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ABSTRACT

This discussion of heuristic learning focuses on inquiry and problem solving: their distinctions, uses, and advantages over traditional methods of science teaching. (MLH)

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HEURISTIC LEARNING AND SCIENCE EDUCATION

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This paper will serve as the basis for a journal article to be published in the near future.

Stanley L. Helgeson
and
Patricia E. Blosser
Editors

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HEURISTIC LEARNING AND SCIENCE EDUCATION

J. Richard Suchman[1]

I first became interested in heuristic learning almost 20 years ago at the University of Illinois. Some research I had been reading brought to my attention the startling fact that children were not asking questions in school. That is, they were not actively inquiring. The teachers were asking questions, but this was mainly for purposes of testing. Teachers also had all the answers. They were asking questions to see if the children had the answers. Nobody seemed to be searching for new knowledge. There was very little heuristic learning.

Having the right answer was seen as more important than having one's own answer, or raising one's own questions. The rhetoric of conclusions in Joe Schwab's words, had displaced the rhetoric of inquiry. Students were expected to be the consumers of knowledge rather than its producers. These traditions of education were at odds with the traditions of science, at least since Galileo's time. It was the rare teacher who posed the challenging questions, and who supported and encouraged the children to search for their own answers. The authoritarian litany of questions and answers was the teacher's attempt to stay in control of the learning process.

I still remember the day my son brought home a science test from his second grade class. It was a fill-in-the-blanks test and one

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of the questions was: "The ______ and the ________ are part of the earth." He had responded: "The air and the clouds" and the teacher had marked his answer "wrong," and had written in the "correct" answer: "The rocks and the trees." The next day I visited the teacher to find out where she had derived her peculiar terrestial limits! Her answer was surprisingly direct, and honest. "From the text." What troubled me was that my son was not at all disturbed by this. He seemed to accept the text as the ultimate source of truth. In fact it seemed to be a comfort to him that knowledge was so conveniently packaged, stored, and guaranteed by authorities. By the middle of the second grade he had already been indoctrinated into a closed system of knowledge in which a problem is solved by "looking it up."

The absence of inquiry in the classroom puzzled me, particularly in the light of Atkin's work as a science consultant in Great Neck, N.Y. before coming to Illinois. He was studying the abilities of elementary children to formulate and test hypotheses in science. Two results were particularly interesting to me. First, he noted that the younger primary grade children related more personally to phenomena and relied on previous personal experiences as a basis for hypothesizing. I recall one instance in which the pet turtle in a first grade class had died. Mike was discussing the event with the children, asking them to speculate as to what might have caused the turtle to die. Virtually all the hypotheses, and there were many, were drawn from personal experience. "He may have died because his water was poisoned. We fed my goldfish too much food at home and he didn't eat it all and the extra food turned the water into poison." The children were also asked to think of ways to test their hypotheses. They were almost unanimous in their willingness to plan and carry out empirical investigations. Their rudimentary notions of experimental design and controls may not have passed muster with a theses committee, but it was clear that the primary grade children from this upper-middle-class community were taking an empirical approach to knowledge and were eager to acquire their own knowledge through their own investigations.

I remember Sam Levinson's recollection that as a boy he and his cronies never accepted any generalizations without testing them. He remembered that they had heard that cats had nine lives and, taking the expression literally, they set about to test its validity. They gathered up all the cats they could find in the neighborhood and took them up on the fire escape and dropped them off one at a time. They discovered with great satisfaction that the generalization did not hold up at all. Cats do not necessarily have nine lives: one had three, another had five, and one had as many as fourteen.

The children in the older elementary grades in the Atkin study began to show signs of losing their earlier empirical basis for hypothesis formation and testing. They trusted less in their own personal experiences and deferred more to authorities for this purpose.

But age was not the only factor. The more authoritarian the teacher the more the students would look to authorities as the source of knowledge rather than their own experiences, observations, analyses,and formulations. In short, it appeared in this and other studies that children start out with a natural tendency to rely on heuristic learning to acquire new knowledge, only to give it up under the pressure of authority, something like the Inquisition.

Two facts led me to investigate heuristic learning and to look for ways to protect, support and enhance its development: (1) it is a natural learning process that starts early and works well, and (2) it is subject to inhibition in our educational system.

