The Direct Teaching of Thinking as a Skill

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The teaching of thinking as a skill is not tomorrow's dream but today's reality, claims one of the world's foremost experts on the topic. He describes his methods for teaching "the generalizable skill of thinking" - methods that have been used from the jungles of South America to the boardrooms of major corporations.

A major trend may be developing in education toward the direct teaching of thinking as a skill. I intend in this article to answer two basic questions related to this trend. First, what is thinking? And second, how can we teach thinking directly? My answers spring from 16 years of experience in the field. During this time I developed an instructional program on thinking skills that is now used by several million schoolchildren in many different countries and cultures.

Of course, some educators believe that thinking is simply a matter of innate intelligence. Two corollaries follow from this belief: 1) we do not have to do anything specific to help highly intelligent individuals learn how to think, and 2) there is little we can do to help less intelligent individuals learn how to think. Thus those who hold this belief rest content. Yet many highly intelligent individuals often seem to be rather ineffective thinkers. Such people are often good at reactive thinking and puzzle solving — but less able to think about topics that require a broader view. They may show cleverness, but not wisdom.

I prefer to see the relationship between intelligence and thinking as similar to the relationship between a car and its driver. Engineering determines the innate potential of the car, but the skill with which the car is driven must be learned and practiced. Thus I would define thinking as "the operating skill with which intelligence acts upon experience."

What, then, is the relationship of information to thinking? It seems obvious to me that God can neither think nor have a sense of humor. Perfect knowledge precludes the need to move from one arrangement of knowledge to a better one. Thus perfect knowledge makes thinking unnecessary. Nonetheless, educators often seem to believe that we can attain such perfect knowledge. However, even if it were possible to absorb perfect knowledge about the past, we can only have very partial knowledge about the future. Yet, as soon as

