Kates, R. W. and C. Katz, 1977. "The Hydrologic Cycle and the Wisdom of the Child" The Geographical Review, Vol. 67, No. 1, pp. 51-62.

[REPRINTED FROM *The Geographical Review*, Vol. 67, No. 1, January 1977]

THE HYDROLOGIC CYCLE AND THE WISDOM OF THE CHILD*

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With the Assistance of the People of Elm Park Center

IN THE eighteenth century, Sir Walter Raleigh tells us, the hydrologic cycle was very much the wisdom of God. "For as it is God's infinite power and everywhere-presence that giveth to the sun power to draw up vapours, the vapours to be made clouds, clouds to contain rain and rain to fall."[1]

The hydrologic cycle as seen by three-to-six-year-olds is hardly a cycle we have discovered. But the youthful conceptions of cloud, pond, and water tap contain similar underlying order and surety. As Jean Piaget states, "There is in the child a tendency towards justification at all costs, a spontaneous belief that everything is connected with everything else and that everything can be explained by everything else."[2]

It was neither theology nor psychology that drew us to ask small children for their perceptions and resource appraisals, but curiosity about the world inside peoples' heads and its relationship to the world perceived by science or, in this case, by adults. In pursuing such an inquiry, we seem to be unique. A review of the voluminous psychological literature from 1927 to the present finds that most studies of children's thoughts, concepts, and perceptions do not deal with children and the physical environment as they experience it.[3]

Elm Park Center, where our observations, interviews, and field trips took place, is a small day care center attached to an equally small training institution for day care workers. The twenty-four children of working parents who come each day are free to choose activities and to move indoors and outdoors in an open-education setting. They are a cross-section of their age group in Worcester, an industrial city of 176,000 in central Massachusetts. It is the special quality of preschool age, the mixture of innocence and worldliness, unspoiled by formal teaching, that allows us to report introductory findings derived with pleasure and delight.

One of us, a resident in this day care setting, began a year ago to collect from the staff anecdotal material and observations related to the children's experiences with water. Our initial reaction as geographers, specialists in water resources and not in child development, was surprise at the sophistication of experience. For example,

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* We wish to thank Hilary L. Renwick for her creativity and skill in drawing illustrations more delightful than we were able to imagine.

[1] Sir Walter Raleigh, quoted in Yi-Fu Tuan: The Hydrological Cycle and the Wisdom of God (Univ. of Toronto Press, Toronto, 1968), p. 38.

[2] Jean Piaget: The Language and Thought of the Child (Humanities Press, New York, 1959), p. 191.

[3] Some notable exceptions are Susan Isaacs: Intellectual Growth in Young Children (George Routledge and Sons Ltd., London, 1930); J. M. Jacquemin: L'Enfant et les fonctions vitales, *Rev. de psychologie et des sciences de l'education;* Vol. 8, 1973, pp. 99–132; Jean Piaget: The Child's Conception of the World (Kegan Paul, Trench, Trubner & Co., Ltd., London, 1929); *idem,* The Child's Conception of Physical Causality (Kegan Paul, Trench, Trubner & Co., Ltd., London, 1930); and Denis Wood: Early Mound-Building: Some Notes on Kids' Dirt Play (unpublished manuscript, 1976).

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four or five boys were working on the project in the sandbox; the main people were F, aged five, and M, aged three and a half. They were using flexible, colorful tubes about three inches in diameter and a foot and a half long. Each could be twisted in all directions. They connected three of the tubes so that they made one long flexible hose about four and a half feet long, and they made a seven-inch mound out of wet sand in the sandbox. They buried one end of this long tube in the mound of sand, and F held up the other end and connected a funnel to the top of it. He was standing in the sandbox when he called out, "All right, I'm ready, bring the water," at which point M, the three-and-a-half-year-old, came running with a bucket of water and all the other kids watched and commented. He ran up and poured the water into the funnel and the translucent tubes; I could see the water slowly flowing down the length of the hose. He poured in the whole bucket of water and then F, obviously the director of this project, said, "Okay, that's enough," and he took the funnel off. All the kids gathered around the mound. F put his mouth to the end of the tube and blew air into the tube; and he blew, and blew, and blew. The mound erupted and all the water bubbled up through the mountain they had made; it went bubbling out, and the kids were excited and delighted by the sight. I asked, "What did you make?" They said, "We made a volcano," and they all agreed that it was their volcano.

