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The Having of Wonderful Ideas

from Duckworth. "The Having of Wonderful Ideas and Other Essays on Teaching and Learning."

Kevin, Stephanie, and the Mathematician

With a friend, I reviewed some classic Piagetian interviews with a few children. One involved the ordering of lengths. I had cut 10 cellophane drinking straws into different lengths and asked the children to put them in order, from smallest to biggest. The first two 7-year-olds did it with no difficulty and little interest. Then came Kevin. Before I said a word about the straws, he picked them up and said to me, "I know what I'm going to do," and proceeded, on his own, to order them by length. He didn't mean, "I know what you're going to ask me to do." He meant, "I have a wonderful idea about what to do with these straws. You'll be surprised by my wonderful idea."

It wasn't easy for him. He needed a good deal of trial and error as he set about developing his system. But he was so pleased with himself when he accomplished his self-set task that when I decided to offer them to him to keep (10 whole drinking straws!), he glowed with joy, showed them to one or two select friends, and stored them away with other treasures in a shoe box.

The having of wonderful ideas is what I consider the essence of intellectual development. And I consider it the essence of pedagogy to give Kevin the occasion to have his wonderful ideas and to let him feel good about himself for having them. To develop this point of view and to indicate where Piaget fits in for me, I need to start with some autobiography, and I apologize for that, but it was a struggle of some years' duration for me to see how Piaget was relevant to schools at all.

I had never heard of Piaget when I first sat in a class of his. It was as a philosopher that Piaget won me, and I went on to spend two years in Geneva as a graduate student and research assistant. Then, some years later, I began to pay attention to schools, when, as a Ph.D. dropout, I accepted a job developing elementary science curriculum, and found myself in the midst of an exciting circle of educators.

The colleagues I admired most got along very well without any special knowledge of psychology. They trusted their own insights about when and how children were learning, and they were right to: Their insights were excellent. Moreover, they were especially distrustful of Piaget. He had not yet appeared on the cover of *Saturday Review* or the *New York Times Magazine,* and they had their own picture of him: a severe, humorless intellectual confronting a small child with questions that were surely incomprehensible, while the child tried to tell from the look in his eyes what the answer was supposed to be. No wonder the child couldn't think straight. (More than one of these colleagues first started to pay attention to Piaget when they saw a photo of him. He may be Swiss, but he doesn't look like Calvin! Maybe he can talk to children after all.)

I myself didn't know what to think. My colleagues did not seem to be any the worse for not taking Piaget seriously. Nor, I had to admit, did I seem to be any the better. Schools were such complicated places compared with psychology labs that I couldn't find a way to be of any special help. Not only did Piaget seem irrelevant, I was no longer sure that he was right. For a couple of years, I scarcely mentioned him and simply went about the business of trying to be helpful, with no single instance, as I recall, of drawing directly on any of his specific findings.

The lowest point came when one of my colleagues gleefully showed me an essay written in a first grade by 6-year-old Stephanie. The children had been investigating capillary tubes, and were looking at the differences in the height of the water as a function of the diameter of the tube. Stephanie's essay read as follows: "I know why it looks like there's more in the skinny tube. Because it's higher. But the other is fatter, so there's the same."

My colleague triumphantly took this statement as proof that 6-year-olds can reason about the compensation of two dimensions. I didn't know what to say. Of course, it should have been simple. Some 6-year-olds *can* reason about compensation. The ages that Piaget mentions are only norms, not universals. Children develop at a variety of speeds, some more slowly and some more quickly. But I was so unsure of myself at that point that this incident shook me badly, and all of that only sounded like a lame excuse.

I do have something else to say about that incident later. For now, I shall simply try to describe my struggle.

Even if I did believe that Piaget was right, how could he be helpful? If the main thing that we take from Piaget is that before certain ages children are unable to understand certain things—conservation, transitivity, spatial coordinates—what do we do about it? Do we try to teach the children these things? Probably not, because on the one hand Piaget leads us to believe that we probably won't be very successful at it; and on the other hand, if there is one thing we have learned from Piaget it is that children can probably be left to their own devices in coming to understand these notions. We don't have to try to furnish them. It took a few months before that was clear to me, but I did conclude that this was not a very good way to make use of Piaget.