My first investigation was the Illinois Studies in Inquiry Training, a project which lasted for about four years. It was an attempt to teach science to upper elementary children by creating a learning environment and teaching strategy that not only encouraged the children to generate their own explanations for physical phenomena through heuristic processes, but eliminated all the alternatives. The initial design of Inquiry Training, as it was called, was based on the process of question asking. The students were first confronted by a film of a physical demonstration that seemed to defy physical laws and could not be assimilated intuitively. These demonstrations were known as "discrepant event," and we used them to motivate inquiry under the supposition that they would generate enough dissonance to prompt the children to search for new data and theories that would clear the whole thing up...demystify the mystery.

The children were aided in their quest for an explanation by having an almost unlimited opportunity to ask questions. They could verify objects, and conditions in the discrepent event and conduct experiments to test their hypotheses. The teacher provided answers to the questions, but offered nothing beyond what was asked for. One of the films showed a bimetal strip being heated over a bunsen burner flame. The blade bent in a downward arc suggesting to the naive child that the it was melting. It was next inserted in a glass cylinder filled with cool water whereupon it promptly straightened out. Placed once more on the flame with the sides reversed, the blade now bent upward! The reaction was almost always one of great surprise. Having already intuitively assimilated the event, as a case of melting, they were at a loss to account for the upward bending. Gravity pulls down, not up. "Was there some kind of trick...Something I couldn't see?" "Is there something about metals, air currents, gas flames, that I don't know?" It was our expectation that just such questions would spur the children to gather additional data, formulate hypotheses, and test them through the medium of question asking. We trained the teachers to answer all types of questions except the one jackpot question: "Why did it behave the way it did?" That answer had to come from the children. We defined the teacher's role as that of setting up the problem and serving as a data source. The role left to the student was that of gathering data and formulating and testing hypotheses.

The original inquiry training project answered a number of questions and raised many new ones. First, we learned that it was indeed possible to create a learning situation in which children were not only free to ask questions as a basis for acquiring knowledge, they were strongly prompted to do so by their own desire to find the solution to a problem. We had succeeded in designing and developing an instructional system based entirely on heuristic learning. Second, the children almost always expressed great satisfaction in this learning model. Because they could learn on their own terms, they were in the driver's seat, so to speak, and could match the learning process to their own needs and styles. Third, the inquiry training approach legitimized the heuristic learning mode which was already familiar to the children, and in fact constituted the earliest and most common learning mode known to the children. In other words, we had tapped a learning mode that was familiar and comfortable to almost all children we worked with. To a person watching a group of children at work on a problem, the differences in style became remarkably visible. The analytical child would quickly set about taking the discrepant event apart piece by piece. His strategy was to make the strange event more familiar by finding familiar parts. Once the blade was found to be made of two metals stuck together, new questions would come to mind. Did both metals behave the same way when heated? Would either of them bend when heated alone? Step by step, analysis paved the way for hypothesis formation, testing, and theory building.

The metaphorical child would look for an analog of the discrepant event. What does he know that bends when heated and straightens out when cooled? Bridges and roads buckle and curl under high temperature. What does the blade have in common with a bridge or road?

The main advantage of verbalized inquiry was the way it exposed the childrens' thinking for us, and for the teachers and the children to observe. The heuristic learning process became something that could be recorded, analyzed, evaluated, and modified. The many opportunities I had to observe childrens thinking raised an entirely new set of questions. What are the tools, raw materials, and products of the inquiring mind? How are these used when learning is self-motivated and self-directed? How do children learn when nobody is teaching them? What conditions favor heuristic learning? How can these conditions be created in the classroom? What is the function of the teacher in a heuristically based curriculum? Are there productive ways to combine heuristic learning and other educational modes such as didactic teaching, demonstrations, text books, programmed learning, etc.? In the years that followed the first inquiry training project I found some answers to these questions. But as I continue to pursue the nature and educational function of heuristic learning I keep finding greater complexity rather than simplification or closure.

I am persuaded that heuristic learning is fundamental: It constitutes the earliest and most pervasive learning in a lifetime. Furthermore, I now believe that any attempt to teach will succeed only to the degree that heuristic learning is taken fully into account and allowed to function optimally. Heuristic learning can be regarded as the process by which experience, a momentary thing, is transformed into meaning, which is a more general and durable thing. If these are valid assumptions, as I now believe they are, teachers and curriculum developers must concern themselves with heuristic learning as a precondition for effective teaching of <u>any kind</u>.