We continued to collect anecdotes and observations, and we also began a more structured inquiry into the children's knowledge of water sources and origins, their appraisal of water utility, and their use of this resource in their play. In following this method of inquiry, we duplicated our adult inquiries into resource knowledge, appraisal, and use. We used similar research tools: observation, interviews, and semi-projective tests that were adjusted to the special capacities of our young friends.

Knowledge of Water

To inspire conversations, pictures of a water tap and cloud (Fig. 1) were shown to separate groups of children (three-, four-, and five-year-olds). The pictures and implied functions were always recognized.[4] Although never quite seen as a cycle, the scope of hydrologic connections increased with each age group. Physical causality, as adults might express it, does not play a large role in the preschooler's world, and most of our questions about "how" and "why" were not answered. The wording of a question is a significant factor in eliciting a response from the children. Martin L. Nass in a study of children's concepts of physical causality discovered that "why" questions produced more non-naturalistic responses than "how is it that" questions on the same topic.[5]

To minimize distraction, the two three-year-olds were interviewed separately, and shown only the tap picture. Neither of them could envision any point farther than the tap as a water source. Nor were they fazed by the contradiction that their baths held more water than could fit in the tap at any time. As to drainage, for one it was simply a two-way process, with the water going back into the tap after her bath. M's knowledge of the water cycle extended to places he could not see. When he was asked where the water went after his bath, M responded, "in the drain . . . down at the bottom of the house . . . under the ground . . . on the bottom . . . down the water." The three-year-olds expressed a limited knowledge of water sources and the hydro-

[4] Edna Heidbreder (A Study of the Evolution of Concepts, *Psychol. Bull.*, Vol. 31, 1934, p. 673) indicates that concepts evolve more easily from pictured material than from verbal material.

[5] Martin L. Nass: The Effects of Three Variables on Children's Concepts of Physical Causality, *Journ. Abnormal and Soc. Psychol.*, Vol. 53, 1956, pp. 191–196.

logic cycle; unlike the older children, they were not inspired to voluntarily discuss any associated aspects of water flow. Their overall conception is shown in Figure 2.

The four-year-olds expressed a greater number of associations inspired by the picture of the tap (Fig. 3). There was a consensus that by turning on the faucet the water will come via a "pole" from the "cellar." One child had further postulations

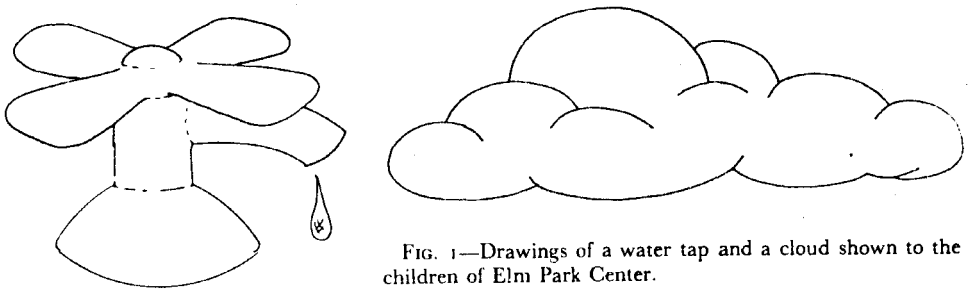

FIG. 1—Drawings of a water tap and a cloud shown to the children of Elm Park Center.

that included the underground river so prominent in myths and even in current adult resource appraisals.

M: Water comes out of the ground.
Cindi: Out of the ground! And how does it get up here [to the faucet] if it comes out of the ground?
M: It's attached to the ground.
Cindi: Ohhh! It's attached to the ground? How is it attached?
M: Under the house it's attached to the ground—in the dirt.
Cindi: And in the dirt is there something for water to come through?
M: And even a river or something.
Cindi: Ohhh.
M: A brook.
Cindi: Is the river or brook near your house?
M: Under it.
Cindi: There's a river under your house?
M: There's a river under every house.

Some sense of cycle exists among the four-year-olds. After the water goes down the drain, it goes "downstairs" by "pipes" to the "ground" and finally by "pipes" to the "river." "Rivers" are filled by home water drainage, anthropogenic pouring, or dumping of water into them.