An alternative might be to keep in mind the limits on children's abilities to classify, conserve, order, and so forth, when deciding what to teach them at certain ages. However, I found this an inadequate criterion. There was so much else to keep in mind. The most obvious reason, of course, was that any class of children has a great diversity of levels. Tailoring to an average level of development is sure to miss a large proportion of the children. In addition, a Piaget psychologist has no monopoly here. When trying to approximate the abilities of a group of children of a given age, able teachers like my colleagues could make as good approximations as I.

What I found most appealing was that the people with whom I was working judged the merits of any suggestion by how well it worked in classrooms. That is, instead of deciding on a priori grounds what children *ought* to know, or what they *ought* to be able to do at a certain age, they found activities, lessons, points of departure, that would engage children in real classrooms, with real teachers. In their view, it was easy to devise all-embracing schemes of how science (as it was in this instance) could be organized for children, but to make things work pedagogically in classrooms was the difficult part. They started with the difficult part. A theory of intellectual development might have been the basis of a theoretical framework of a curriculum. But in making things work in a classroom, it was but a small part compared with finding ways to interest children, to take into account different children's interests and abilities, to help teachers with no special training in the subject, and so forth. So, the burden of this curriculum effort was classroom trials. The criterion was whether they worked, and their working depended only in part on their being at the right intellectual level for the children. They might be perfectly all right, from the point of view of intellectual demands, and yet fall short in other ways. Most often, it was a complex combination.

As I was struggling to find some framework within which my knowledge of Piaget would be useful, I found, more or less incidentally, that I was starting to be useful myself. As an observer for some of the pilot teaching of this program, and later as a pilot teacher myself, I found that I had a certain skill in being able to watch and listen to children and that I did have some good insights about how they were really seeing the problem. This led to a certain ability to raise questions that made sense to the children or to think of new orientations for the whole activity that might correspond better to their way of seeing things. I don't want to suggest that I was unique in this. Many of the teachers with whom I was working had similar insights, as did many of the mathematicians and scientists among my colleagues, who, from their points of view, could tell when children were seeing things differently from the ways they did. But the question of whether I was unique is not really pertinent. For me, through my experience with Piaget of working closely with one child at a time and trying to figure out what was really in that child's mind, I had gained a wonderful background for being sensitive to children in classrooms. I think that a certain amount of this kind of background would be similarly useful for every teacher.

This sensitivity to children in classrooms continued to be central in my own development. As a framework for thinking about learning, my understanding of Piaget has been invaluable. This understanding, however, has also been deepened by working with teachers and children. I may be able to shed some light on that mutual relationship by referring again to 6-year-old Stephanie's essay on compensation. Few of us, looking at water rise in capillary tubes of different diameters, would bother to wonder whether the quantities are the same. Nobody asked Stephanie to make that comparison and, in fact, it is impossible to tell just by looking. On her own, she felt it was a significant thing to comment upon. I take that as an indication that for her it was a wonderful idea. Not long before, she believed that there was more water in the tube in which the water was higher. She had recently won her own intellectual struggle on that issue, and she wanted to point out her finding to the world for the benefit of those who might be taken in by preliminary appearances.

This incident, once I had figured it out, helped me think about a point that bothered me in one of Piaget's anecdotes. You may recall Piaget's account of a mathematician friend who inspired his studies of the conservation of number. This man told Piaget about an incident from his childhood, where he counted a number of pebbles he had set out in a line. Having counted them from left to right and found there were 10, he decided to see how many there would be if he counted them from right to left. Intrigued to find that there were still 10, he put them in a different arrangement and counted them again. He kept rearranging and counting them until he decided that, no matter what the arrangement, he was always going to find that there were 10. Number is independent of the order of counting.

