The Warp and Woof of Curriculum Development

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Several years ago, working with a Manhattan public school teacher, I designed a program to help bottom-tracked fourth graders learn to read using their own oral compositions. The teacher and I became interested in the spontaneous questions that the children always seemed eager to ask during rare leisurely moments. Their questions didn't fit the many curricula available in the class, although the curricula sometimes sparked the questions. Nor could their questions be answered with a few words or by handing them a book. When a Chinese-American fourth grader on the Lower East Side asks you why people are different colors, a pat answer won't suffice. A scientific answer presupposes a background of information and concepts, a way of reasoning about the answers to your questions.

The children's questions also displayed an expansive interest in the world, ranging over exotic animals, the solar system, people in other parts of the world, oceans, volcanoes, world maps, etc. Both boys and girls were obviously interested not only in the pieces of a puzzle but in how all the pieces fit together. The similarity of these children's questions to those I had asked growing up in rural Michigan years ago was astonishing. I began to wonder if piecing together a model of the world is a universal task of middle children – the years between six and twelve.

The teacher, Bill Currier, and I began to think about how the children might be able to reason through answers to their own questions. For example, if a child asks why human beings have different skin colors, what information and activities will enable the child to reason about possible answers to the question. What seemed to be required from children to achieve this process of thinking was a coherent program of studies with a structure based on the questions, interests, and logic of children in this age range; a program that explored an organized view of the world.

It was obvious that a lot of brainstorming and basic research would be involved; it was not so obvious how long construction of a curriculum would take or how difficult it is to reconcile competing views of child development and competing aims of education. Bill had been teaching the Bruner-inspired curriculum, *Man: A Course of Study,* and from that experience it was clear to us that Bruner's idea of translating the basic ideas of a field of knowledge into the thought forms of children is flawed (Bruner, 1968). Instead, we wanted to begin with the fields of knowledge, basic ideas, and thought forms suggested by the children's questions. We drew upon the theory and research methods of Jean Piaget to help us understand more clearly how children view the world. We wanted to design the curriculum experimentally, in classrooms where we would be in constant contact with children and experienced teachers. It was a wish that, from

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the beginning, brought us face to face with two fundamental problems: how to blend and balance children's exploratory thinking with a coherent body of knowledge about the world; and how to organize the process of gathering information so as to guide the designing of the curriculum. A small-scale, clinical approach to curriculum development, involving only a few classrooms and researchers, with teachers and researchers working in a partnership, was clearly more appropriate for this kind of research and development than the large, expansively funded projects popular in the 1960s. This paper will expand upon the problems we faced, the solutions we worked out, provide a sketch of the curriculum, and conclude with some guidelines that might have broad applicability.

CHILDREN AS PHILOSOPHERS

Early in his career (1931), Piaget wrote an essay called "Children's Philosophies" in which he asserted that the differences between the way children and adults view the world is not predicated on children's ignorance. Rather, children and adults have different epistemologies. The structure and process of a child's thinking, and therefore a child's ideas, differ fundamentally from the conceptions of adults, but the child's view of the world is no less authentic. Piaget has devoted his long and still active career to researching and describing the mental processes of children and the stages through which these processes develop. It is an extremely complex, theoretical, and expansive literature, including books such as *The Child's Conception of the World* (1960), *The Child's Conception of Physical Causality* (1969), and *The Construction of Reality in the Child* (1971). But the complexity need not obscure the simple clarity of the fact that a child has an epistemology. Conceptions of the world are not acquired by being exposed to "correct" ideas. Children do have conceptions of the world. The question is how those conceptions evolve and what kinds of information and activities help children deepen and expand upon their ideas.

Our work concentrated itself on children in the third, fourth, and fifth grades. Around the age of seven or eight, children typically develop a stage of thought that Piaget calls concrete operations. They become capable of forming, manipulating, and coordinating logical concepts. These new intellectual operations have enormous implications. In combination with language (and symbolism in general), thought is liberated from immediate experience and is able to range over time and space. Thought becomes detached from actions so that concepts can be represented and manipulated in the mind. Reasoning becomes capable of dealing with cause-and-effect. The physical world, which has previously been viewed as an extension of the child's own actions and feelings, is not viewed objectively. Reasoning remains delimited to the concrete world until adolescence (when thinking becomes propositional), but these powerful new instruments of thought, which amount to a system of logic, make a new epistemology and view of the world possible.