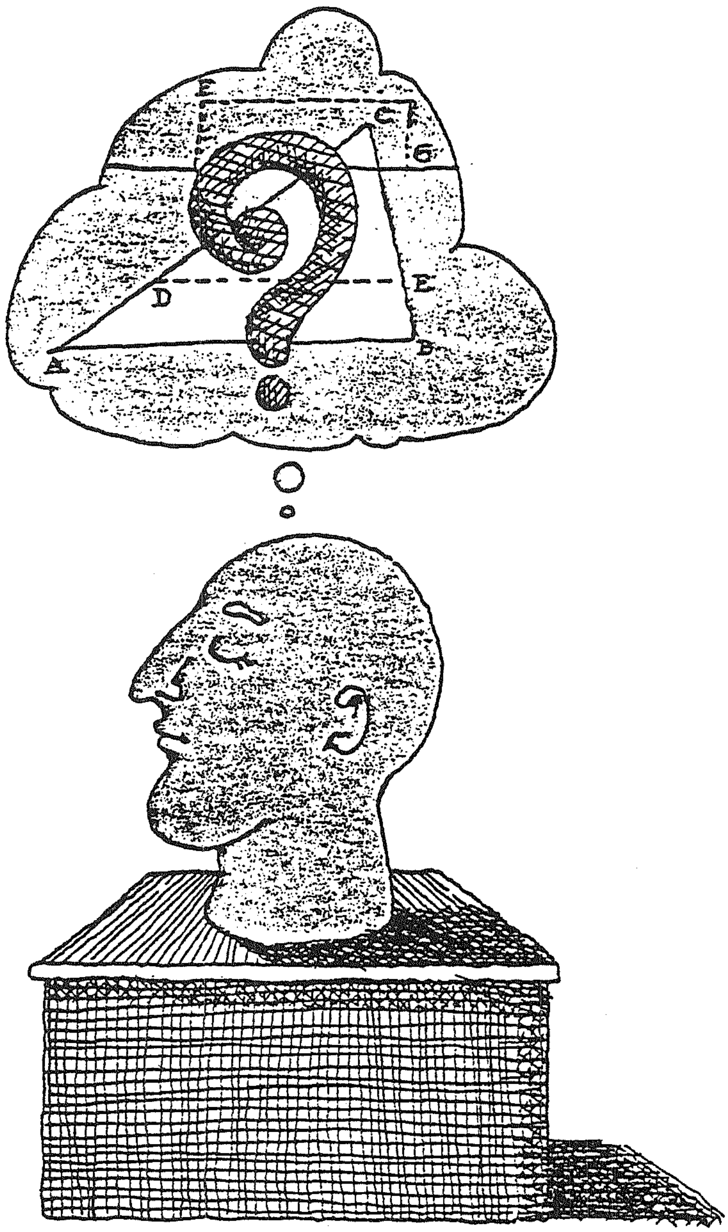

Illustration by Andrea Eberbach

a youngster leaves school, he or she will be operating in the future. Every initiative, decision, or plan will be carried out in the future and thus will require thinking, not just the sorting and re-sorting of knowledge. I have coined the term "operacy" to stand alongside literacy and numeracy as a primary goal of education. Operacy is the skill of doing things, of making things happen. The type of thinking that my program (which I will describe later) teaches is very much concerned with operacy.

In short, information is no substitute for thinking, and thinking is no substitute for information. The dilemma is that there is never enough time to teach all the information that could usefully be taught. Yet we may have to reduce the time we spend teaching information, in order to focus instead on the direct teaching of thinking skills.

The relationship between logic and thinking is likewise not a linear one. The computer world has a saying, "Garbage in — garbage out." In other words, even if the computer is working flawlessly, this will not validate a given outcome. Bad logic makes for bad thinking, but good logic (like the flawless computer) does not insure good thinking. Every logician knows that a conclusion is only as good as the premises. Mathematics, logic (of various sorts), and — increasingly — data processing are excellent service tools. But the deeper we advance into the computer age, the greater the need to emphasize the perceptual side of thinking, which these tool serve.

Meanwhile, emotions, values, and feelings influence thinking at three stages. We may feel a strong emotion (e.g. fear, anger, hatred) even before we encounter a situation. That emotion channels our perceptions. More usually, there is a brief period of undirected perception, untill we recognize the situation. This recognition triggers emotion, which thereafter channels perception. The trained thinker should be operating in the third mode: perception explores the situation as broadly as possible, and, in the end, emotions determine the decision. There is no contradiction at all between emotions and thinking. The purpose of thinking is to arrange the world so that our emotions can be applied in a valuable manner.

The relationship of perception to thinking is, to my mind, the crucial area. In the past, far too many of our approaches to thinking (e.g., mathematics, logic) have concerned themselves with the "processing" aspect. We are rather good at processing but poor in the perceptual area.

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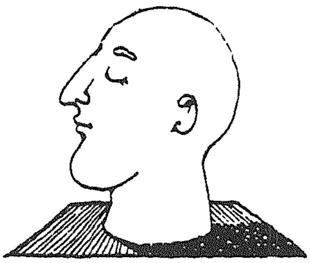
What do I mean by perception? Quite simply, the way our minds make sense of the world around us. Language is a reflection of our traditional perceptions (as distinct from the moment-to-moment ones). Understanding how perception works is not so easy. But this is a crucial point — one that has a direct effect on the way we teach thinking.

Imagine a man holding a small block of wood. He releases the wood, and it falls to the ground. When he releases it a second time, the wood moves upward. This is strange and mysterious behavior. The third time he releases the wood, it remains exactly where it is — suspended in space. This is also mysterious behavior. If I were now to reveal that, in the second instance, the man was standing at the bottom of a swimming pool, then it seems perfectly natural for the wood to float upward. In the third instance, the man is an astronaut in orbit; thus it is perfectly natural for the wood to remain suspended, since it is weightless. Behavior that seemed strange and unaccountable suddenly seems normal and logical — once we have defined the "universe" in which it is taking place.

The traditional universe of information handling is a "passive" one. We record information through marks on paper or marks on magnetic tape. We can handle and process that information. The marks on the surface of the paper or tape and the information itself do not alter, unless we alter them.