My problem was this: In Piaget's accounts, if 10 eggs are spread out so they take more space than 10 eggcups, a classic nonconserver will maintain that there are more eggs than eggcups, even if he counts and finds that he comes to 10 in both cases. Counting is not sufficient to convince him that there are enough eggcups for all the eggs. How is it, then, that for the mathematician, counting was sufficient? If he was a nonconserver at the time, counting should not have made any difference. If he was a conserver, he should have known from the start that it would always come out the same.

I think it must be that the whole enterprise was his own wonderful idea. He raised the question for himself and figured out for himself how to try to answer it. In essence, I am saying that he was in a transitional moment, and that Stephanie and Kevin were, too. He was at a point where a certain experience fit into certain thoughts and took him a step forward. A powerful pedagogical point can be made from this. These three instances dramatize it because they deal with children moving ahead with Piaget notions, which are usually difficult to advance on the basis of any one experience. The point has two aspects: First, the right question at the right time can move children to peaks in their thinking that result in significant steps forward and real intellectual excitement; and, second, although it is almost impossible for an adult to know exactly the right time to ask a specific question of a specific child—especially for a teacher who is concerned with 30 or more children—children can raise the right question for themselves if the setting is right. Once the right question is raised, they are moved to tax themselves to the fullest to find an answer. The answers did not come easily in any of these three cases, but the children were prepared to work them through. Having confidence in one's ideas does not mean "I know my ideas are right"; it means "I am willing to try out my ideas."

As I put together experiences like these and continued to think about them, I started developing some ideas about what education could be and about the relationships between education and intellectual development.

Hank

It is a truism that all children in their first and second years make incredible intellectual advances. Piaget has documented these advances from his own point of view, but every parent and every psychologist knows this to be the case. One recurring question is, why does the intellectual development of vast numbers of children then slow down? What happens to children's curiosity and resourcefulness later in their childhood? Why do so few continue to have their own wonderful ideas? I think part of the answer is that intellectual breakthroughs come to be less and less valued. Either they are dismissed as being trivial—as Kevin's or Stephanie's or the mathematician's might have been by some adults—or else they are discouraged as being unacceptable—like discovering how it feels to wear shoes on the wrong feet, or asking questions that are socially embarrassing, or destroying something to see what it's like inside. The effect is to discourage children from exploring their own ideas and to make them feel that they have no important ideas of their own, only silly or evil ones.

But I think there is at least one other part of the answer, too. Wonderful ideas do not spring out of nothing. They build on a foundation of other ideas. The following incident may help to clarify what I mean.

Hank was an energetic and not very scholarly fifth grader. His class had been learning about electric circuits with flashlight batteries, bulbs, and various wires. After the children had developed considerable familiarity with these materials, the teacher made a number of mystery boxes.* Two wires protruded from each box, but inside, unseen, each box had a different way of making contact between the wires. In one box the wires were attached to a battery; in another they were attached to a bulb; in a third, to a certain length of resistance wire; in a fourth box they were not attached at all; and so forth. By trying to complete the circuit on the outside of a box, the children were able to figure out what made the connection inside the box. Like many other children, Hank attached a battery and a bulb to the wire outside the box. Because the bulb lit, he knew at least that the wires inside the box were connected in some way. But, because it was somewhat dimmer than usual, he also knew that the wires inside were not connected directly to each other and that they were not connected by a piece of ordinary copper wire. Along with many of the children, he knew that the degree of dimness of the bulb meant that the wires inside were connected either by another bulb of the same kind or by a certain length of resistance wire.