It is important to remember that the intellectual operations described by Piaget are achieved only gradually and imperfectly. Applications to diverse fields of knowledge depend upon a child's experience and education. But these mental operations do help explain why there is a new range of thought, a greatly enlarged interest in the objective world, during middle childhood. This new scanning of the world, which can be both exhilarating and puzzling, was the source of the questions children were asking in Bill Currier's classroom.

OVERVIEW OF COURSE CONTENT

Thinking about how children answer their own questions turned us to a consideration of which disciplines represent broad, coherent perspectives on the world. Subject matter was, of course, suggested by the children's questions, and I want to explain just how the topics and concepts were chosen and shaped compatible with children's interests. But it will be useful, first, to give a general overview of the content of the developed course.

The curriculum is organized around a sequence of four disciplines: astronomy, physical world geography, zoology, and physical anthropology. Each discipline embodies a distinctive perspective on the world, yet the perspectives are interrelated. Each obviously contains a rich array of concepts of fundamental significance to a world view. The Copernican view of the universe, for example, began a revolution in thinking and astronomical exploration that is just peaking today with space probes beyond Jupiter and revised theories of the universe. World geography has been extended from cartography to photographs of the earth from outer space, to mapping the ocean bottoms, and to theories of drifting continents. Descriptive zoology has achieved a worldwide picture of the vast kingdom of animals; evolutionary zoology enables us to reconstruct the underlying structural unity of all animal life while tracing the differentiation of a single branch such as the mammals into the higher order of primates, including man. Physical anthropology offers new explanations of where we have come from and of why, despite a common ancestry and identity as a species, humans are so varied. There is plenty of fascinating material here to sort and sift into a course of study with a powerful view of reality. The real problem is how to delimit, sequence, and shape the material around the thinking patterns of an age group.

Our premise was that the construction of a world view should begin with the most encompassing conceptual framework that makes sense to children. The course, therefore, opens with a unit of solar system studies. They frame the rest of the curriculum in important ways. Learning about the discrete objects in the solar system – their attributes, movements, and classification – begins a chain of reasoning about the nature of physical reality which, if systematically cultivated, can carry into more emotion-laden subjects like skin-color variations among humans and human relationship to other primates in the animal kingdom. The solar system also conveys the Spaceship Earth perspective, a decentered, outside view of the geography and unity of life on the planet.

Many people argue that elementary school social studies and science should be organized around the local community and common phenomena, moving from the familiar to the unfamiliar. But anyone who has listened closely to children will know how many questions and ideas they have about subjects far from the local or common, such as the sun, moon, stars, and planets. The following questions were collected from children in several third and fourth grade classrooms:

> How was the moon made? How do the stars shine at night and how does the moon glow? How long does it take for the moon to get refilled? Why

> does the moon follow you when you walk? Why doesn't the moon fall? How did the earth get a moon? How did the sun get where it is? Where did the sun come from? What is inside the sun? Why does the sun shine? How do the planets move around the sun? Are there seas on other planets? Why is Saturn tilted on an angle? Why does Saturn have rings? Why does Jupiter have so many moons? Who gave the planets their names? How did the solar system start? How do spacemen get to the moon?

It is also said that inner-city poor children are intellectually deprived and ought to concentrate their energies on basic skills. Much of this curriculum was designed while working with such children and they were as excited and thoughtful about the solar system as children from more privileged circumstances, whether in the city or suburbs. This is not to argue against basic skills or studies focused on the everyday life of children, but to argue for enabling children to use the full range of their intellects in school settings.

The solar system studies are organized around information and conceptual tasks selected through a process of research described later in this paper. The topics include differences between planets, and between stars, planets, and moons; how the planets got their names and the celestial mythology of many cultures; the relative sizes of objects in the solar system and a scale of distances between them; planets as spheres, how they move in space, and how light and gravity act upon them; the human adventures and technology of space exploration; use of telescopes; and how the solar system as a whole is organized. The pedagogy, which will be described later, too, is designed to help children go beyond verbal learning to conceptualize these phenomena. The solar system is a well-worn topic in American elementary schools. What is new here is the entry into the subject through the context of children's questions, a pedagogy designed to develop logical operations in the Piagetian sense, and the relationship of the subject to other parts of the curriculum. The traditional program of reading, with pictures and even films, is inadequate for these ends.