I*t is possible to establish both habits of mind and specific thinking techniques that can be applied in any subject area.*

An "active system is totally different; here, the information actually organizes itself into patterns. We human beings have self-organizing information systems. I first wrote about them in 1969 in my book, *The Mechanism of Mind.*[1] I showed then how such systems work, and I suggested how the structure of a nerve network would produce such patter-making effects. My hypothesis has since been simulated by computer, and the nerve network functions substantially as I had suggested.[2] In the world of information handling, the concept of self-organizing information systems is now coming to the fore.[3] Such systems are quite different from our usual computers.

Once we enter the "universe" of active, self-organizing systems, then the behavior of such things as perception and creativity becomes quite clear. The processes are no longer mysterious. Just as happened with the block of wood, phenomena that seemed to be unaccountable are suddenly seen to be explicable — once we have identified the appropriate universe.

The function of self-organizing system is to allow incoming experience to organize itself into patterns. We could loosely compare these patterns to the streets in a town. The self-organizing system is immensely efficient; it allows us to get up in the morning, cross a road, recognize friends, read and write. Without such a pattern-making and pattern-using system, we would spend about a month just in crossing a road.

However, the advantages of a patterning system are also its disadvantages. "Point-to-point thinking" is a good example. In this kind of thinking, we follow a pattern from one point to the next — and then follow the dominant pattern from that next point onward. In an experiment that I conducted jointly with the Inner London Education Authority,[4] I asked 24 groups of 11-year-olds to discuss the suggestion that 'bread, fish, and milk should be free." Although many of the children came from deprived backgrounds, 23 of the 24 groups opposed the idea of free bread, fish, and milk. The point-to-point thinking that led to this stand went as follows: 1) the shops would be crowded; 2) the buses going to the shops would be crowded; 3) the bus drivers would demand more money; 4) the drivers would not get more money, and they would go on strike; 5) other people would go on strike as well; and 6) there would be chaos — so giving away bread, fish, and milk is a bad idea. Thus can point-to-point thinking lead us astray, as we miss the forest while fixating on the trees.

However, direct teaching of thinking can offset the disadvantages of a patterning system. At the end of a pilot project on the teaching of thinking in Venezuelan schools, for example, we held a press conference. A journalist attending that conference claimed that all attempts to teach thinking are really a form of brainwashing in western capitalist values. The journalist happened to be wearing spectacles. So I removed her spectacles and asked what she used them for. She told me that she used the spectacles in order to see things more clearly. I then explained that the perceptual tools we were teaching in the lessons on thinking served the same purpose. The tools enable youngsters to scan their experiences so that they can see things more clearly and more broadly. A better map of the world is the result. These thinkers can still retain their original values and choices, however. Giving spectacles to nearsighted individuals enable them to see three glasses on a table — containing wine, orange juice, and milk. The individuals still exercise choice as to which drink each prefers. In the same way, our instructional program cuts across cultures and ideologies. The program is used in industrialized nations, such as Canada and Great Britain, and in developing nations, such as Venezuela and Malaysia; it will soon be used in Cuba, China, and Bulgaria — as well as in Catholic Ireland.

My point is that, in terms of perception, we need to achieve two things: 1) the ability to see things more clearly and more broadly and 2) the ability to see things differently (i.e. creativity or "lateral thinking"[5]). As I have said, perception takes place in an "active" information system. Such systems allow experience to organize itself into immensely useful patterns, without which life would be impossible. But, as I said above, the very advantages of the patterning system are also its disadvantages. We must overcome these disadvantages and improve perception in two ways: in breadth and in creativity or lateral thinking (both of which fall under the heading of "change").

Let me turn now to the second question that I posed at the beginning of this article. How can we teach thinking as a skill? Such teaching is going on right now; it is not tomorrow's dream, but today's reality. Millions of children are involved. In Venezuela, for example, 106,00 teachers have been trained to use my program, and every schoolchild takes a course in thinking. By law, Venezuela, for example, 106,000 teachers have have two hours of direct instruction per week in thinking skills. The contracts of some labor union members in Venezuela specify that their employers must make provisions to teach them thinking skills. My program is also in use in many other countries — including Australia, the U.S., and Israel, as well as those nations I have mentioned previously.