In an attempt to analyze heuristic learning, I have developed two models that help me conceptualize and describe the main elements of the process, and the relationships among them. At this time I am going to present only one of these, which represents in very simple form the manner in which experience is transformed into meaning. I call this the MEANING MODEL.

(Slide 1)

The term ENCOUNTER refers to unorganized sensory experience. We are almost continuously encountering the world around us. Unless these raw sensations are organized in some way, they remain as little more than a bombardment of the senses, an apperceptive mass. However, we have the capacity to create for ourselves, or acquire from other sources, cognitive tools which I call ORGANIZERS. Organizers come in several forms. A concept is an organizer. I am sitting with a typewriter in front of me. My eyes and ears are subject to stimulation by the presence of the machine. With no relevant organizers I may be limited in my interpretation of form, color, shape, sound variations, etc. But with the possession of a network of concepts that constitute the overall concept "typewriter" and its related meanings, my encounter with the typewriter can produce a rich fabric of meaning. I will recognize that I am indeed encountering a typewriter which is powered by electricity, operated by keys, and is a tool that permits me to compose language on paper. I am able to make the meaningful statement that I am sitting in front of a typewriter and using it to prepare a manuscript.

It is significant to note that neither the encounter nor the organizers separately can generate new meanings. The encounter is nothing more than sensory stimuli. The organizers are nothing more than tools for relating the stimuli to my existing knowledge network. But the two in combination produce meaning.

Concepts are not the only forms of organizers. Prior encounters stored away for later use may also be organizers. The second time in your life that you encounter a hot dog is more meaningful than the first time because there was a first time. You were able to recognize the second encounter as "another one of those hot dogs." You might even have the basis for a comparison. "This hot dog is juicier than the first," a meaningful statement that would not have been possible without the prior encounter with the first one serving as an initial organizer for future hot dog encounters. Bruner was dealing with the same notion when he speculated (with a twinkle in his eye) that probably the earliest sign of intelligence on this earth was when the polyp poked his head up out of the ground and said to the polpy next to him, "There goes thingembob AGAIN!"

Prior meanings can also serve as organizers. What we already accept as true will strongly influence what we make of new encounters. If you believe the Loch Ness monster exists you are far more likely to see the monster in response to practically any encounter with anything moving in the water at Loch Ness.

The MEANING MODEL is a way of describing what happens in heuristic learning. For one reason or another a person is prompted to engage in the heuristic process. He may seek to generate new meanings for himself, or he may be curious to learn why the blade bent upward. Or, he may simply enjoy the process of heuristic learning, the excitement of encountering and organizing, what J. McV Hunt calls the "motivation inherent in information processing and action."

Whatever the motivation, the heuristic learner has two ways to enhance his generation of new meanings. (1) He can intensify his encountering activities. This might entail becoming more active or becoming more observant. In either case, the net effect is to make more encounters available as the raw material for meaning generation. (2) He can enhance the generation of meaning by bringing more organizers into play. Since meaning is the function of the interaction between encounters and organizers, the more of each to be involved in the heuristic process the more meanings will result.

Thus far I have described a more or less mathematical process in which the quality of the product is not taken into consideration.

I have spoken of increasing the amount of encountering and organizing as a way to increase the amount of meaning. However, it is hardly ever the case that our needs or standards in the pursuit of meaning allow us to regard all meanings with equal urgency. Usually we are in search of a particular answer to a question or a particular solution to a problem. We have criteria by which we judge the value of a new discovery.

If we were to take a wholly random strategy we might go about randomly encountering anything and everything that happens to enter our respective phenomenal fields. On the other side of the model, we might randomly scan our store of organizers retrieving this one or that to be brought into play with the randomly generated encounters. The meanings generated might be a fascinating mosiac but the process would probably take as long to produce the desired solution as theproverbial monkeys at the typewriters would take to generate the entire works of Shakespeare.

In any case, the random generation of meaning is probably an impossibility since human beings are incapable of truly random activity. In fact, randomness like beauty may exist only in the eye of the beholder. We frequently use the term to account for events we either cannot explain in any other way, or do not wish to. If I pick up a handful of sand and release it on a table top, thousands of grains hit the table and each other in an exceedingly complex set of interactions. The laws governing the movement of each grain are well known. Had I the time and the appropriate instruments I could analyze the complex event to account for every movement of each grain based upon the size, weight and shape of each and the forces exerted on each at the time of its release. Yet we speak of the falling and dispersing sand as a random event. It is no more random than the throw of the dice. It has always been a matter of amusement to me that nothing is more controlled than our meticulous efforts to generate a set of random numbers. We so distrust our human proclivity for non-random acts that we have had to turn to special tables or computers to generate randomness!

