The unschooled mind: why even the best students in the best schools do not understand

Howard Gardner

I am very honoured to have been invited to give the Peterson lecture to gathered representatives of the IB Organization. I must confess that I did not even know about the IB until a year or two ago. It was my loss and my ignorance but everything that I have learned about it has intrigued me, and I think you have a convert on your hands. (Addendum in 2003: By now I know a fair amount about IB, have studied the theory of knowledge course, and am an unabashed fan.)

I am a developmental psychologist and Geneva is in fact a special place for me. Twenty-five years ago I married a developmental psychologist and we decided to launch our honeymoon by coming to Geneva. We met and shook the hand of Piaget. At the time I knew that I would study cognitive development but of course could not anticipate what I would have to say about developmental psychology in the future. I have had a very lively career over the last 25 years during which I challenged Piaget on several issues because I felt he was very central to my work and I admired him. My three arguments with him were as follows.

First of all, Piaget believed that if you studied children you had to know what they were going to become—what the end state of development is. Piaget thought it was to be a scientist; that is what Piaget was. However, in my own training I had spent a lot of time working in the arts. I felt that there was something wrong with a theory that only talked about the mind of the scientist as being the end-all of a child's development. So I began to explore what development would be like if one thought of participation in the arts as an artist, or a critic, or a performer or a connoisseur as being a viable end state for human development. This is not to say that human beings should develop to become artists any more than they should develop to become scientists but rather that we can develop many different kinds of human beings.

The second argument I had with Piaget, and the one that I became infamous for, was against the notion that there was a single thing called intelligence, which could be measured by an intelligence test. It is not widely known that Piaget studied in Alfred Binet's laboratory. Binet was dead but the laboratory was still there under the direction of a psychologist named Théodore Simon who had worked with Binet. Piaget became interested in children's minds because of the mistakes the children made on the intelligence tests. Binet was a great scientist, credited with the creation of the IQ test. I do not blame him for any of the abuse done in the name of intelligence and intelligence testing. Binet's ideas affected an American named Lewis Terman who in 1916 created the first normed standardized intelligence tests. Forever afterwards psychologists assumed that they could establish how smart somebody was, and in fact what intelligence is, by giving a test that took an hour or so.

This article is based on a transcript of the Peterson Lecture that Howard Gardner presented informally in Geneva on 1 December 1992. It was lightly edited in 2003 in the interests of clarity, but has not otherwise been updated. For Howard Gardner's more recent thoughts on these topics, see *The Disciplined Mind*: New York, Penguin, 2000.

In fact, some people now give the QT (the quick test) that takes just four or five minutes. Why spend an hour if you can test intelligence in four or five minutes? Those of you who are from the United Kingdom will doubtless recognize Hans J Eysenck, the world's most famous psychologist [shows a picture of Hans Eysenck wearing the "IQ helmet": a multi-channel brain function monitoring system]. He used to be a great defender of intelligence tests until this "hair dryer" [picture] came along with 18 electrodes attached to it. Mr Eysenck and his friends now believe [Hans Eysenck has since died (4 September 1997)] that if you simply put this "beanie" [hat] on a person's head and look at the brain waves for a few seconds, you can tell how smart that person is. Well, I think that the mind and the brain are much more complicated than that and thanks to a project in which I became involved over 10 years ago, and where I had the pleasure of meeting Leo Fernig [of UNESCO], I developed a quite distinctive way of thinking about intelligence.

The way that I define intelligence is the ability to solve a problem, or to make something, to fashion a product that is valued in at least one culture or community. That may not seem like an exotic definition to those of you who are not psychologists, but in fact it is not consistent with what most psychologists believe. Psychologists think solving problems is important, but they shy away from any concern in making something, writing essays, staging plays, designing buildings, because you can not assess that in four or five minutes, or with a beanie. Moreover psychologists get very upset when you talk about an ability being valued in a culture; that is because it suggests that, unless a culture provides certain opportunities, a person might not seem to be smart. What should be disturbing to everybody in this room is that most psychologists believe that intelligence is completely in the brain…and if you know exactly where to stick the thermometer with a dipstick you can figure out how smart that person is.

My view of intelligence, which I'm not going to expand on today, says intelligence is always interaction between potentials and what is available in a culture. For example, Bobby Fischer is one of the greatest chess players in the history of the world. But if Bobby Fischer had been born in a culture where there was no chess, he would just be a *schlemiel* [idiot] because he had a brain that was perfectly matched to something in his culture, namely chess, but mismatched to just about everything else.