The program of which I speak is called CoRT. (The acronym stands for Cognitive Research Trust, located in Cambridge, England.) I have already outlined the theoretical foundation for the design of this program. The lessons themselves focus on the perceptual aspect of thinking. The design of the tools takes into account the behavior of self-organizing paterning systems.

The design criteria for a practical instructional program should include the following elements.

- The program should be usable by teachers who represent a wide range of teaching talents, not just by the highly gifted or the highly qualified. (The 106,000 Venezuelan teachers were not all geniuses.)

- The program should not require complicated teacher training, since it is difficult to generalize such programs. (The CoRT program can be used by teachers with no special training or with only simple training.)

- The program should be robust enough to resist damage as it is passed along from trainer to trainer — and thence from new trainer to teachers and, finally, to pupils.

- The program should employ parallel design so that, if some parts of the program are badly taught and other parts are skipped or later fogotten, what remains is usable and valuable in its own right. (This contrasts with hierarchical design, in which a student must grasp a basic concept before moving on the next concept layer; failure at any concept layer in a program of this type makes the whole system unworkable.)

- The program should be enjoyable for both teachers and youngsters.

- The program should focus on thinking skills that help a learner to function better in his or her life outside of school, not merely to become more proficient at solving puzzles or playing games.

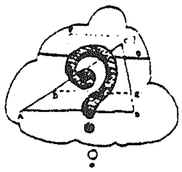
Before considering ways of teaching thinking, we must confront a prior question: Should thinking be taught in its own right? Certain practical considerations affect the answer to this question. For example, there are no gaps in the school schedule as it now exists. Thus it seems to make more sense to insert thinking skills into an existing subject area. English makes a good home, because a natural synergy exists between thinking and the expression of thought in language. In addition, the teaching style is often more open-ended in English classes than in some other subject areas. However, the CoRT program has been used effectively by science teachers, by music teachers, and even by physical education teachers.

Despite these practical considerations, I believe that we should have a specific place in the curriculum that is set aside for the teaching of thinking skills. This formal recognition is essential so that pupils, teachers, and parents all recognize that thinking skills are being taught directly. In time, I would certainly hope that the skills taught in the "thinking lessons" would find their ways into such subject areas as geography, history, social studies, and science. However, the first step is to establish "thinking" as a subject in its own right.

Having dealt with this question, we can now look at some of the traditional approaches to the teaching of thinking:

- *Logic, mathematics, and data processing.* These are very important subjects, but they concern themselves with processing, not with the perceptual side of thinking. The better that students become at processing, the more they need to strengthen their perception.

- *Critical thinking.* This is a popular approach because it is traditional. It also employs a relatively easy teaching method (the spotting of faults). This approach has only limited value, however. The spotting of faults — regardless of its usefulness in debate or argument — is only one spect of thinking. The approach includes no generative, constructive, or creative elements. The avoidance of faults does not improve one's ability to plan or to make decisions. The avoidance of faults is, to my mind, an aspect of thinking that has traditionally been overvalued.



Thinking is best taught to youngsters in the middle grades. They really enjoy thinking, and their motivation is very high

• *Discussion.* Directly or indirectly, discussion must be the most widely used method of teaching thinking. Youngsters are asked to discuss (or write essays on) a subject. The aim is to provide practice in thinking. The teacher notes and comments on faults and inappropriate uses of evidence, hoping that students will extract from these clues some general principles of thinking, which they will then use in future, unrelated situations. In reality, relatively little transfer of thinking skills from one situation to another takes place.