James Austin[1] in his forthcoming book Chase, Chance, and Creativity gives us a fresh look at the element of chance in the process of inquiry, and particularly at the ways and degrees by which we can make chance work for us instead of against us. To begin with, he accepts the fact that there are situations where the outcomes are purely a matter of dumb luck. He calls this Type I Chance. His example is being dealt a bridge hand with 13 spades. The odds are one in 6.3 trillion. (Austin apparently regards the dealing of cards as a random process, but there are many losers who would argue the contrary.) In any case there is no help for Type I Chance situations.

Type II Chance tilts the odds in favor of the active inquirer. Charles Kettering is quoted as saying, "Keep on going and the chances are you will stumble on something, perhaps when you are least expecting it. I have never heard of somebody stumbling on something sitting down." In terms of the meaning model, Kettering is saying

[1] "The Roots of Serendipity", Saturday Review and World, Nov. 2, 1974, pp. 60-64.

that the more in motion you are the more encountering you will generate; and the more you encounter the more raw material you will have to organize, and consequently the more meanings you will produce. Of course, none of this guarantees quality. But as a general rule, the more ore you process at any given mine, the more metal you are likely to find.

Type III Chance involves a special receptivity and discernment in the inquirer. His mind is prepared. His encounters may be fortuitous, but the real payoff lies in the range and depth of organizers which enable him to recognize new and critical meanings when the lucky encounter comes along. Alexander Fleming is Austin's prize example. Fleming's highly special knowledge and experience gave him an almost unique preparation to recognize the significance of the dead bacillus in the presence of the bread mold, not yet known as penicillin. Only one or two other people in the world might have been so prepared to grasp the full meaning of that encounter.

By far the best odds for making chance pay off belong to those whose entire life pattern is built around the pursuit of a given area of knowledge and meaning. Then almost everything one does is geared toward producing the best matching of encounters and organizers. One spends his time in what he has come to know as the best fishing ground, as it were. He has also eliminated those organizers from his active repertoire that have proven to be least productive in the past. The inquirer operating on Type IV Chance has evolved a life style that supports his particular brand of inquiry, and has honed his encountering and organizing down to a highly efficient process. He has learned how to avoid wasting his time and energy on unproductive forms of activity. Furthermore, he has accumulated so many encounters and organizers that he can spend large amounts of time carrying out encounter/organizer matchings in his mind without the need of concrete empirical operations.

It is interesting to note how closely Austin's Chance levels parallel Piaget's stages of epistomological development. Where Austin speaks of Type II Chance as action increasing the odds for discovery, Piaget in a similar sense refers to the sensory-motor stage which is characterized by unplanned actions something like play. David Hawkins promotes "messing about" as a vehicle for this and Robert Wirtz achieves it through a mathematics program that generates above all a "friendliness with numbers." All of this corresponds to learning based on encountering, acquiring organizers, and engaging in a free process of matching the one with the other to produce new meanings.

Austin's Type III Chance, where the odds of discovery are enhanced by the prepared mind, corresponds to Piaget's concept of operational thinking. In both instances organizers govern the encountering process and serve to give meaning to the encounters as they occur. In contrast to pre-operational thinking, in Type III Chance the structures of the mind, the organizers, <u>guide</u> the encountering rather than following in its wake. Piaget's distinction between concrete operations and formal logical operations can be seen in terms of the meaning model. In the case of concrete operations, encounters are varied within a fixed framework of organizers. The resulting events are noted as discrete meanings. (E.g. "When I did X,Y was the result.) and form the basis for generalizations (E.g. "Whenever I do X, Y is the result"). Formal logical operations do not rely at all on encounters. Instead, the mind manipulates the previously formed meanings, i.e., generalizations, which results in the recognition of constant relationships or laws. ("S is releated to Y in the following manner.") Typically, the discovery of regularities is experienced as sudden ("aha"), but the preparation for such discoveries must be inherent in the preparation of the mind through a buildup of organizers and meanings and a learning environment that is repleat with opportunities for encountering.