Anyway, doing a fairly elaborate analysis that is described in a book called *Frames of mind*, I eventually argued that there are seven different kinds of intelligence. I am not going to run through them because that would be another lecture. It is worth pointing out, however, that Piaget thought he was studying all of intelligence. But I believe he was studying logical, mathematical intelligence (later in his life, I think he came to the same conclusion about the focus of his own work) whereas I talk about intelligence that artists have as well as those that are in the human sphere—something that I think is a great concern to you as you begin to deal with global issues, moral issues, issues of value and the like.

My third argument with Piaget—the deepest one and the one I want to talk about today—had to do with the most interesting claim that he made. If you remember anything from your studies of Piaget, you will remember that he maintained that children pass through stages of cognitive development. So infants know the world in one way, five-year-olds in another way, ten-year-olds in another way, and fifteen-year-olds in still another way. Part of this developmental sequence is that when you go from nine to eleven or from thirteen to sixteen years not only do you see the world in a very different way, you can't even remember how you used to see the world.

So at age seven you don't believe that you ever thought that if a ball of clay was squished, there was less clay there; or that if water were poured into a different kind of vessel, there will be more or less water depending on the shape of the vessel. Yet every four-year-old in the world believes that. Anyway I am not going to argue that Piaget's demonstrations were wrong because many of them were more correct than wrong. Where Piaget was wrong, I believe, was in his argument that when people get older they see the world in a different way and they no longer have access to earlier ways of knowing. In fact, I am going to argue that most of us, except in areas where we are expert, continue to think the way we did when we were five years of age. We continue to think the way we did before we went to school. That is a pretty radical thesis, and I decided I was not going to pre-judge the IB schools. Maybe you are exceptional in that you have succeeded in extinguishing the less productive aspects of the five-year-old mind. I hope we will have time to discuss that after my talk.

So, my talk is on the subject of education for understanding. If I asked you: What *is* understanding and *how* can we determine whether understanding has been achieved? That is a much more difficult question.

I am going to define understanding as the capacity (knowledge, skills, concepts, facts) learned in one context, usually the school context, and used in a new context in a place where you haven't been forewarned that you should make use of that knowledge. That is what understanding is. If you were only asked to use knowledge in the same situation in which it was introduced, you might understand, but you might not; we can't tell. But if something new happens out in the street or in the sky or in the newspaper, and you can draw on your earlier knowings, then you understand.

In my book, *The Unschooled Mind*, I have a section on the 1991 Gulf War that provided brilliant examples in America of not understanding at the highest levels. In history, in political science, in economics and in physics, there were rampant examples of misunderstanding. I will not go into that now. Instead, I'm going to introduce my *problématique* with three quite common-sense examples.

Example 1. In the first five years of life children all over the world, with very little formal tutelage, learn to speak, to understand, to tell stories, to tell jokes, to draw, to sing, to invent new tunes, to engage in pretend play—all the things that Piaget and other psychologists demonstrated. Even though nobody knows how to teach these things, kids learn them all. Then they go to school and suddenly, in the very place where we are supposed to know how to teach them, it is very hard and many of them do not do well. That is a paradox. That is an enigma.

Example 2. Students at the very best universities in the United States (places like MIT and Johns Hopkins), with very high grades in physics, leave their class and are given a problem to solve on the street, or a game to play, that involves various physical principles. Not only do they fail to use what they learned in school but they actually answer in the same way that five-year-olds do, or for that matter in the way pre-Aristotelians and Aristotelians did.

Let me use another example. Ask almost anybody what happens, what forces obtain when you flip a coin. Most people will come up with the following answer (even people who have taken physics courses): you have a certain amount of force in your hand and you transfer that force to the coin; for a while that force makes the coin go up and then, when the force kind of gets spent, the coin is tired and kind of flips to the ground. (Now, I'm not a physicist so I believe that account, more or less). However, physics friends tell me that the second you release the coin, the only force that obtains on the coin is gravity; that is the only force that is working.

However, that goes against a very powerful theory that you develop when you are young. And it is not that theory that is abandoned, it is Newton's and Galileo's laws of motion that prove very difficult to master.

Example 3. This is a personal one. I have a daughter, a very nice girl and a very good student. She graduated Phi Beta Kappa from a very good American college. She called me up when she was a sophomore in college, crying on the telephone. I said: "Why are you crying?" She said, "It's my physics; I don't understand it." I said: "Well, you know (and I was telling the truth) I really respect you for taking physics because it's difficult and I wouldn't have taken it in college." And I didn't take it in college. I then lied to her and said: "I don't even care what grade you get, but it's really important that you understand your physics." So I said: "Go to your instructor and have him or her explain to you what it is you don't understand." And she said: "Dad, you don't get it! I've never understood."