The second unit of the course focuses on the physical geography of the planet earth, as if viewed from space. The central content is the topography of the continents. Phenomena such as volcanoes and the water cycle, which engage casual reasoning, are examined. The oceans, using Rachel Carson's classic, *The Sea Around Us,* are explored. After topography, map reading skills are introduced. It is a brief unit with a simple purpose: to bring children to the point where their geographical reasoning is sufficiently elaborated to think about animals and humans in terms of world geography.

The third unit is composed of studies in the animal kingdom. The children formulate a classification of all animals known to the class, arranging them in named groups and listing the attributes they have used to form the groups. The same animals are then studied in terms of attributes underlying scientific classification, and reclassified. Where these animals live in the world is identified and the surrounding environments examined. The unit then concentrates the children on the class of mammals, examining mammals in terms of the children's interests and basic concepts of anatomy, behavior, and adaptation to the environment. The heart of the unit is comparative case studies of whales and wild chimpanzees, emphasizing mammalian characteristics and primate specializations. The ethical dilemma of man's relationship to whales and chimps is posed. The chimpanzee case study is constructed from Jane Goodall's work and will be sketched in more detail later in this article to illustrate the pedagogy involved and the children's responses. The concepts that grow out of these case studies underlie the final unit on humans.

After exploring the children's conceptions of "cave man," the last unit introduces the fossil evidence for extinct pre-man and the children speculate about classification in the primate order. The evidence for the subsequent major stages of human evolution is examined – Homo erectus, Neanderthal, and early modern man. Cultural innovations, geographical radiation across the continents, and both physical and cultural adaptations to parts of the earth are introduced through themes such as hunting strategies, shelter, the family unit, communication, etc. Simple genetics underlying variations in eye color, hair, and fingerprints are considered. The curriculum concludes with consideration of several dilemmas involved in man's relationship to the resources of the earth and possible rules for governing our personal lives and communities.

THE PROCESS OF SHAPING THE COURSE CONTENT

During the 1972-73 school year, four elementary school teachers* agreed to work on the project, with their classrooms as the experimental base. As a group, we developed two general objectives. First, we met together every week or two and developed plans or compared activities, materials, and the response of children. Each teacher had enormous latitude to try out his or her own ideas. Secondly, we collected enough information by the end of the school year to sketch a first draft of the curriculum as a whole. My role was to chair the meetings, keep an account, and work in the four classrooms collecting data as time permitted.

**Bill Currier, P.S. 1; Margot Jones, P.S. 42; Harrison Knight, P.S. 42 (experimental class for disruptive boys); Zina Steinberg, P.S. 42, all on the Lower East Side of Manhattan.*

One of the pitfalls of curriculum design is trying to consolidate a plan before you have sufficient information from classrooms. On the other hand, you have to work with some kind of plan. So we defined four general questions meant to provide both a flow of information and criteria to guide us when the year's experience came to be distilled into a first draft. The questions were the following:

1. What knowledge is basic to a world view?
2. How do children reason about this knowledge?
3. What specific concepts and topics are most interesting to children?
4. What forms of transactions between children, teachers, and subject matter are most effective?

These four questions represent competing, even conflicting, interests in education. In regard to the first question, Bruner argues with great clarity that the central purpose of education is teaching the basic ideas of important fields of knowledge; the accompanying mission of the curriculum developer is translating those basic ideas into the thought forms of children. But from a Piagetian perspective, the concept of teaching basic knowledge, even in the broad context of a world view, is didactic and places the cart before the horse. *Man: A Course of Study,* where the aim was to take basic concepts from the social sciences and introduce them to children, provides many examples of this strategy: the distinction between innate and learned behavior, the theory of natural selection, or structure and function in animal anatomy. In other words, teaching basic knowledge can mean imposing adult concepts or the structure of a body of knowledge on the spontaneous ideas developing through the child's activity. This leads to an emphasis upon mastering specified concepts rather than upon elaboration of the structure of thought itself.