After seeing the tap picture, the group of five-year-old children described a more complex and extensive hydrology (Fig. 4). The water comes from "the stream," which no longer has to be in the immediate vicinity of the home, but has underground pipes leading to the house. At the house, the water goes up a pipe "through the walls and everything" to the faucet. After it comes out of the faucet, it goes down "the drain under the street . . . in a pipe." Under the street, the water goes "to the bottom of a hill and then there's another pipe." When the water finally gets out of this maze of pipes "it's under the dirt," where "people use it for grass and stuff and gardens and flowers."

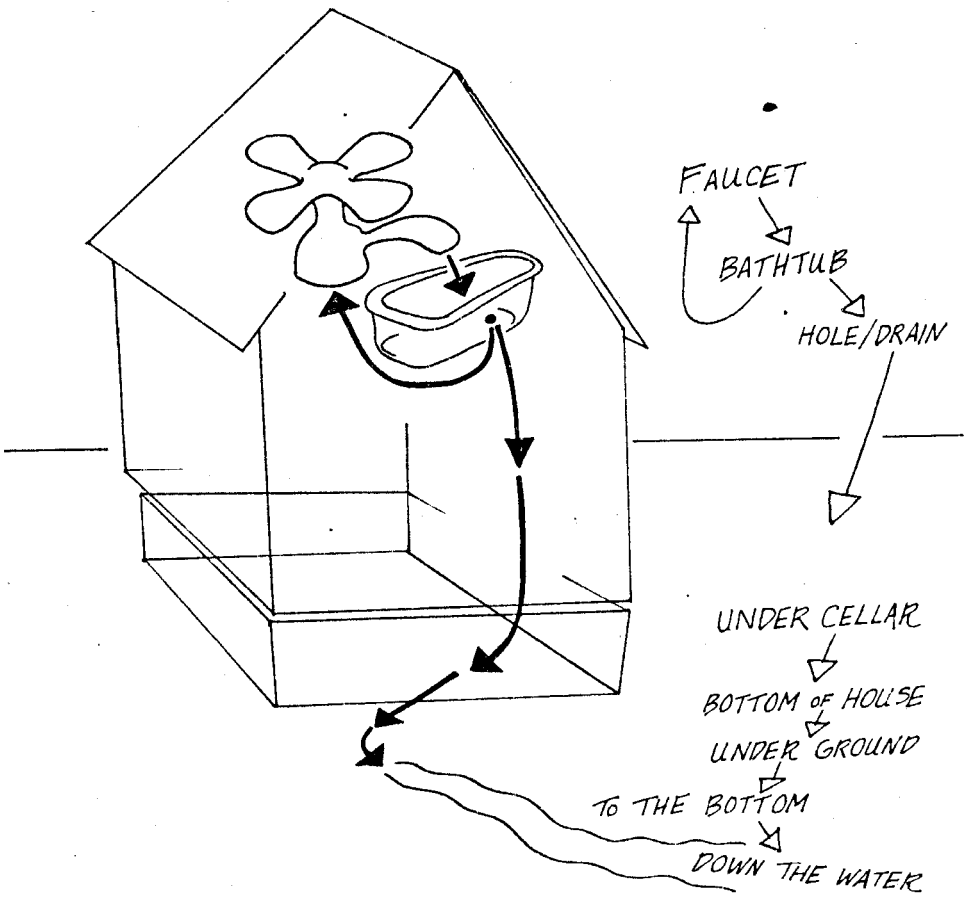

FIG. 2—Three-year-olds' conception of the hydrologic cycle.

This understanding of a portion of the hydrologic cycle seems stable because it was a replication of the five-year-olds questioned a year earlier using the same picture. Although reservoirs are the actual source in Worcester, no one credited them as such. Both groups entertained the possibility of the ocean as a source but eliminated it because of its salinity. The children made no connection between rain and water sources, and when asked how the water gets into the rivers, two children suggested a "water truck." The associations with the water tap by the children of any age group were limited, concrete, and based on their knowledge of water as they encounter it daily.

The picture of the cloud was not as readily explained, and it led both the four- and five-year-olds to some imaginative, if not fantastic, associations.[6] Both groups immediately designated the cloud as a rain cloud that means "it's gonna rain." This connection is not adult causality but what Piaget terms phenomenistic causality:

[6] For an elaboration of this idea, see I. Huang: Children's Explanations of Strange Phenomena, *Smith College Studies in Psychol.*, No. 1, 1930. It is interesting to note that many of the nonmaterialist, prelogical responses recorded by Piaget were obtained in response to his questions about celestial bodies, wind, and other intangible events and objects.