• *Puzzles, games, and simulations.* I have used games and problems as motivators, to get people interested in thinking. However, because of the difficulty of transfer, I do not believe that such devices have much teaching value. A skillful chess player does not transfer to his or her everyday life the fine sense of strategy developed through playing this game. A youngster may develop a puzzle-solving method, but thinking does not seem to proceed in that same fashion in real life. I have grave reservations about the traditional information-processing model of thinking, which seems more a description than a system of operating.

This brings me to the central problem: transfer and content. Does a generalizable skill of thinking exist? Many theorists think not. They believe instead that there is thinking in mathematics, thinking in science, and thinking in history — but that in each case the rules are different, just as the rules for Monopoly differ from those for chess. I do not see this as a point of view with which I must either agree or disagree totally. Clearly, subject idioms exist. Nevertheless, it is possible to establish both habits of mind and specific thinking techniques that can be applied in any subject area. For example, the willingness to look for alternatives is a generalizable thinking habit. And deliberate provocation is a technique that can be applied to generate ideas in any situation.

Because we cannot succeed in teaching generalizable thinking skills through the use of specific content materials, some theorists believe that such skills cannot exist. But there is another way of looking at this situation: the view that generalizable thinking skills exist but cannot be taught using specific content. My experience has led me to the latter viw. As I have already noted with regard to "discussion method" of teaching thinking skills, little transfer of such skills seems to take place from one situation to another. Given the mechanics of perception and attention, this is hardly surprising. If the subject of a discussion is interesting, then — by definition — attention is not focused on the metacognitive level; that is, participants are not thinking about the *thinking* that they are using to discuss the subject. Moreover, it is very diffcult to transfer a complex action sequence from one situation to another. That is why the CoRT program deliberately focuses on "tools" that can be transferred.

I have noticed among U.S. educators a tendency to try to teach thinking through content materials. This approach seems — to its proponents — to have two merits. First, this approach makes it easier to introduce thinking into the curriculum, because the material must be covered anyway (and it is already familiar to the teacher). Second, this approach seems to be killing two birds with one stone: teaching thinking *and* teaching content. But this approach is not effective. I am afraid that the nettle must be grasped. Either one wishes to teach thinking effectively or merely to make a token gesture. Attending to content distracts from attending to the thinking tools being used. Theory predicts this outcome: you cannot build meta-patterns on one level and experience patterns on another level at the same time. Experience backs up this expectation. Wherever there has been an attempt to teach thinking skills and content together, the training in thinking seems to be weaker than when those skills are taught in isolation.

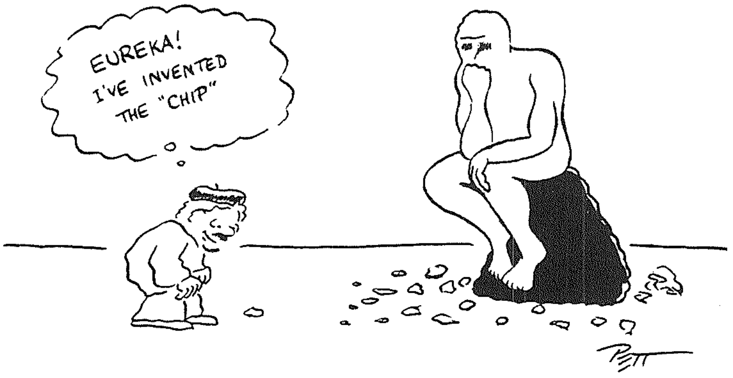
So so what is the CoRT method? It is best to illustrate this method with an example.

I was teaching a class of 30 boys, all 11 years of age, in Sydney, Australia. I asked if they would each like to be given $5 a week for coming to school. All 30 thought this was a fine idea. "We could buy sweets or chewing gum.... We could buy comics.... We could get toys without having to ask Mum or Dad."

I then introduced and explained a simple tool called the PMI (which I will describe later). The explanation took about four minutes. In groups of five, the boys applied the PMI tool to the suggestion that they should be given $5 a week for coming to school. For three to four minutes they talked and thought on their own. At not time did I interfere. I never discussed the $5 suggestion, other than to state it. I did not suggest that the youngsters consider this, think of that, and so forth. At the end of their thinking time, the groups reported back to me: "The bigger boys would beat us up and take the money.... The school would raise its charges for meals.... Our parents would not buy us presents.... Who would decide how much money different ages receive?... There would be less money to pay teachers.... There would be less money for a school minibus."