There is considerable evidence from the work of Kubie[1] and others that a large portion of the screening of encounters, the scanning for appropriate organizers, and the trial matching between elements of each takes place in the area of the mind known as the preconscious. This area is not governed by formal rules of logic as is the conscious zone, nor is it governed by the powerful pressures to disguise unwanted feelings that are found in the unconscious. The preconscious acts as the play area where new patterns of throught are rehearsed, where almost anything goes, and almost nothing is for keeps. It seems to be the ideal cognitive

[1] Kubie, L.W.,"Research in Protecting Preconscious Functions in Education", in Nurturing Individual Potential, A.H. Passow (ed.) Wash. DC, Assn. for Supervision & Curric. Development, 1964, pp. 28-42.

setting for the process of running off trial matchings between encounters and organizers. Here neither rules nor vested interests within the mind can bias the generation of meanings. There is little doubt in my mind that the world of the preconscious is the home of heuristic learning. The moment we unleash powerful emotional needs or impose rigid rules of logic on the search for personal meaning, we throw the delicate process of heuristic learning out of whack. No new meanings emerge.

To be sure there are many scientists and science teachers who believe that the young mind must first be disciplined in the history and traditional methods of a science before it is allowed to assume the role of inquirer or researcher. All too often the exhibits at science fairs reveal how thoroughly the students have incorporated segments of the history of science rather than pursuing questions of their own.

If it is true that heuristic learning resides in the preconscious, we must learn more about the conditions that liberate and support this area of the mind. One things seems certain from my own experience and that is that heavy handed teaching may produce outward conformity in students but it is certain to mess up the delicate processes by which personal meanings are generated.

It may sound insane to say this, but I believe that teachers and students need to be encouraged to play, to go crazy, and to be irrelevant. Play is a creative process. Its justification is intrinsic. One does not play to achieve some other purpose.

Play brings immediate satisfaction. It's fun. One truly at play is not concerned about outcomes or the judgements of others. He is too absorbed in what he is doing, and how he is feeling. Play is a form of heuristic learning.

Play is often regarded as non-productive because it _is_ fun. But play also generates encounters and organizers, and new meanings. Playing with a flatworm, a pocket calculator, or a set of pulleys is bound to produce heuristic learning. It is only when play becomes unplayful and firm, that it loses its heuristic qualities. Most golfers I have seen are not playing. It appears more as though they are working. What is to prevent science education from becoming a form of play?

Now, about students and teachers going crazy: "Sane" people are predictable. What they say and do fits the norms so they are outside the institutions. Crazy people are not predictable and don't follow the norms. They are inside the walls.

Where heuristic learning is concerned, the less conventional person is more likely to generate the more original and creative meanings. His use of organizers will be less likely to follow traditional patterns.

The Synectics[1] people at Cambridge have become quite successful at teaching people problem solving through the use of metaphor. They break out of old ruts in their thinking by deliberately taking familiar encounters and making them strange through the unconventional use of organizers. The results are usually refreshing and creative.

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[1] Gordon, W.J.J. & Tony Poze, _Synetics_, Synetics Educational Systems, Cambridge 1973.

A beautiful example of this ocurred in a fifth grade science class when a girl named Karen and a few of her classmates were inquiring into a discrepant event in which two men were eating soup at a restaurant. One man got up, walked around to the front of his table and quickly jerked the tablecloth out from under a complete table setting. Nothing fell from the table. The second man, intrigued by what he had just seen did what appeared to be the same thing to his table cloth, except that almost all the dishes fell to the floor.

Karen spent about thirty minutes with her teacher and classmates asking questions, experimenting and formulating hypotheses as to what had happened in each case, and what accounted for the difference. Finally, she burst forth with an "aha!" "You see, it's something like people. When you jerk the table cloth out suddenly you get it out before the dishes realize what is happening. But when you do it slower, the dishes have time to grab on and so they go along with the cloth." By some standards Karen might be thought crazy. Her hypothesis was far from conventional. Her metaphor of "things grabbing on" was a creative use of organizers that wasn't too far from the conceptsof friction and inertia. And in the absence of these two organizers she made do very well with what she had.

The question of relevance is a sticky one where inquiry is concerned, mainly because true inquiry is a response to the goals of the inquirer himself. If suddenly his search veers off in a new direction, who is to say he is being irrelevant. Under the conditions of traditional learning, relevance is determined by the topic of the moment, determined by the course, lesson plan, text, or the teacher. Deviations from these are called irrelevant. I recall a high school English teacher who was very easy to get off the track with irrelevant questions. He and the class enjoyed these detours enormously and I dare say that we learned more from them than the more formalized and preplanned lectures.