The teacher expected them to go only this far. However, in order to push the children to think a little further, she asked them if they could tell whether it was a bulb or a piece of wire inside the box. She herself thought there was no way to tell. After some thought, Hank had an idea. He undid the battery and bulb that he had already attached on the

*This activity is from the Elementary Science Study's *Batteries and Bulbs*. This and the other ESS units are currently available from Delta Education, Nashua, New Hampshire.

outside of the box. In their place, using additional copper wire, he attached six batteries in a series. He had already experimented enough to know that six batteries would burn out a bulb, if it was a bulb inside the box. He also knew that once a bulb is burned out, it no longer completes the circuit. He then attached the original battery and bulb again. This time he found that the bulb on the outside of the box did not light. So he reasoned, rightly, that there had been a bulb inside the box and that now it was burned out. If there had been a wire inside, it would not have burned through and the bulb on the outside would still light.

Note that to carry out that idea, Hank had to take the risk of destroying a light bulb. In fact, he did destroy one. In accepting this idea, the teacher had to accept not only the fact that Hank had a good idea that even she did not have, but also that it was worthwhile to destroy a small piece of property for the sake of following through an idea. These features almost turn the incident into a parable. Without these kinds of acceptance, Hank would not have been able to pursue his idea. Think of how many times this acceptance is not forthcoming in the life of any one child.

But the main point to be made here is that in order to have his idea, Hank had to know a lot about batteries, bulbs, and wires. His previous work and familiarity with those materials were a necessary aspect of this occasion for him to have a wonderful idea. David Hawkins has said of curriculum development, "You don't want to cover a subject; you want to uncover it." That, it seems to me, is what schools should be about. They can help to uncover parts of the world that children would not otherwise know how to tackle. Wonderful ideas are built on other wonderful ideas. In Piaget's terms, you must reach out to the world with your own intellectual tools and grasp it, assimilate it, yourself. All kinds of things are hidden from us—even though they surround us—unless we know how to reach out for them. Schools and teachers can provide materials and questions in ways that suggest things to be done with them; and children, in the doing, cannot help being inventive.

There are two aspects to providing occasions for wonderful ideas. One is being willing to accept children's ideas. The other is providing a setting that suggests wonderful ideas to children—different ideas to different children—as they are caught up in intellectual problems that are real to them.

What Schools Can Do

I had the chance to evaluate an elementary science program in Africa. For the purposes of this discussion it might have been set anywhere.

Although the program was by no means a deliberate attempt to apply Piaget's ideas, it was, to my mind, such an application in the best sense. The assumptions that lay behind the work are consistent with the ideas I have just been developing. The program set out to reveal the world to children. The developers sought to familiarize the children with the material world—that is, with biological phenomena, physical phenomena, and technological phenomena: flashlights, mosquito larvae, clouds, clay. When I speak of familiarity, I mean feeling at home with these things: knowing what to expect of them, what can be done with them, how they react to various circumstances, what you like about them and what you don't like about them, and how they can be changed, avoided, preserved, destroyed, or enhanced.

Certainly the material world is too diverse and too complex for a child to become familiar with all of it in the course of an elementary school career. The best one can do is to make such knowledge, such familiarity, seem interesting and accessible to the child. That is, one can familiarize children with a few phenomena in such a way as to catch their interest, to let them raise and answer their own questions, to let them realize that their ideas are significant—so that they have the interest, the ability, and the self-confidence to go on by themselves.

Such a program is a curriculum, so to speak, but a curriculum with a difference. The difference can best be characterized by saying that the unexpected is valued. Instead of expecting teachers and children to do only what was specified in the booklets, it was the intention of the program that children and teachers would have so many unanticipated ideas of their own about the materials that they would never even use the booklets. The purpose of developing booklets at all is that teachers and children start producing and following through their own ideas, if possible getting beyond needing anybody else's suggestions. Although it is unlikely to be completely realized, this represents the ideal orientation of the program. It is a rather radical view of curriculum development.

It is just as necessary for teachers as for children to feel confidence in their own ideas. It is important for them as people and it is important in order for them to feel free to acknowledge the children's ideas. If teachers feel that their class must do things just as the book says and that their excellence as teachers depends on this, they cannot possibly accept the children's divergence and creations. A teachers' guide must give enough indications, enough suggestions, so that the teacher has ideas to start with and to pursue. But it must also enable the teacher to feel free to move in her own directions when she has other ideas.