The second question – how children think about a field of knowledge – is closer to Piagetian or child-centered interests; through children's expressed interests and questions, and through their actions and structures of thought, their view of the world can be understood. Here, we were seeking some balance between the traditional aim represented by the first question and the Piagetian aim represented by the second.

The third question seeks to sort out within a domain of knowledge what topics and what concepts are of greatest significance to children, emotionally as well as cognitively. This interest has been best articulated within the tradition of psychoanalytic theory, through such books as Richard Jones' *Fantasy and Feeling in Education* (1968) and Erikson's *Children and Society* (1963). The focus here is on fantasies, inhibitions, repulsions, arousal, attention, personal interests, and the preoccupations of a particular stage of life. The idea that concepts have emotional significance is not new, but it is not well stated in Piaget's or Bruner's writing and is seldom given much attention in curriculum development. We were interested in locating those intersecting areas in children's lives where feelings and ideas come together, generating intellectual excitement. Whales and dinosaurs are good examples. These animals conjure up fantasies of monsters in children and at the same time they are willing to master the most realistic details about these animals. Social structure in animal species – group and family life – is another example of where children's personal feelings arouse intense interest in academic concepts. A final example is mythology, where enlarged characters, actions, and emotions have an affective appeal to children and at the same time stimulate them to distinguish between fantasy and reality. Through collecting data on children's affective responses to topics and concepts in a curriculum draft, we had a guide to where learning was lively and where it was absent.

Answering the fourth question amounted to probing for effective pedagogical strategies, taking into account a number of factors: the centrality of children's need to manipulate objects, to make and observe things happen, and to have social intercourse with peers if logical operations are to be developed; the practical constraints upon teachers with 25 to 30 children to manage; the limitations upon resources; the modes of inquiry traditional to disciplines; and multiple learning outcomes.

These categories of information were collected in several ways during our exploratory year. Children's questions and ideas were collected from small group discussions and clinical interviews. We collected the drawings and models they made, and we observed their activities with structured materials. Of the many lessons, materials, and instructional sequences worked out by the group, or individually by the teachers, we worked towards a consensus about what worked best. Thus the project moved towards the point at which the work of curriculum design could become systematic without losing touch with the children and teachers. This is sometimes called the predevelopment or formative stage, in which a project takes on a theoretical perspective, produces a rough draft, and blocks out areas and methods for further investigation.

By the summer of 1973, we were ready to make our blueprint for the course. In the spring I had taken a job at Yale and the project gained access to some of that university's resources. During that summer, two tasks had to be accomplished. The broad general plan had to be differentiated into detailed units with discrete lessons and objectives; and we had to get organized for further, more defined, experimental teaching and research in the classrooms during the 1973-74 school year.

YALE STUDY GROUP

At Yale, several child psychologists, departmental scholars, and New Haven teachers became interested in the project. Under the rubric of a "Study Group on Child Development and Curriculum," we met regularly in a summer workshop to discuss, debate, and mull over the experiences of that first year. Several important ground rules were required for a group of this nature. The mix of expertise was one, so that any issue could be viewed from several angles. The group agreed to follow up on the summer discussions by meeting monthly during the school year while the new plans were being classroom-tested. The teachers' views were examined from a theoretical perspective and vice versa. The four questions stated earlier in this article acted as criteria for designing the parts of the curriculum out of the multitude of suggestions from within the study group. At this point, our answers to those questions were partly data-based and partly professional opinion.

The workshop made for an exhilarating summer. The group mulled over subjects ranging from how children develop spatial concepts and think about the evolution of species to hypothetical activities for teaching the movement of the planets and the physical geography of the continents. A Yale astronomer, John Larson, summarized for the group what is known about the nature of the sun in comparison to other stars and joined in the speculation about what might be taught to children about the sun. The Yale observatory telescope was made available to the group and used many times in the following years. David Philbeam, a Yale anthropologist, summarized recent theories of early man and made available the department's collection of fossil casts and film library. Tom Achenbach, a Piagetian scholar at Yale, gave a series of talks on intellectual development in children and the implications that have been drawn for classroom instruction. Out of this rich process of brainstorming, individual or paired members of the study group were assigned to draft specific parts of the units, bringing their work back into the group for critical review and polishing.