This had a profound impact on me. My daughter was not saying that she was a faker or a "poseur". What she was saying is what I think most of us experience: we know the moves to make in school, to get good grades and even to be successful, but we know that if people put the questions to us in another way, if they push to see how much we have really understood, the whole house of cards might fall. That is what she was saying.

At least in the United States, there are great obstacles to understanding.

- **Short-answer assessments** or what I call a "text test context". You read a textbook. The test is based on the textbook and the textbook tells you the answers you have to give.
- **The correct answer compromise** is an "entente" between the teacher and the student. If you respond this way, nobody should ask any further question. No one is made uncomfortable, but deeper understanding is avoided.
- **The pressure for coverage**: there are 37 chapters in the book and you must get through all 37 chapters.

So, we have three vignettes. The young child learns so easily; the school child has difficulty. The students who get "A"s at the best universities in the world are still Aristotelians in their models of the physical world. And then, of course, the most powerful evidence of my daughter. What is going on here? This is the answer: I call it cognitive Freudianism.

Freud convinced people that, as adults, we continue to have the same personality traits as when we were children. We fight the same battles we fought with our parents and our siblings. Most people who live in a modern western society believe this. (If you don't believe it and you pay me US$100 an hour, I will convince you that it is true.) That is what psychoanalysis is all about. I'm making the claim that Freud was correct in an area that he wasn't expert in, but that Piaget was. Namely, except in areas where we are experts, most of us continue to think the way we did when we were five years of age.

An expert is a person who comes to understand the world differently. But that is very, very difficult to do and I'm going to argue today that it's not done very often. This is the thesis of the talk.

Later on, I am going to give you evidence that no matter where you look in the curriculum, you will find students who do not understand: physics, mathematics, biology, literature, art. It is ubiquitous. Then when I get two thirds into the talk, I will tell you that there are things we can do about it. It's not hopeless. It is possible to educate for understanding.

But now, I will do something that is going to take about ten minutes. When I met Patricia Davidson [chair of the IBO Examining Board] in the airport in Zurich, I said to her: "is this lecture ceremonial or should I deal with real content?" She said: "Make them work hard, make the interpreters work hard and make the audience work hard." So what I'm going to do now is give you a fairly technical description of why it is so difficult to go beyond the five-year-old mind.

My analysis has three focuses that I have introduced to you already. There is the young natural learner: that 3-, 4- or 5-year-old who speaks so much about the world without formal tutelage. There is a student in most schools who basically masters what school requires so he or she can get to the next level. But I will argue that he doesn't really understand. Then there is the individual we want: the person who can use knowledge in new situations. That is my definition of an expert.

There is a form of knowing (theory of knowledge) that goes with each of these three focuses. The expert is a person who can use the skills that are valued in his or her culture in context. So when a historical example comes up, he can draw on history; when a physical example comes up he can draw from physics, and so on. That is what we want; that is why we go to school. If people are not going to be able to use the knowledge we may as well close schools down. Scholastic knowledge is what we are very good at doing in school; but unless that scholastic knowledge can be activated in new circumstances it remains inert and essentially useless.

We teach people notations, squiggles on a paper like some of you are doing, formal concepts—what is gravity, what is density, what is force. People who have no sense of what it is like in the world can give you a formula and a definition if that's what is called for in class. Then, if you are lucky and you attend an IB school, you get epistemic forms. Epistemic forms relates to how the people think in the different disciplines because to think like a historian is not the same as to think like a literary critic or a biologist. (This, I have subsequently learned, is the focus of the IB theory of knowledge course.)

So that is what school is supposed to do. But in the first years of life a natural learner benefits from what Piaget so brilliantly described: sensory motor knowledge, learning about the world, using your hands and your eyes, exploring the world of objects, the world of liquids poured from one container to another and what I call first-order symbolic competence. People use words, pictures and gestures, to communicate meanings. That is what every five-year-old can do.

That is the good part. However, five-year-olds do one thing that is troublesome: they form intuitive conceptions or theories—theory of matter, theories of mind, theories of life. Every normal five-year-old develops these theories. And it is very good for getting along in the world. However, the theories are wrong. School is supposed to replace the erroneous theories with better theories.

So what is a theory of matter? A theory of matter is: if I have a heavy object in this hand, a light object in this hand and I release them at the same time, the heavier one will fall more quickly. That is what you learn intuitively. Heavy things fall more quickly. However, Galileo went to the tower of Pisa, dropped two objects, and since then we understand that that is not in fact what happens. We understand that the laws of acceleration are independent of weight. But as children we develop a very powerful theory of matter and that is very hard to shake.

Here is a theory of life: every five-year-old believes that if it is moving, it is alive; if it is not moving, it is dead. This is a very useful theory. However sleeping dogs, and computers are a real problem. Are computers that display moving images alive or dead? It is very hard to say.