When they had finished their reports, I again asked the boys to express their views on the suggestion of pay for attending school. This time, 29 of the 30 had completely reversed their opinion and thought it a bad idea. We subsequently learned that the one holdout received *no* pocket money at home. The important point is that my contribution was minimal. I did not interact with the boys. I simply explained the PMI tool, and the boys then used it on their own — as *their* tool. My "superior" intelligence and broader experiences were not influences. The boys did their own thinking.

The PMI is a simple scanning tool designed to avoid the point-to-point thinking that I mentioned earlier. The thinker looks first in the *P*lus direction (good points), and then in the *M*inus direction (bad points), and finally in the *I*nteresting direction (interesting things that might arise or are worth noting, even if they are neither good or bad). Each direction is scanned formally, one after another. This formal scan produces a better and broader map. Thinking is used to explore, not merely to back up a snap judgement. The thinker then applies judgement to the better map. The PMI is



the first of the 60 CoRT lessons.

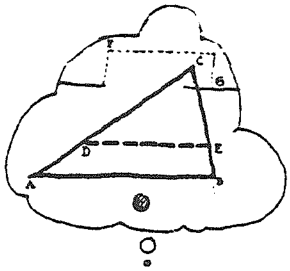
For the rest of this particular lesson on thinking, I might have asked the boys to apply the PMI in various ways (e.g., one group doing only "Plus" or "Minus" or "Interesting") to a number of thinking items, such as: Should all cars be colored yellow? Would it be a good idea for everyone to wear a badge showing his or her mood at the moment? Is homework a good idea? Note that the items are not related. Moreover, the groups would be allowed to spend only two to three minutes on each. This is quite deliberate and essential to the method.

The items are switched rapidly so that attention stays on the PMI tool and *not on the content.* Once skill in the use of the tool is developed, students can apply the PMI to other situations in other settings. One girl told us how she used the PMI at home to decide whether or not to have her long hair cut. Some children report that they have used the PMI with their parents, in discussing such major decisions as moving to a new town or buying a car. This is the sort of transfer that the CoRT program aims to achieve.

The PMI is a scanning tool, not a judgement tool. If a thinker spots 10 "Plus" points and only two "Minus" points, this does not necessarily mean that the idea is a good one. Like all scanning, the PMI is subjective, depending on the thinker's perspective. One boy said, as a "Plus" point, that yellow cars would be kept cleaner. Another boy stated this as "Minus" point — because he had to clean his dad's car and would therefore have to perform this chore more often. Both were right.

The PMI is designed to be artificial, memorable, and easy to pronounce. At first, some teachers rejected "PMI" as pointless jargon. They preferred to encourage or exhort the youngsters to look at the good points and the bad points in any situation. The youngsters probably did so — at that moment. However, without the artificial term "PMI" crystallize the process and to create a metapattern, the exhortation does not stick. One teacher told me how he had used the term "PMI" and how his colleague, in a parallel lesson, had used exhortation. His colleague was soon convinced of the value of the term "PMI."

One girl said that she initially thought the PMI a rather silly device, since she knew how she felt about a subject. But she noted that, as she wrote things down under each letter (she was doing a written exercise instead of the usual oral approach), she became less certain. In the end, the points she had written down did cause her to change her mind. Yet *she* had written down the points. That is precisely the purpose of a scanning tool.



P*erhaps the most important aspect of direct teaching of thinking as a skill is the self-image of a youngster as a "thinker." Such value images are self-reinforcing.*

It is important to realize that the description of thinking and the design of tools are two totally different things. It is possible to describe the process of thinking and to break it into components. But then one is tempted to turn each component into a tool, on the premise that, if the components are taught, thinking skills must surely be enhanced. However, teaching someone how to describe a flower does not teach him or her how to grow a flower. The purpose of analysis and the purpose of an operating tool are separate and distinct.