To bring this paper to a focal point that is both concrete and practical, I would like to describe a particular form of heuristic learning whose great potential I am just beginning to appreciate, and that is problem solving. While I have always been aware of the term and the concept in its broadest sense, in recent years I have been experimenting with the problem solving format as a design for instructional systems. The key elements of problem solving as an instructional problem are:

1. A learning objective for which the problem was selected or designed.
2. A clear goal for the learner. This would consist of a product or some form of problem solution.
3. A work medium within which the learner operates in an effort to reach the goal or solve the problem. The means for solving the problem or reaching the goal must not be obvious or immediately evident to the learner.
4. Constraints that prescribe or proscribe problem solving activity. The rules of the game.

With the clear goal in mind and the work medium at his disposal the learner, in the absence of an algorithem or other known formula, must find or create a way to proceed. In short, he is cast inevitably in the role of heuristic learner. The distinction between problem solving and inquiry is in the goal setting. For problem solving the teacher or other person sets the goal. It is only when the learner sets his own goals that the process becomes inquiry.

Problem solving has a number of advantages that may not be immediately obvious. First, of course, it is a form of heuristic learning with all of the attendant advantages outlined earlier in this paper. Second, there is an important division of control between the teacher and the student. The teacher designs the problem to suit the learning needs of the student. If the objective is to learn electrical circuitry, the problem is couched in that area. The teacher in designing the problem establishes the learner's goal, the work medium, and success criteria. He may provide batteries, bulbs, wire, wire cutters, a switch, and whatever else might seem appropriate,although not all of it necessary. The goal would be to make a bulb light. All of the foregoing elements would be the result of teacher decisions. The learner is free to decide how to approach the problem. In other words, he is in control of the learning process. The elements of the instructional problem design are by no means limited to what I have just described. These are just the essential elements. Once the student has begun to engage himself with the problem, the teacher is in an excellent position to observe the heuristic learning process and judge for himself whether intervention is called for and when, how and by whom it should be applied. Intervention can take many forms. The teacher's very presence, available to listen to ideas, to encourage experiments, to raise questions can lend support to the learner. Or, if the problem is quickly solved, the teacher might extend the learning effort by raising new questions such as: "Can you find another way to make a bulb light, using the given materials?" And even further down the line, "What things or arrangements of things are absolutely necessary for a bulb to light?" Notice how the questions build from simple generalizations to the formulation of principles.

Other forms of intervention include the introduction of new encounters and/or new organizers to increase the odds of creating the meaning required by the problem goal. Several demonstrations of simple circuitry could be given. The student could be encouraged to take working circuits apart to see what changes make the light go off. If the key organizer of the simple series circuit does not become apparent to the student, the teacher can further intervene by introducing the organizer and illustrating its importance in electric circuitry. It is not at all necessary for the student to arrive at the problem solution entirely by himself. The important factor is that he is working toward that goal heuristically and has access to assistance when he needs it. In the problem solving mode, the learner is in the driver's seat. He is in control of the central heuristic process of matching encounters and organizers to create his own meanings. He is free to negotiate this delicate process according to his own cognitive needs and style. He can move at his own pace and in accordance with his own cognitive style. He has access to help on demand. He is working in an environment which is designed to support heuristic learning. At any time, the teacher who is observing the heuristic learning process, which is by nature open and visible, can intervene to provide assistance or modify the conditions of the problem either to pose new challenges or alter the level of difficulty.

Any time a student elects to design his own problems and set his own goals he has made the crucial shift from problem solving to inquiry. Having made the bulb light he may now want to design more elaborate circuits. In both problem solving and inquiry no potential resource need be automatically excluded. Recourse to reference books, texts, consultants and fellow students are all legitimate sources of organizers. I have found the children happy to adhere to one ground rule. Regardless of the resources used, the student or group of students working on a problem must formulate the solution themselves. Encounters and organizers can be obtained from any source, but meanings must be personal and original.

The fact that the children generally insist on that rule should be an important message to all of us. We are, after all, dealing with creatures who are very sophisticated learning systems. They are born to learn without even thinking about it.

From birth they instinctively go about it the right way, and are eminently successful. They learn to walk, understand and speak a language, to make highly refined perceptual discriminations well before their second birthday, and all without the benefit of teaching. As we contemplate interventions we would be wise to tread cautiously. If we must teach, let us not forget that our clients, who never invited us, were accomplished learners long before we came on the scene.