For instance, the teachers' guides for this program include many examples of things children are likely to do. The risk is that teachers may

see these as things that the children in their classes *must* do. Whether or not the children do them becomes a measure of successful or unsuccessful teaching. Sometimes the writers of the teachers' guides intentionally omit mention of some of the most exciting activities because they almost always happen even if they are not arranged. If the teacher expects them, she will often force them, and they no longer happen with the excitement of wonderful ideas. Often the writers include extreme examples, so extreme that a teacher cannot really expect them to happen in her class. These examples are meant to convey the message that "even if the children do that it's OK! Look, in one class they even did this!" This approach often is more fruitful than the use of more common examples whose message is likely to be "this is what ought to happen in your class."

The teachers' guides dealt with materials that were readily available in or out of schools, and suggested activities that could be done with these materials so that children became interested in them and started asking their own questions. For instance, there are common substances all around us that provide the essential basis of chemistry knowledge. They interact in all sorts of interesting ways, accessible to all of us if only we know how to reach out for them. This is a good instance of a part of the world that is waiting to be uncovered. How can it be uncovered for children in a way that gives them an interest in continuing to find out about it, a way that gives them the occasion to take their own initiatives, and to feel at home in this part of the world?

The teachers' guide suggests starting with salt, ashes, sugar, cassava starch, alum, lemon juice, and water. When mixed together, some of these cause bubbles. Which combinations cause bubbles? How long does the bubbling last? How can it be kept going longer? What other substances cause bubbles? If a combination bubbles, what can be added that will stop the bubbling? Other things change color when they are mixed together, and similar questions can be asked of them.

Written teachers' guides, however, cannot bear the burden alone, if this kind of teaching is totally new. To get such a program started, a great deal of teacher education is necessary as well. Although I shall not try to go into this in any detail, there seem to be three major aspects to such teacher education. First, teachers themselves must learn in the way that the children in their classes will be learning. Almost any one of the units developed in this program is as effective with adults as it is with children. The teachers themselves learn through some of the units and feel what it is like to learn in this way. Second, the teachers work with one or two children at a time so that they can observe them closely enough to realize what is involved for the children. Last, it seems valuable for teachers to see films or live demonstrations of a class of children learning in this way, so that they can begin to think that it really is possible to run their class in such a way. A fourth aspect is of a slightly different nature. Except for the rare teacher who will take this leap all on his or her own on the basis of a single course and some written teachers' guides, most teachers need the support of at least some nearby co-workers who are trying to do the same thing, and with whom they can share notes. An even better help is the presence of an experienced teacher to whom they can go with questions and problems.

An Evaluation Study

What the children are doing in one of these classrooms may be lively and interesting, but it would be helpful to know what difference the approach makes to them in the long run, to compare in some way the children who were in this program with children who were not, and to see whether in some standard situation they now act differently.

One of my thoughts about ways in which these children might be different was based on the fact that many teachers in this program had told us that their children improved at having ideas of what to do, at raising questions, and at answering their own questions; that is, at having their own ideas and being confident about their own ideas. I wanted to see whether this indeed was the case.

My second thought was more ambitious. If these children had really become more intellectually alert, so that their minds were alive and working not only in school but outside school, they might, over a long enough period of time, make significant headway in their intellectual development, as compared with other children.

In sum, these two aspects would put to the test my notions that the development of intelligence is a matter of having wonderful ideas and feeling confident enough to try them out, and that schools can have an effect on the continuing development of wonderful ideas. The study has been written up elsewhere (Duckworth, 1978), but let me give a summary of it here.

The evaluation had two phases. The procedure developed for the first phase was inspired in part by a physics examination given to students at Cornell University by Philip Morrison. His examination was held in the laboratory. The students were given sets of materials, the same set of materials for each student, but they were given no specific problem. Their problem was to *find* a problem and then to work on it. For Morrison, the crucial thing is finding the question, just as it was for Kevin, Stephanie, and the mathematician. In this examination, clear differences in the degree of both knowledge and inventiveness were revealed in the problems the students set themselves, and the work they did was only as good as their problems.