An interesting illustration of the process of drafting parts of the course is the animal classification exercises of Unit 3. One of the teachers had discovered that his class possessed considerable knowledge about animals. They readily classified a long list of animals known to them into related groups or "families." These groupings, however, did not match scientific classes. Rather than didactically teaching the correct classes, the teacher had probed his children's thinking and discovered that they thought in terms of attributes that are not reflected in classical taxonomy, a fact predicted by Piaget's theory. For example, the class made the following kinds of groupings.

horse family: four legs, breathe air, tails,
good runners, square teeth, fur.

dog family:	four legs, sharp teeth, fur, claws, paws and pads, fight with teeth, breathe air, smarter than horse family.
shell family:	hard shells, live in sea, close up tight.
traveling fish:	live in sea, travel, gills, scales, fins, teeth, breathe water, eat little fish.

This procedure for inductive logic was incorporated into the curriculum because it enables children to use the logic of zoological classification in their own terms. It also reveals which animal attributes used in scientific classification are not part of the children's spontaneous reasoning. We were then able to design observational exercises that cultivate an understanding of the characteristics of five scientific classes of animals: reptiles, birds, amphibians, fish, and mammals. We believed that this method of approaching animal classification with children might make learning less verbal and shallow, more operational and exciting, a proposition which could be classroom-tested.

The study group also defined procedures for gathering data while the new draft of the course was being taught, the most important of which was the clinical interview of individual children using methods recommended by Piaget. An interview protocol around the key concepts in each unit was designed. Using a sample of children, these interviews were to be conducted by the teachers and other members of the study group before and after each unit was taught, a procedure that enabled us to gather systematic data on the children's spontaneous and instruction-influenced conceptions of varied subjects, and one that proved invaluable in choosing the operations to be emphasized. In the process, the teacher became intimately familiar with the children's levels of thinking.

Other research procedures were devised, as well. We keyed classroom observations by nonteaching members of the study group to various lessons and activities. In order to see at least a profile of children's involvement in the curriculum and their cumulative learning over an entire school year, we decided to prepare case studies of one boy and one girl in each classroom. Instruments were devised for evaluating the students' progress through each unit.

The study group process outlined above continued with increasingly refined drafts of the units and research questions through the next two school years and summers until we completed a final draft of the curriculum in the summer of 1974.

BALANCING TWO PRINCIPLES

The study group was seeking to balance Bruner's principle of selecting the most important and basic concepts from fields of knowledge with Piaget's principle of teaching to children's developmental stage of questions and exploratory thinking. A further illustration is the Unit 3 case study of chimpanzees. We knew we would have to prepare children carefully before approaching the major concepts of Unit 4 – human relationship to the animal kingdom, stages of human evolution, and the unity and variability of the human species around the earth. The popular mythology of "cave man" obscures the great cultural achievements and human qualities of early humans. Emotion-laden and sometimes religious beliefs conflict with the kinship between humans and other primates. A grasp of the stages of human evolution requires detailed attention to fossil data. So we planned the case study of wild chimpanzees to establish a base of knowledge about primate physical and behavioral specializations within the general mammalian pattern.

Initially, we had no clear sense of just how much children could learn from an in-depth zoological case study of chimpanzees. To explore the possibilities, we showed children in several classrooms an extraordinarily vivid and detailed film, "Miss Goodall and the Wild Chimpanzees," and followed with open-ended small group discussions and individual interviews. They turned out to be intensely interested in certain themes: (1) chimp communication and whether they have a language or not; (2) comparisons between chimp and human anatomy; (3) social behavior, especially the bonds between young and adult chimps; (4) tool-making; (5) intelligence; (6) the African environment; and (7) Jane Goodall's life and work. Voracious reading and a lot of drawings about chimps followed the lively discussions, and the children spent a lot of time examining the photographs of chimpanzees in the *National Geographic Magazine* and *In The Shadow of Man.* We knew immediately that we had both an excellent background study for early man and the core of the animal kingdom unit.