The CoRT tools are designed specifically as operating tools. Such design has two components: 1) the tool must be easy to use, and 2) it must have useful effect. Abstract analyses and subdivisions of the thinking process may be intellectually neat, but this does not guarantee usability or effectiveness. My many years of experience, working with thousands of executives and organizations in different countries, have given me some insight into those aspects of thinking that have practical value. I have also worked with scientists, designers, lawyers, and many others who are involved in the "action world" of thinking, as distinct from the "contemplative world."

The CoRT program[6] has six sections, each consisting of 10 lessons: CoRT I (breadth), CoRT II (organization), CoRT III (interaction), CoRT IV (creativity), CoRT V (information and feeling), and CoRT VI (action). All teachers who use the program should teach CoRT I. (Some teachers use *only* the 10 lessons of CoRT I.) Thereafter, the sections can be used in any order. For example, a teacher might use CoRT I, CoRT IV, and CoRT V. The last section (CoRT VI) is somewhat different from the other sections, in that it provides a framework for a staged approach to thinking.

I believe that thinking is best taught to 9-, 10- and 11-year olds. Youngsters in the middle grades really enjoy thinking, and motivation is very high. They have sufficient verbal fluency and experience to operate the thinking tools. The curriculum is more easily modified in the middle grades to include thinking as a basic subject. But the CoRT materials have also been used with children younger than 9 and with students ranging in age from 12 to adult.

So basic is thinking as a skill that the same CoRT lessons have been used by children in the jungles of South America and by top executives of the Ford Motor Company, United Kingdom. The lessons have been taught to students ranging in I.Q. from below 80 to 140. The lessons have also been used with groups of mixed ability.

David Lane, at the Hungerford Guidance Centre in London, found that the teaching of thinking to deliquent and violent youngsters brought about an improvement in behavior, as measured by a sharp fall in the number of disciplinary encounters these youngsters had with supervisors.[7] William Copley and Edna Copley, in preliminary work at an institution for young offenders, found similar changes.[8] They recounted how one youth, on the verge of attacking an officer with a hammer, brought to mind a thinking lesson concerned with consequences — and quietly put the hammer down. I mention these changes in behavior for two reasons. First, I believe that the true test of teaching thinking is the effect of such teaching on behavior. Second, we do not really have any adequate way of measuring thinking performance. Standardized tests are largely irrelevant, because they do not allow us to observe the thinker's composite performance.

John Edwards taught the CoRt program in lieu of a portion of the science syllabus to a class in Australia. Using an analysis-of-discourse approach to measurement, he found that the trained student did significantly better at thinking than untrained peers; the trained students even seemed to do better in science, although they had had less instructional time devoted to that subject.[9] It is not difficult to show that pupils who have had training in thinking produce a wider scan when they are asked to consider some subject. In Ireland, Liam Staunton found that, before CoRT training, individuals produced an average of four sentences on a topic, whereas after CoRT training they produced an average of 47.[10] We are currently analyzing data from the experiment in Venzuela and data from the Schools Council project in England.

I prefer that CoRT users carry out their own tests and pilot projects. Tests carried out by the designers of a program are of limited value for two reasons: 1) the conditions of teaching are ideal (and often far removed from those prevailing in schools where the program will be used), and 2) such studies always contain an element of bias.