A theory of mind is very relevant to what I have heard talked about with my new acquaintances here in the world of the IB. I've got a mind; you've got a mind. If we look the same our minds are the same. If we look differently, our minds are different. If you look like me, you've got a good mind; if you look differently, you've got a bad mind. This is a very powerful theory that is very well entrenched. It shows up in all kinds of places. Just turn on the television for evidence. It is this that education is supposed to deal with, and it is this, I maintain, that education has, by and large, failed to deal with. These are again just the scholastic acquisitions.

Why does this happen? I claim it happens because there are different kinds of constraints operating on us.

The first constraint has to do with the kind of species we are. We learn certain things very easily. We develop certain theories very readily, and other ones are very, very hard for us to develop. Why this should be the case is a whole interesting evolutionary question.

Then there are institutional constraints. If you put 50 people in a room like this and one person in front of them, it is very hard to explain things so that all 50 people can understand; for every person who is nodding, three are nodding off.

There are also disciplinary constraints. As I said, the moves that have been developed over the centuries for analysis in one discipline are very different from the moves in other disciplines. Physical causality is not like historical causality or literary causality.

So, those are constraints that contribute to the problem I am describing.

However, on anticipating what we might do, there is some hope. The hope lies in two institutions. One of them, the apprenticeship, is very old. There are many powerful clues about how to educate for understanding contained in the apprenticeship. The other is a new institution, more familiar in the United States than in most other countries, but it is spreading rapidly: the children's museum, or the science museum, or the discovery museum, or, for those of you who have been to San Francisco, the *Exploratorium*. There are very powerful education implications in those two institutions.

What follows is an attempt to summarize this very technical argument.

The natural learner displays what I call intuitive understanding. He or she is very promiscuous with the theories already developed in the young mind. Whenever anything happens, the young child draws on the theories of mind, matter and life, to explain them, whether or not those theories are appropriate at all.

The scholastic learner never tries to apply the theory anywhere, except where he or she is told to. It is exactly the opposite of the natural learner. So the scholastic learner gives a ritualized performance. The teacher asks the question, the student gives the prescribed answer or they are told that they are wrong, and you go on to the next student. The disciplined learner, the expert, produces a discipline of understanding: not only can he or she draw on knowledge when it is appropriate but, equally important, does not draw on that knowledge when it is not appropriate. The five-year-old is too promiscuous and uses the knowledge always. The ten-year-old is repressed (the opposite of being promiscuous) and never uses it. But the person with disciplined understanding has good taste and uses the knowledge just when it is appropriate. This comes about because there are constraints, also gaps.

What I have tried to do is to say that there are some deep, if you will, some epistemological reasons, why it is very difficult to teach for understanding.

What I want to do now is to take a "Cook's Tour" of the different disciplines to show you that this is not a problem just for somebody else's discipline; it is a problem for every discipline.

I have already mentioned physics. Most people remain five-year-olds or Aristotelians even though they studied physics. Here is a wonderful example, actually from astronomy. Some of you may have seen this film. Twenty-five Harvard students have just graduated, all wearing their gowns and their mortar boards. An interviewer says to the students: "Tell me, why is the earth warmer in the summer than it is in the winter?" Twenty-three out of the 25 students immediately came up with the same answer, the answer that you would come up with if you did not know what I was lecturing about: namely that the earth is closer to the sun in the summer than it is in the winter. Now if we think about it, that does not make any sense because it would not account for the seasons in different parts of the world. The right explanation has to do with the angle of the world on its axis as it spins around. But 23 out of 25 students forget to apply what they have learned in their astronomy classes and give the same five-year-old kind of answer.

You might say physics is hard. How about biology? Perhaps biology is much easier? Research shows that students who have taken not one, but two or three courses in biology focusing on the topic of evolution, still do not understand the basics of evolution. They still believe that something in one generation can be passed on to the next, even if it was acquired in that generation. They are also still perfectionists. They think that each organism is trying to get more perfect and there is an unseen hand that is guiding that perfection rather than simply variation and selection within a particular ecological niche. So problems in physics extend to biology and to the other sciences as well.

What about mathematics? Mathematics is all abstract. It has nothing to do with the real world. So maybe people do not have misconceptions in the area of mathematics. What they have instead is what I call rigid algorithms. They learn to fill in numbers into a formula.

This is the problem. There are six times as many students as professors. If there are ten professors, how many students are there? Does anybody want to risk an answer? I guess the answer is no. Anyway, that is quite a simple problem. The answer is 60. If I ask you to capture the above information in a written equation where S stands for students and P stands for professors, most people will write the following equation: 6S=P. This is because if you parse the sentence it says there are six times as many students as there are professors. However what they are actually writing is "six times sixty equals ten" which is clearly an absurd result.