Using Goodall's *In The Shadow of Man,* we drafted a series of booklets to expand upon the information introduced through the film and the themes of most interest to children. The first booklets concentrated on an old mother chimp, Flo, and her family unit, including the growth of a newborn, Flint. Other topics in the series include "Chimp Calls and Faces," "How Chimps Use Their Bodies to Communicate," "Fights," "Rituals," "Chimp Infancy," "Chimp Childhood," "Chimp Adolescence," "The Adult Chimp," and "Chimps are an Endangered Species." Activities were designed that have the children investigate their own infancy in comparison to Flint's development, construct a model of the chimp's natural environment in Africa, compare chimps to other great apes and primates, and compare the structural and functional differences between chimp and human skeletons. A version of the Scopes trial was introduced to illustrate the controversy that sometimes surrounds scientific ideas and the particular idea that humans and apes are related.

THE PEDAGOGY OF THE COURSE

The combination of experimental teaching and group analysis of feedback from classrooms enabled us to generalize a pedagogical sequence that interrelates the Piagetian theory of concept formulation and classroom activities related to specific domains of knowledge. This sequence can be summarized as follows:

1. **Articulation of spontaneous concepts.** Each unit opens with the teacher conducting clinical interviews, moderating small group discussions, and introducing an array of unit-related materials into the classroom. These strategies put the teacher in the role of listener and observer, and serve several important functions. First, children are given the opportunity to make their spontaneous conceptions explicit to themselves and others in language or through the manipulation of materials; their interest and their questions in a domain of knowledge are aroused; and a plurality of peer viewpoints is introduced to each child. Secondly, the teacher gains ac-

cess both to the children's concepts and levels of reasoning, and to an inventory of questions and problems that can be integrated into the ensuing instructional activities.

One can get a sense of the texture of the clasroom during this process by examining children's thinking in response to a question in the clinical interview protocol: "Where does the moon go in the daytime?" Frequently, the children said that they had never seen the moon in the daytime. They had varied concepts about where it goes:

Mitchell (age 7.10): *Sometimes you can see it, about twice a year. The moon turns and slows down and doesn't turn around fast enough.*

Beverly (8.3): *In the morning it turns into a sun. In the afternoon it gets down and hides behind the bushes or the clouds.*

Kenny (8.4): *The moon goes somewhere behind, like behind the clouds until night and then the earth rotates again and the sun hides behind the clouds and the moon comes out.*

Susanne (8.7): *The sun is racing the moon and the sun goes faster and it gets up earlier in the morning.*

Bridget (8.9): *It goes home. It lives in the sky, and it comes back at night because it knows it's nighttime.*

Often the children's preoccupation with the questions continued after the interviews. For example, the children in our classroom noticed the daytime moon for the first time on their way to school, an observation that contradicted what they held to be true. When that observation was reported, an animated discussion followed:

Frank: *The clouds covered the sun so the sun couldn't shine on the earth, so it shined on the moon.*

Teacher: *Does everyone agree with Frank's theory?*

Crystal: *I think the moon just stayed out all night, from night till day.*

Kenny: *I've never seen the moon stay out from night till day before. From what I've seen it's always cloudy when the moon's out in the daytime.*

Teacher: *Is it always cloudy when the moon is out?*

Tony: *The only reason we see the moon now is because the moon orbits the earth and that's why we see it now.*

Thomas: *If the clouds cover the sun, then how come we see it now?*

Frank: *Because when the sun is shining on the moon, the moon lights up the earth.*

Angela: *I don't think clouds are blocking the sun. If the sun is shining on the moon at night and if the moon is not giving us daylight then, why are we getting daylight now? The earth goes around the sun, right? And the moon is going around the earth slower than it usually does, or the earth is going around the sun faster, making the moon go around slower. Or like last year, I saw the moon in October out in the daytime. Maybe it's a change in the year. I'm not sure, but in the winter the days are shorter and so the moon goes slower.*

Dimas: *I think the moon just stopped going around!*

In this example, a new observation had contradicted the conceptions articulated by the children in clinical interviews. This, in turn, stimulated a new line of reasoning, a new set of questions; the classroom interest in activities that lead towards a conclusive answer became intense.

