviors that Piaget sees happening at the formal stage, they often have a lot in common with what you can concretize with a computer as opposed to what you can concretize with more static representations. In fact, almost all of them involve being able to generate systematically the set of all elements that satisfy a set of conditions. This is not something that you can easily do with pencil and paper. You can do it with materials like different colored blocks but there is no particular pay-off for being able to generate all the combinations of colors of a set of blocks or colored beads. It might be funny but it is not an activity that motivates itself in a natural way. With a computer, the activity of having a process run through all the states as one or more variables get changed is a very natural process.

**BW:** Yes, and it certainly is something that you need to do often when creating computer programs.

**SP:** Right, it can be motivated by all sorts of activities. For example, when children are writing graphics programs, they do it to explore all of the patterns you can get out of a particular program with different values for the variables. That is exciting! They are surprised a little bit. They are looking for something

— for instance, they are hoping to find a cute pattern. So, there is a concrete opportunity and a high degree of motivation for doing one of Piaget's formal operations in an environment where even very young children can do it, in principle.

**BW:** Would this mean that these children would have acquired formal operational thinking?

**SP:** There are two possible things that it can mean. It can mean that these permutations and combinations have now been concretized, and they are no longer formal operations, so that children at the early concrete stage might now be able to pass the test that Piaget used to define the formal operational stage. You can take that as meaning that these children are using formal operations at a very early age, or you can take it as meaning that what used to be a test for formal operations no longer is: what used to be a formal operation is now a concrete operation. But, in either case, the order of things that Piaget saw has been changed. I am inclined at the moment to say, on the basis of the children we are seeing, that the formal becomes concretized. I think that the mistake in much of Piaget's discussion of the question is to identify the particular behavior with the stage. I think there is such a thing as "formal", which could define such a thing as formal thinking. But you can't define it as Piaget did, in terms of a particular operation.

**BW:** How would you define formal thinking, then?

**SP:** I think that it is a way of thinking where you step outside the use of any specific and concrete situations that you know, you step outside the familiar scheme. Now, to do that requires a different kind of reasoning from what you need in order to operate within the specific and concrete. At what age do we do this? Maybe we do it when we run into problems in a situation where we don't have any concrete means of handling it. We can't relate the situation sufficiently closely to some familiar scheme, and we have to do this other thing of dealing with it in an abstract or formal way.

**BW:** Do you think that if children have a lot of experience with a computer language like Logo, it will facilitate that kind of abstract thinking, or will it just make different kinds of things concrete?

**SP:** I think that working with Logo does facilitate abstract thinking because it throws children into many situations where they are taken by surprise, where they can't understand what is happening, and where they can get out of the situation by thinking about it in an abstract way.

**BW:** Don't you think that getting children to deal with interpersonal relationships could accomplish the goal of creating surprise more effectively? When I try to think of the domain where I am surprised most frequently, it is in dealing with people as opposed to domains like computers or mathematics. One reason I like entities such as computers or mathematics is that they are very predictable and I have control over them. They don't do things that I don't expect them to do. At least if they do, I can explain it: I can find the bug. Whereas, with people that is just not true. There are people whom I have known for many years whose behavior I still cannot accurately predict.

**SP:** First of all, to have the kind of effect that I was talking about, you have got to be able to dominate that surprise. If the surprise is so surprising that you can't do anything about it, it might be wonderful to enjoy that feeling of being surprised, but it is not going to help your understanding. I was thinking of situations where there is surprise that you can bring back under control. In order to bring the situation back under control, you need a great variety of different means, often means that you haven't encountered before.

Now, on the other point, that it is in personal relations that this happens more, I think that is a serious point. I think that a lot of the best thinking develops through interpersonal relations and through the kinds of problems and complications that arise in real personal and interpersonal life. So, I don't see these as opposed to one another. But if we are talking about a child of eight, nine, or ten, the opportunities for effective action in the interpersonal domain are pretty restricted. You need greater skill than they have to try things. I do think, more and more, that interpersonal relations, thinking about people, plays a key part in everybody's intellectual development.

**BW:** In fact, one could argue that one of the most dramatic recent changes in society that is affecting children's lives is the complexity of interpersonal relationships that they are exposed to via television and the movies. Further, one could even argue that being exposed to soap operas makes more of a difference in children's lives than being exposed to computers.

**SP:** That may be true, but it is difficult to test any ideas that you have about these messy and complicated situations that are on television. So, an important element is missing: the element of being able to confront the consequences of acting on your understanding of the situation. Computers allow children, in domains where they can act with the computer, to see what happens. They might or might not want to confront the situation, but if they choose to, they can.

**BW:** This gets us nicely into the question of what kinds of computer environments are best for producing the kinds of experiences that you describe. For example, what I try to do in my research is to create a sequence of constrained situations designed to help students to notice that they have misconceptions and provide them with tools for helping them to revise their understanding of the situation. This is in contrast with the more open ended environments that you have been working with such as letting children do their own projects using Logo. Given that computers facilitate the development of new kinds of interactive learning environments, what kinds of computer environments are best?

**SP:** From this point of view, there are two important characteristics of computer learning environments. One is that you really care about the domain you are working in, because it is only when you really care that you really learn much from it. Second, it must be an environment in which you can act and follow through the consequences of your actions. Now, these characteristics allow the environments to be very wide open or very constrained. From this point of view, there isn't an advantage of one over the other. From other points of view, the open versus constrained is a bigger issue. For example, in developing a sense of personal control over the world, a sense of entrepreneurship, a sense of being able to imagine a project and carry it through, you need an environment with sufficient space for a child to invent something and feel that it is a personal thing. For that, you need a very open environment. For some other situations, like some you have been interested in, where you were looking at the development of particular concepts in physics, a narrower environment is obviously geared to that more quickly.

**BW:** So you are saying that the more open ended environments have certain advantages, mainly that there is more space for the child to pursue different activities, whereas the narrower environments have the advantage of helping the child to learn certain things more quickly.

**SP:** Right. It's not that we have to choose one or the other. A lot of the discussion about computers and education is dominated by a false sense of the need to make choices. We only need to make choices because we have been in such a primitive situation, with hardly any computers and hardly any people making software. So, you can't have everything. You have to choose and take sides about what to choose.

Some of the choices are real, however. For example, I think the question of drill and practice computer assisted instruction versus intelligent computer assisted instruction represents a real choice. Again, I suppose that if there is a need to work on some specific small issue, where the child or grown-up needs a very specific type of remedial instruction (we all need remedial instruction at some point), then you might need an environment which allows you to learn certain things quickly. But, on the whole, I think that sort of learning environment is very dangerous. It doesn't encourage a sense of independence, of taking charge of the learning process.

**BW:** On the other hand, the argument is that if you just leave children in totally open-ended environments, there are a lot of things that are important for them to learn that they will never learn. What you might really want to do is put them in more structured environments, where nevertheless they are still solving problems.

**SP:** I didn't say there should only be open ended environments, I think there is room for a mixture of different degrees of openness. The particular kind of structuring inherent in most computer aided instruction is, I think, a bad kind of structuring. It imposes a particular view that learning consists of being taught. You are led through a sequence of experiences by someone else. And you see very clearly when working with elementary school children, and even some graduate students, that you continually have to fight against this effect from the standard school system. This is unfortunately the way children have come to think of learning.