What happens in mathematics is that students learn how to plug numbers into formulas, how to solve equations. As long as the information is presented to them in a certain canonical order, they will get the answer right. If, however, the problem is presented in a new way, in a way that actually describes understanding of the formalism, most people will not get it right because they will not understand the formalism.

I can think back to my own education. I studied the quadratic equation and I must have solved 500 problems with the quadratic equation. I'm sure by the time I finished school, I could do the quadratic equation in my sleep. Never did anybody give me any education of what a quadratic equation stood for. Nowadays if I ran into a problem I wouldn't have a clue that it involved the quadratic equation, even though I might, on a dark and stormy night, remember what a quadratic equation was. But I got very good grades in mathematics because I wasn't expected to know where to use this kind of formalism.

So, the problem in science is misconceptions. The problem in mathematics is rigidly applied algorithms.

How about in the arts, in the humanities?

In the arts and the humanities the problem is different. It is what I call scripts or stereotypes. Early in life children develop very powerful theories about the world. A favourite script is the restaurant script. Every four-year-old knows that if you go to a restaurant, somebody comes and seats you. You are given the menu; you order. Food comes. You eat it and then you call for the cheque, and you leave.

If you go to McDonald's you pay first but that is an exception to the script. Every four-year-old also knows about birthday parties: who comes, what you serve, that kind of thing. The rules are different in different cultures but everybody knows about birthday parties.

Another script that you develop when you are very young is the Star Wars script—named both after the movie and after President Reagan's strategic defence initiative. Star Wars says: it's good to be big; you should be big yourself; if you're not big, align yourself with somebody who is big. If you look like that person, you will be good and people who look different will be bad. That is the Star Wars script and it is very very powerful!

You can ask people who have studied world history about the causes of the first world war, and they say: "Oh, it's very complicated. There was colonialism, imperialism, ethnic strife and long term rivalries" and they give you a very nuanced response. Then you say to them: "Well, what's happening in the Gulf?" They will say: "Well, there is this bad guy named Saddam Hussein and if we get rid of him, everything will be OK." Now, that is a Star Wars type of explanation and, as I hinted before, it was very widely used in my country. In fact, we like to use Star Wars wherever we can in the United States.

In 1986 the bad guy was Muammer Kaddaffi; in 1988 it was Manuel Noriega. (We got rid of him, but the problems remained; in fact, they got worse.) In 1990 it was Saddam Hussein and in 1992 I think it was Bill Clinton, but he won so we had to find somebody new! But it is a very powerful way of thinking and you find it in social studies.

Actually, the best example of the unschooled mind in the arts comes out of the university of Cambridge in the UK. In the 1920s a literary critic and poet named IA Richards did a study of Cambridge undergraduates. He published it in a book titled *Practical Criticism*. He took Cambridge undergraduates who were the best and brightest literary students. He gave them twelve poems and he asked them two questions about the poems:

1. what do they mean?

2. are they any good?

He performed one manipulation on the poems. He removed the names of the poets. (It is like going to the Louvre without the labels, right?)

What did he find? He found that the students did not have a clue about which poems were good (according to the critics) and which were bad. They rejected John Donne. They rejected Gerald Manley Hopkins. They embraced a Sunday poet who couldn't get into the "Cambridge Chronicle" and, when they were asked what accounted for the quality, they replied: if a poem rhymed, scanned, dealt with a pleasant subject, but was not too sentimental, it was good. But if it dealt with philosophy

or anything tragic or anything abstract, it was bad. So, here you have very, very good students who have studied literature, who, when the book clue is removed (namely this is by a good poet, this is by a bad poet or by a non poet), display the same kind of taste that someone with no education in literature would exhibit.

So, what I have tried to do now in part two is to argue that in every area of the curriculum you have real problems that reveal how difficult it is to educate for understanding. You have misconceptions in the sciences, rigidly applied algorithms in mathematics and scripts and stereotypes in social studies, humanities and the arts. Well, this is the end of the bad news part of the talk. We now move into a mode where I'm going to try to say that there is some hope after all. As I said, one source of hope is in taking some lessons from the old institution of apprenticeships and the new institution of children's museums.

Now, I want to be very clear about this point. People usually misunderstand me to say that we should institute seven-year agreements between the apprentice and the master where the apprentice is indentured and has to sweep the floor and that kind of thing, or that we should close schools down in an Ivan Illich sense and put everybody in children's museums. That is not what I mean.