In our evaluation study, we had to modify this procedure somewhat to make it appropriate for children as young as 6 years of age. Our general question was what children with a year or more of experience in this program would do with materials when they were left to their own resources without any teacher at all. We wanted to know whether children who had been in the program had more ideas about what to do with materials than did other children.

The materials we chose were not, of course, the same as those that children in the program had studied. We chose materials of two sorts: on the one hand, imported materials that none of the children had ever seen before—plastic color filters, geometric pattern blocks, folding mirrors, commercial building sets, for example. On the other hand, we chose some materials that were familiar to all the children whether or not they had been in the program—cigarette foil, match boxes, rubber rings from inner tubes, scraps of wire, wood, and metal, empty spools, and so forth.

From each class we chose a dozen children at random and told them—in their own vernacular—to go into the room and do whatever they wanted with the materials they would find there. We told them that they could move around the room, talk to each other, and work with their friends.

We studied 15 experimental classes and 13 control classes from first to seventh grades. Briefly, and inadequately, summarizing the results of this phase, we found that the children who had been in the program did indeed have more ideas about how to work with the materials. Typically, the children in these classes would take a first look at what was offered, try a few things, and then settle down to work with involvement and concentration. Children sometimes worked alone and sometimes collaborated. They carried materials from table to table, using them in ways we had not anticipated. As time went on, there was no sign that they were running out of ideas. On the contrary, their work became so interesting that we were always disappointed to have to stop them after 40 minutes.

By contrast, the other children had a much smaller range of ideas about what to do with the materials. On the one hand, they tended to copy a few leaders. On the other hand, they tended to leave one piece of work fairly soon and to switch to something else. There were few instances of elaborate work in which a child spent a lot of time and effort to overcome difficulties in what he was trying to do. In some of these classes, after 30 to 35 minutes, all the children had run out of ideas and were doing nothing.

We had assessed two things in our evaluation: diversity of ideas in a class, and depth to which the ideas were pursued. The experimental classes were overwhelmingly ahead in each of the two dimensions. This first phase of assessment was actually a substitute for what we really wanted to do. Ideally, we wanted to know whether the experience of these children in the program had the effect of making them more alert, more aware of the possibilities in ordinary things around them, and more questioning and exploring during the time they spent outside school. This would be an intriguing question to try to answer, but we did not have the time to tackle it. The procedure that we did develop, as just described, may have been too close to the school setting to give rise to any valid conclusions about what children are like in the world outside school. However, if you can accept with me, tentatively, the thought that our results might indicate a greater intellectual alertness in general—a tendency to have wonderful ideas—then the next phase takes on a considerable interest.

I am hypothesizing that this alertness is the motor of intellectual development (in Piaget's terms, operational thinking). No doubt there is a continuum: No normal child is completely unalert. But some are far more alert than others. I am also hypothesizing that a child's alertness is not fixed. I believe that, by opening up to children the many fascinating aspects of the ordinary world and by enabling them to feel that their ideas are worthwhile having and following through, their tendency to have wonderful ideas can be affected in significant ways. This program seemed to be doing both those things, and by the time I evaluated it, some children had been in the classes for up to three years. It seemed to me that we might—just might—find that the two or three years of increased alertness that this program fostered had made some difference to the intellectual development of the children.

In the second phase, then, we examined the same children individually, using Piaget problems administered by a trained assistant who spoke the language of the children. A statistical analysis revealed that on five of the six problems we studied, the children in the experimental classes did significantly better than the children in the comparison classes.