Small group discussions serve a purpose similar to the interviews, but in addition, the group setting enables each child to hear the ideas of other children and, as they become more capable of orderly discussion, to interact with divergent ideas. Research in child development indicates that the process of coordinating one's own viewpoint with those of peers is a primary stimulus of cognitive development. The outcomes in learning are not obvious overnight, but with the give-and-take of a curriculum that uses these methods systematically over the course of a year, both the mental training and the conceptual growth can be impressive.

The conceptions revealed by the interviews and discussions are often startling to teachers accustomed to didactic pedagogy and right/wrong answers. The pedagogical implications are not self-evident. But as the children's intellectual operations with a subject such as celestial mechanics become more visible, pedagogical strateiges are implied, which have been embodied in the course. It is also not common to find classroom teachers backing off sufficiently to allow children to articulate their conceptions and viewpoints. But once the process is implemented, there is a crucial clarifying effect for both children and teachers about gaps in both information and reasoning, which guides movement through a new field of knowledge with greater care and exactness.

2. Representational concepts. When children become interested in an object, they often represent their conception in a drawing or three-dimensional construction. These representations often summarize what a child knows about an object rather than copying visual perception. Young children's drawings of the sun and moon, for example, are usually animistic rather than "realistic." Third, fourth, and fifth graders move towards more complex representational forms – bicycles, space ships, monsters, and innumerable other subjects. How they conceive of the subject is depicted in the representations. The relationship between children's conceptual development and their representations has been described in *The Teaching of Young Children* (Brearley, 1970) and elsewhere and need not be reviewed here. In the pedagogical sequence of our curriculum, representational activities serve a purpose similar to the interviews and group discussions, except that children are able to work in a nonverbal medium as they elaborate their concepts. Thus each unit includes model-making as a major project. In the first unit, children are encouraged to construct a papier-mâché model of the whole solar system, with each object in the system completed by small groups of chilren until the whole can be arranged. The second unit involves making relief or topographical models of the continents and various continental environments. Later, models are constructed of animal species and their habitats, and, finally, of human settings. Obviously such projects are time-consuming, but the payoff in skills and conceptual elaboration is considerable if the teacher plays the supportive but detached supervising role that was also required for the discussions. The completed models remain a touchstone throughout the units.

As long as too great a burden of new information is not required, the representational activities need not be restricted to the children's work. They can include science fiction stories, mythology, photographs, films, etc.

3. Operational concepts. Representations are generally static concepts. After children have articulated and represented their ideas, more dynamic concepts become appropriate. Simulations, demonstrations, experiments, and selected observations of natural phenomena can all engage operative intelligence. The import of such activities, where they are used in elementary school classrooms, is often underrated. They often contradict spontaneous conceptions. Demonstrations of celestial mechanics with models, of fluid dynamics, of changes in state of matter, all require of children a different order of conceptual reasoning. This conceptual restructuring requires both rich experience and time. Each unit of the course involves a set of such activities to enable children to move gradually from figurative to operational reasoning about the relevant concepts. One example is the use of models to stimulate the motions of the earth-moon-sun system; another is demonstrations of how spheres reflect light from a single source such as a projector, viewed from varied angles. Many examples are available and they all draw on an insight from cognitive psychology: logical concepts must be constructed by the individual child, and at this age children need to participate in activities or operations from which the concepts can be gradually abstracted. Words and graphic representations are not sufficient mediums for acquiring dynamic concepts.

4. A body of information. Each unit in the curriculum concludes by exposing children to an abundance of materials, such as films, books, maps and charts, that enable them to gain a refined mastery over a body of knowledge. We found that children were far more receptive and able to deal with conventional information after they had been through the steps described above. They were more willing to read for sustained periods, they see more in films, and they become capable of formulating answers to some of their own questions. Both the content and process of reasoning in specific fields of knowledge become extended and enlarged.