What I mean is that there are very powerful educational messages in these two institutions that I think can help educate for understanding. In the case of the apprenticeship, a young person works for someone who is the master of his or her discipline or craft, and who uses that discipline or craft every day in the course of genuine problem solving. The master poses the problems and requires products from the apprentice at his or her level of competence; when the apprentice becomes more competent then the standards are raised.

The master never has to take kids and test them at the end of the week, or the end of the year because, essentially he and the student are assessing every day. Moreover the master embodies the learning that he or she wants the child to have.

So, in the United States, every teacher can read and write but very few of our elementary school teachers actually *do* read and write. In fact, in a very alarming statistic, the average American school teacher reads one book a year. People who live in a literate world who read and write and talk about what they are reading and writing will have youngsters who do the same. People who simply say you should read but turn on the TV for seven hours give a very different message.

As far as the children's museum is concerned this is a very new invention. Basically, until 25 years ago, there were almost no children's museums. But these are places that contain very lively demonstrations of many of the principles that students learn about in school, across the curriculum. They allow children to explore those principles, those ideas, at their own pace and in ways that are comfortable for that child. Frank Oppenheimer, who founded the *Exploratorium* in San Francisco, said: "Nobody flunks museum." It is a very powerful idea.

I became a devotee of children's museums because when I took kids to children's museums I often found that kids who were called bright in school could not find their way around. They were very unschooled. But kids who were not considered bright in school could often learn very well in those contexts. I will explain later why that is very important.

For each of the areas of the curriculum in which I have diagnosed a problem, I believe there is a move that we can make as educators that can be very helpful.

In the case of misconceptions, in the celebratory year 1992 I recommend Christopherian encounters, named after Christopher Colombus. If you believe the world is flat, but every day or every year you travel around the world and you come back to where you started before, that tends to belie the notion that the world is flat. In a Christopherian encounter you expose your theories to disconfirmation. If your theories are consistently disconfirmed, you will slowly abandon them, and hopefully construct a better theory.

Most American school kids, probably most school kids everywhere, believe that the reason that you are warm when you put on a sweater, is because that sweater has warmth in it. If every year, in school during the winter, you put a sweater outside and you come in the morning and find it is freezing cold, that tends to disconfirm the notion that there is warmth inherent in the sweater.

Christopherian encounters have to happen over and over again. To use an analogy that I used when I spoke with the interpreters about my talk, what I believe is: think about the brain with a mind as a surface that, earlier in life, becomes very much engraved with these primitive theories. What school usually does is simply to put some powder over that engraving so you can't see it. And as long as you are in school, the powder is what you notice. When you leave school, and you slam the door, the powder puffs up and the engraving is still there, the early theory. What happens in the Christopherian encounter is that you slowly upgrade that early engraving and you etch a new and better one.

But you can see that it doesn't happen in one time. Let me tell you what is wrong with the "one time" thing. If you ask my son Benjamin, who is now all of seven years old, what's the shape of the world, he will tell you it is round. This makes you think he is very smart. But if you asked Benjamin where he is standing he will say: "That's easy. I'm on the flat part underneath." His theory has been totally unaffected but he has learned the powder that is required: namely, if you want to shut up your father, you say that the world is round because that's what grownups say, but who could believe it?

Thus Christopherian encounters challenge those notions every day.

In mathematics, the cure for a rigidly applied algorithm is what I call rich exploration of the relevant semantic domain. What that means in English is that you must know what the equation stands for. You have to understand the formalism. So if you are going to do distance, rate and time problems—a common algebra exercise—you do a lot of experimenting. You try to predict how long it will take for something to get from one point to the other. You develop an intuition for the formalism so that when you learn the formalism it actually refers to something that you already have an intuition for, that you already have an understanding for.

This has been done quite brilliantly with calculus where, before any of the formalism is introduced, kids learn to make predictions about their bodies moving at various speeds and what kind of graphs would be produced over the course of time, and things like that.

A mathematician is not somebody who remembers all the formalisms. A mathematician is somebody who doesn't care if he remembers because, if necessary, he/she can derive it again because he/she understands what it stands for. That is why most of us are not mathematicians.

In the case of the humanities, the cure for stereotypes is the regular adoption of multiple stances. If it becomes a regular habit of mind to look at things from many different points of view, you will gradually abandon stereotypical thinking.

During the Gulf war, my older son went to school where there were kids from many different countries. The teacher had a very good idea. Rather than everybody just giving what the cable news network reported, he had a student from Iran, and a student from Kuwait, and a student from Israel etc, give their understanding of what was happening every day. Then, a few weeks after that, the teacher asked the kids in the school: "What do you think Moshe will think about this and what do you think Omar will think about this?" That is giving students the opportunity to put themselves into other people's minds.