I find this a pretty stunning result on the whole. But I want to insist on one particular view of the result. I do not, in any way, want to suggest that the important thing for education to be about is acceleration of Piaget stages (see chapter 3). I want to make a theoretical point. My thesis at the outset of this chapter was that the development of intelligence is a matter of having wonderful ideas. In other words, it is a creative affair. When children are afforded the occasions to be intellectually creative—by being offered matter to be concerned about intellectually and by having their ideas accepted—then not only do they learn about the world, but as a happy side effect their general intellectual ability is stimulated as well.

Another way of putting this is that I think the distinction made between "divergent" and "convergent" thinking is oversimplified. Even to think a problem through to its most appropriate end point (convergent) one must create various hypotheses to check out (divergent). When Hank came up with a closed end point to the problem, it was the result of a brilliantly imaginative—that is, divergent—thought. We must conceive of the possibilities before we can check them out.

Conclusion

I am suggesting that children do not have a built-in pace of intellectual development. I would temper that suggestion by saying that the built-in aspect of the pace is minimal. The having of wonderful ideas, which I consider the essence of intellectual development, would depend instead to an overwhelming extent on the occasions for having them. I have dwelt at some length on how important it is to allow children to accept their own ideas and to work them through. I would like now to consider the intellectual basis for new ideas.

I react strongly against the thought that we need to provide children with only a set of intellectual processes—a dry, contentless set of tools that they can go about applying. I believe that the tools cannot help developing once children have something real to think about; and if they don't have anything real to think about, they won't be applying tools anyway. That is, there really is no such thing as a contentless intellectual tool. If a person has some knowledge at his disposal, he can try to make sense of new experiences and new information related to it. He fits it into what he has. By knowledge I do not mean verbal summaries of somebody else's knowledge. I am not urging textbooks and lectures. I mean a person's own repertoire of thoughts, actions, connections, predictions, and feelings. Some of these may have as their source something read or heard. But the individual has done the work of putting them together for himself or herself, and they give rise to new ways to put them together.

The greater the child's repertoire of actions and thoughts—in Piaget's terms, schemes—the more material he or she has for trying to put things together in his or her own mind. The essence of the African program I described is that children increase the repertoires of actions that they carry out on ordinary things, which in turn gives rise to the need to make more intellectual connections.

Let us consider a child who has had the world of common substances opened to him, as described earlier. He now has a vastly increased repertoire of actions to carry out and of connections to make. He has seen that when you boil away sea water, a salt residue remains. Would some residue remain if he boiled away beer? If he dissolved this residue in water again, would he have beer again—flat beer? He has seen that he can get a colored liquid from flower petals if he crushes them. Could he get that liquid to go into water and make colored water? Could he make colored coconut oil this way? All these questions and the actions they lead to are based on the familiarity the child has gained with the possibilities contained in this world of common substances.

Intelligence cannot develop without matter to think about. Making new connections depends on knowing enough about something in the first place to provide a basis for thinking of other things to do—of other questions to ask—that demand more complex connections in order to make sense. The more ideas about something people already have at their disposal, the more new ideas occur and the more they can coordinate to build up still more complicated schemes.

Piaget has speculated that some people reach the level of formal operations in some specific area that they know well—auto mechanics, for example—without reaching formal levels in other areas. That fits into what I am trying to say. In an area you know well, you can think of many possibilities, and working them through demands formal operations. If there is no area in which you are familiar enough with the complexities to work through them, then you are not likely to develop formal operations. Knowing enough about things is one prerequisite for wonderful ideas.

I shall make one closing remark. The wonderful ideas that I refer to need not necessarily look wonderful to the outside world. I see no difference in kind between wonderful ideas that many other people have already had, and wonderful ideas that nobody has yet happened upon. That is, the nature of creative intellectual acts remains the same, whether it is an infant who for the first time makes the connection between seeing things and reaching for them, or Kevin who had the idea of putting straws in order of their length, or a musician who invents a harmonic sequence, or an astronomer who develops a new theory of the creation of the universe. In each case, new connections are being made among things already mastered. The more we help children to have their wonderful ideas and to feel good about themselves for having them, the more likely it is that they will some day happen upon wonderful ideas that no one else has happened upon before.