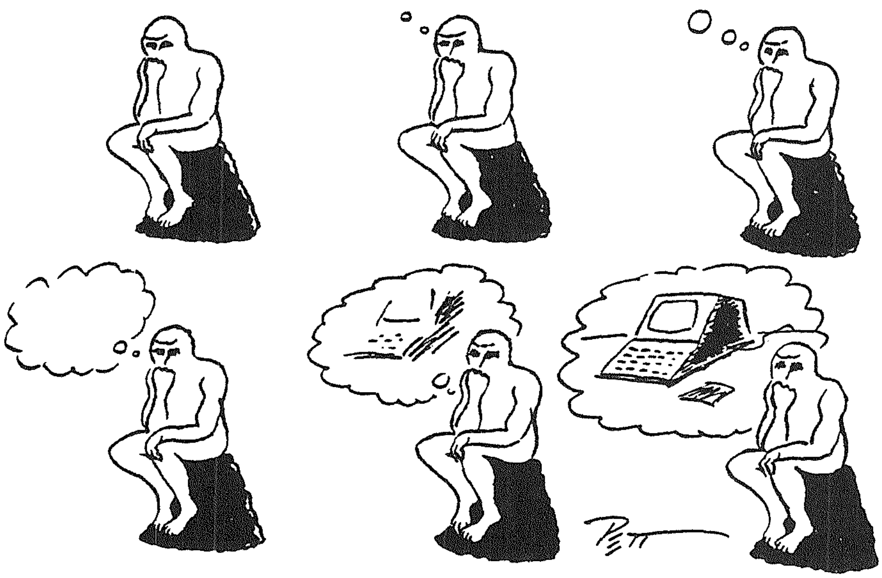
It is impossible, however, to measure the soft data: the confidence of those who have had training in thinking, the focus of their thinking, their willingness to think about things, the effectiveness of their thinking, their structured approach and breadth of consideration. Teachers often sum up these factors as "maturity", in commenting about those children who come to their classrooms after some training in thinking.

I would expect four levels of achievement in the acquisition of thinking skills through use of the CoRT program:

- *Level 1.* A general awareness of thinking as a skill. A willingness to "think" about something. A willingness to explore around a subject. A willingness to listen to others. No recollection of any specific thinking tool.
- *Level 2.* A more structured approach to thinking, including better balance, looking at the consequences of an action or choice (taking other people's views into account), and a search for alternatives. Perhaps a mention of a few of the CoRT tools.
- *Level 3.* Focused and deliberate use of some of the CoRT tools. The organization of thinking as a series of steps. A sense of purpose in thinking.
- *Level 4.* Fluent and appropriate use of many CoRT tools. Definite consciousness of the metacognitive level of thinking. Observation of and comment on the thinker's own thinking. The designing of thinking tasks and strategies, followed by the carrying out of these tasks.

In most situations, I would expect average attainment to fall somewhere between levels 1 and 2. With a more definite emphasis on "thinking," this would rise to a point between levels 2 and 3. Only in exceptional groups with thorough training would I expect to find average attainment at level 4.

Perhaps the most important aspect of the direct teaching of thinking as a skill is the self-image of a youngster as a "thinker," however. This is an operational image. Thinking becomes a skill at which the youngster can improve. Such a self-image is different from the more usual "value" images: "I am intelligent" (I get on well at school) or "I am not intelligent" (I do not get on well at school, and school is a bore). Value images are self-reinforcing. So are operational images — but the reinforcement goes in opposite directions at the negative end. In other words, the less intelligent students find repeated evidence of their lack of intelligence, but they also notice those occasions when they do manage to come up with good ideas.



1. Edward de Bono, *The Mechanism of Mind* (New York: Simon & Schuster, 1969)
2. M.H. Lee and A.R. Maradurajan, "A Computer Package of the Evaluation of Neuron Models Involving Large Uniform Networks," *International Journal of Man- -Machine Studies,* 1982, pp. 189-210.
3. John Hopfield, "Brain, Computer, and Memory," *Engineering and Science,* September 1982.
4. Unpublished material, Cognitive Research Trust.
5. Edward de Bono, *Lateral Thinking* (New York: Harper & Row, 1970).
6. CoRT Thinking Program, Pergamon, Inc., Maxwell House, Fairview Park, Elmsford, NY 10523.
7. Personal communication from David Lane.
8. William Copley and Edna Copley, *Practical Teaching of Thinking,* forthcoming.
9. Upublished paper by John Edwards, James Cook University, Queensland, Australia.
10. Personal communication from Liam Staunton.