If you study any revolution, from the point of view of the vanquished as well as the victors, you get a very different story. If you study the American revolution from the point of view of the British, where it was a colonial uprising, and from the point of view of the French, where it was a good opportunity to get at the British, it is a very different story than if you just read the average American text book. That is how you break down stereotypical thinking, but it has to be a regular habit of mind, otherwise it won't work at all.

Well, you might say this is all very good and just what I would expect of a Harvard professor: lots of theory. I actually do a lot of empirical work, but that's another story. However, I am going to describe, as we get to the close of my presentation, a new project that I'm involved in which is actually designed to educate for understanding.

It is based upon three core ideas that I have worked out in conjunction with some colleagues at Harvard:

- the identification of rich, generative ideas; nutritious topics on which it is worth spending a lot of time;
- the development of different kinds of teaching languages—multiple ways to approach those topics, so we can be sure that students have maximum access to those ideas; and
- what I now call "ongoing assessment".

"Ongoing assessment" (which I used to call "assessment in context") means assessment is taking place all the time by students and by peers as well as by the teacher.

We believe that if you can identify rich ideas, explore them in multiple ways and give students much opportunity to assess their own learning, that there is a chance for education for understanding.

I now want to flesh those ideas out because they are very abstract.

First of all, the greatest enemy of understanding is coverage. I said that earlier. If you are determined to cover everything in the book, you virtually guarantee that very few students will understand. So, if you want to educate for understanding you have got to make tough choices about what to focus on. And obviously you should focus on those things that have the biggest mileage. If you are teaching a course in history or social studies and you decide, say, to focus on democracy, or if you are teaching a course in biology and you choose to focus on evolution, you can cover a lot of the important material in those subjects by focusing on those topics. It will mean, however, that if you are doing history you are not going to get through every decade. If you are doing biology, you are not going to get through every cycle or through every part of the cell, or every part of the tree. It's a hard choice, but we think it is a choice worth making. If you have rich concepts and you spend time on them, you can approach them in different ways.

Growing out of my theory of multiple intelligences, I claim that almost any topic that is worth spending time on can be approached from at least five different "windows" into the same room.

1. Narrational—basically the story mode.
2. A quantitative, logical rational way of dealing with numbers, principles, causality.
3. What I call a foundational way, asking very basic kinds of questions such as: Why is this important? How does it relate to what came before? How is it related to today?
4. Aesthetic—What does it look like? What does it sound like? What appearance does it make? What patterns and configurations? How does it impress you?
5. Finally, hands on—What is it actually like to be this thing, to do this thing? If you are studying evolution, what is it like to breed drosophila? If you are studying democracy, what is it like to be in a group that decides by consensus as opposed to one that decides by autocracy, oligarchy or some other political principle?

There are two advantages of using these multiple entry points.

First of all, you are more likely to reach every child, because not every child learns most easily in the same way. That is one of the burdens of the theory of multiple intelligences, which you've been spared today, but I believe that kids have different ways of learning.

Second of all, and equally important, if you approach a topic from many different vantage points you are modelling for a student what it is like to be an expert. Because an expert is always somebody who can represent knowledge in more than one way. No expert can think about his or her topic in only one way. Experts have very flexible ways of thinking about their topics and that is what you are modelling as a master to your apprentices if you approach a topic in a number of different ways.

That leaves assessment.

In what we call authentic assessments, we get very far away from short-answer examinations, which are particularly a plague of the USA, to what I call performance-based exams where you actually demonstrate what it is that you are supposed to be able to do. Only in the USA would there be a conviction that, if you want to know how somebody can write, rather than ask him to write, you ask him to fill in the blanks. But other things that you have heard of—projects, exhibitions, portfolios and what I call "process folio" which is not just your finished work, but actually your drafts and your thinking *en route* to fashioning a product—are good ways of assessing whether the students are really understanding.

In the work that we are doing on this project on understanding we work with teachers in local schools and we ask them first to define what we call "understanding goals"—these are the broad things that we want to achieve in a course. They will be very familiar things to you, like having a sense of the scientific method or understanding something about the nature of revolution.

What we then do, which may not be so familiar to you, is we define a whole family of "understanding performances"—these are performances that, if a student can carry them out, will count as evidence for understanding.

This is a play with language, but I think it is an important play, because people tend to think of understanding as something that happens in the head. We say, maybe it does but we don't know whether

you understand unless you can perform your understanding publicly. So, your performance involves analyses, critiques, debates, projects that you create, exhibitions that you put on, things like that.