5. Assessment. The conclusion of each of the units is a set of evaluation exercises designed to probe conceptual development. The clinical interviews are repeated with the same sample of chilren. By comparing post-instructional ideas with the pre-instructional interviews, the teachers clarify what has been gained in conceptual reorganization and language usage. Using questions collected from children in the initial round, another round of small group discussions is conducted, the objective of which is to learn whether the children can formulate answers to some of their own questions. Other evaluation exercises are designed around problems related to the subject matter of the unit but new to the children; these usually involve the manipulation of objects or models. An example from the solar system unit is drawing an imaginary solar system and describing in writing the objects, their motions, and other characteristics of the system. This provides a sense of whether the children have acquired and can apply the intellectual operations that the units were designed to convey.

CLASSROOM TESTING

Eleven classroom teachers have field-tested the draft from the 1972-73 summer in editions revised over three years. All were volunteers who had a sympathy for the style of the course. Only one had serious difficulties with the role of probing the thinking of children as a preliminary to formal instruction. The open-ended discussion strategy was popular with all these teachers while some found the clinical interviews difficult or time-consuming. Others found the interviews a fine-grained guide to the conceptual development of their students. Most of these teachers conduct modified open classrooms; that is, activity-based classrooms with flexible schedules, but considerably more orderly and systematic than radical open classrooms run by teachers who do not believe in any kind of sequential curriculum. Thus they had little difficulty with the structure of the units, although all found they could not give children adequate time on the parts of the curriculum and complete it in one school year. Several taught the course over two school years where they could take the class for the next grade. Those who taught the course for a second time with a new group of children felt that they achieved a far better dialectic between children's questions and ideas, on the one hand, and the disciplines and concepts covered by the course.

Most of the teachers became interested in developmental theory after teaching the course. Some began to study Piaget, Bruner, and other scholars of child development. All found the course intellectually engaging, not only for the pedagogy involved but also for the information from astronomy, geography, zoology, and paleontology. Most teachers welcome intellectual stimulation from the curricula they teach, and the work of Jane Goodall, Leakey, and others is as interesting to adults as it is to children.

But the development and initial field-testing of a course such as this is a different matter from widespread dissemination and use. We feel that the course has been practically designed for widespread usage, especially through the involvement of experienced teachers and careful attention to children's reactions, but that test lies in the future. The course will be published by Pergamon Press, probably in the spring of 1976.

CONCLUSIONS

What conclusions can be reached on the basis of the kind of project I have described. First, there is an alternative to the large, expensive curriculum development models that were popular in the 1960s. A small, clinical model has many advantages. A project can begin with a general curriculum idea in several classrooms, or even one classroom, without becoming trapped in a web of quantitative data, logistical problems, and fund-raising, and work from that point towards a polished model for wider summative evaluation.

Second, teachers and children need not be mere consumers of curricula developed by publishing houses or schools of education, nor even play the passive role of testing a formalized model developed outside classrooms. They can actively participate in elaboration of the conceptual content, the pedagogical strategies, and the specific lessons and materials of a new model.

Third, there are university scholars who are willing and able to collaborate in bringing recently discovered knowledge to elementary school children; they do this by helping shape curricula and by making their departmental resources available to enterprising teachers or principals. Many scholars with youngsters themselves have a deep interest in communicating their knowledge to children. This group includes not only educational psychologists but scholars in traditional disciplines like biology and anthropology. David Pilbeam's research in human evolution, Goodall's research on primates, Cousteau's research on whales are a few examples of the rich variety of knowledge that can be shaped into pedagogical forms –

experiments, audio-visual materials, readers, etc. – appropriate for children at varied levels of development.

Fourth, children have a far broader range of intellectual interests than has generally been recognized. Bringing them into contact with fields of knowledge, methods of inquiry in these fields, and the processes of logical reasoning at a time when they have a natural receptivity can have a fundamental impact on their intellectual confidence, which will serve them well in later school years. The content of elementary education need not be trivial nor composed totally of tedious work on the traditional basic skills. There is room enough for children to exercise higher level cognitive abilities suggested by their own questions.

Fifth, children are a primary source of ideas, theories, interests, feelings, and questions, which can be tapped systematically in the service of sensitive and accurate teaching. Interviews, discussions, and observations of children manipulating materials and ideas are relatively simple ways for teachers and curriculum developers to keep their ears to the ground, and to discover, keep alive, and cultivate the intellectual interests and capacities of children.

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