Finally, given the "understanding goals" and the "understanding performances", how are those performances going to be assessed? And, as I think is the case with IB, you make the assessment criteria absolutely clear. People know exactly what they are going to have to be able to do in order to perform an understanding. There are no surprises, no mysteries, no key to the answers, but rather examples all around of what a good performance is and what are not such good performances, from apprentice level all the way to that of a master.

Now I am going to make an interesting kind of confession to you. I have talked about this stuff for a while and I have researched it for a long time, but, like many other professors, I never actually used it in my own teaching. Last year, I decided to do an experiment with my students who are even more privileged than IA Richard's Cambridge undergraduates—these are Harvard graduate students. I took my Harvard graduate students in the basic course in cognitive development where they study Piaget, Bruner, Vygotsky and people like that, and I tested them three times during the course of the year: in the beginning, in the middle and at the end. I tested them for two things: their mastery of content and their understanding in the terms that I have defined today. Could they use what they were learning in the course to explain new situations, things in the newspapers, vignettes that I brought in, and so on? The results were quite shocking!

Imagine a graph in your mind—this is good, this is bad, this is over the course of the year; you can reverse them. In content, the students went steadily up. They knew very little content in the beginning, a fair amount in the middle and were very good at the end. They were good students. They are Harvard students. But you know what happened to the understanding? Absolutely flat—and not a ceiling effect, but a floor effect. They were not very good in the beginning, they were not very good in the middle, they were not very good at the end. There were a few exceptions, just like there are few exceptions everywhere, but even at Harvard, students do not necessarily understand what their professors are teaching!

So fortunately, we got a grant (that is always what you should try to do when you have a negative result) and this year, we are going to try to teach for understanding. It is going to be very different. I hope the results will show that we are successful. But if not, we will just keep doing it again, because obviously it is very important for students to understand.

I am going to finish with a number of thoughts that I have had during the past year. Little epigrams that summarize the things that are important to me.

First of all, after working for 25 years in the area of psychology I realized that I have been interested primarily in two things. One is how to observe students carefully, and multiple intelligence theory is a way to look at students more carefully. The other is how to observe student work more carefully, and this is done by having assessment that looks at student performances very carefully.

I do not know how it is in your schools but I can tell you that in most of the schools that I visit, not much time is spent watching the students and developing a model of how particular students learn; not nearly enough time is spent looking at student work. I will give you a few more examples of this. This is what I call the teacher's fallacy. I succumbed to it for 20 years. I taught a great class, therefore the students understood. It is rather Cartesian isn't it? I teach, therefore you understand. The only way you can find out if students are understanding is to actually have them do some work.

One thing that has become very popular in the United States is the minute paper. At the end of the course, and every session, you ask the student to write down one thing that he or she learned in the period and one question that they have. It's a revelation! I never cease to learn when I do the minute paper. And the misconceptions are of course what is beautiful. They are wonderful misconceptions but unless misconceptions get out in the open they sit there underneath that powder. Portfolios are great! But I don't have time to look at my students work! I'm too busy, too much pressure for coverage, too many faculty meetings. I have a second job.

If you don't have time to look at students' work, the unfortunate conclusion is that you shouldn't teach. Because, if you don't look at your student's work, you have no idea whether they are learning anything. I used to think that, if we simply change the assessment, everything else will be fine.

Because in the United States we have, typically, terrible assessments. I did realize that you can have wonderful assessment. But if the curriculum isn't good, the assessment is worthless. You can have wonderful examining boards sitting here in Geneva but if the curriculum is not adhered to or has not been made up yet, it is worthless. I am sure you have had experience with that. You can have wonderful assessment and curriculum but if the staff is not developed, teachers are not educated even before or during the experience, the assessment and curriculums are worthless.

There is also something that I have to deal with and I think you have to deal with as well even if all these things are in place: if people do not really want to have that kind of education, it is not going to work out.

We now come to my last slide that says: "school doesn't have to be the way you remember it."

Unfortunately, the unschooled mind even applies to parents and teachers; they have a stereotype formed by the age of five about what school is like. Namely, somebody in front of the room talking like me, and they are sitting in their seat, trying to be quiet and all the knowledge is in my head and the purpose is to put it into your head.

That is a very powerful idea. Whether people love school or hate school, they all have that stereotype.

Unless we can help people think differently about what school can be like, what can be studied, how it can be taught, how it can be learned, then the opportunity for education for understanding is not going to be seized.

Now Piaget said one valuable thing that I did not adhere to. He said that developmental psychologists should not try to be educators. And he steered clear of ever having any educational theory. I have stepped into the lion's den today and given you an educational theory that comes out of developmental psychology.

I did say I didn't know whether it would resonate with those of you working in the IB because maybe all of your students, all of your teachers, do understand. But, if so, I'd like to hear how you do it and if not, I will be happy to work on the problem together with you.