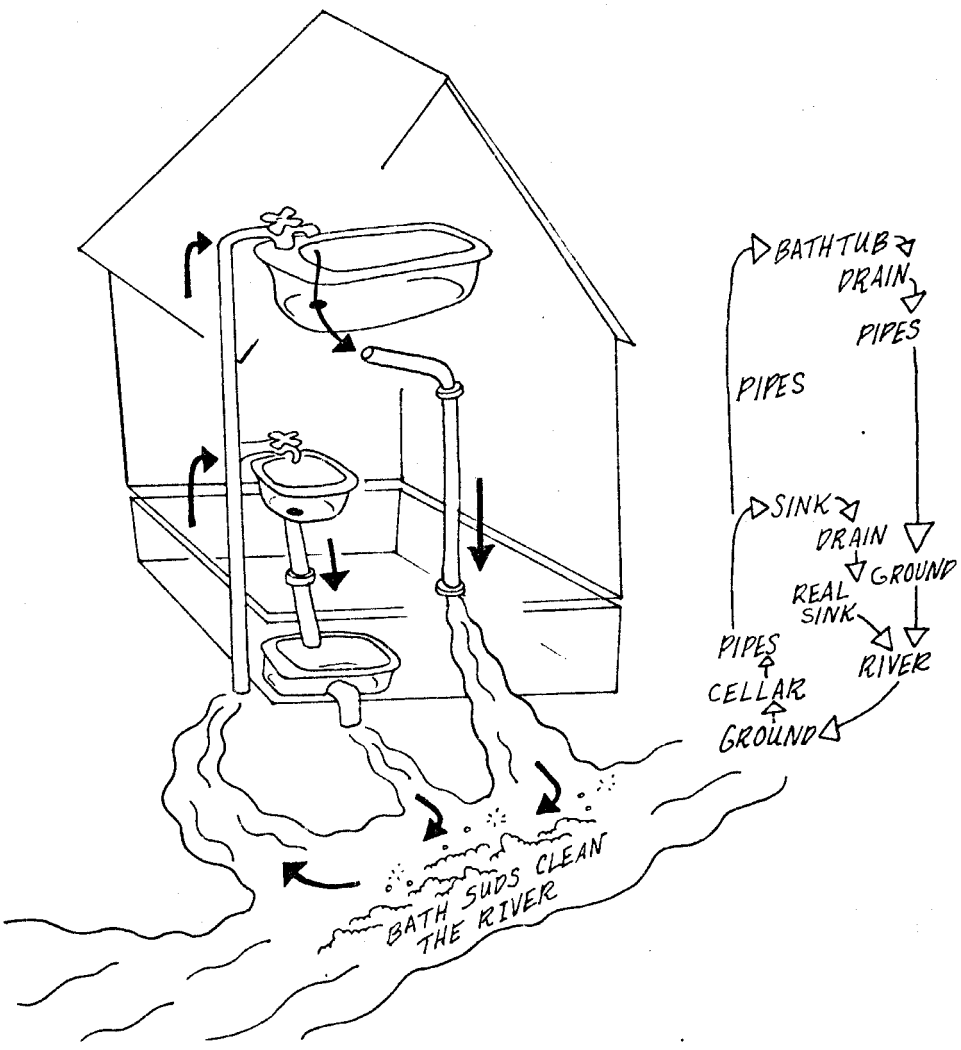

FIG. 3—Four-year-olds' conception of the hydrologic cycle.

"Two facts given together in perception, and such that no relation subsists between them except that of contiguity in time and space, are regarded as being connected by a relation of causality."[7] Clouds and rain are two phenomena that occur together, and to the children this suffices as causality without an intervening causal connection.

For the four-year-olds (but not for the five-year-olds), snow and clouds are made by God and the angels (Fig. 5). Clouds get into the sky by "magic" and "move over to the other side of the land." Water is almost always attributed as one of the ingredients in clouds. For one four-year-old, they are "water and gas," for another they are "snow and water," and for a third, they are just "snow." Although everybody agreed that rain or snow came from clouds, the children were not sure how they got into clouds. One four-year-old said that rain "falls into clouds . . . from the top"; another thought snow goes into clouds by "dropping up." A five-year-old had a sense of

[7] Piaget, The Child's Conception of Physical Causality [see footnote 3 above], p. 259.

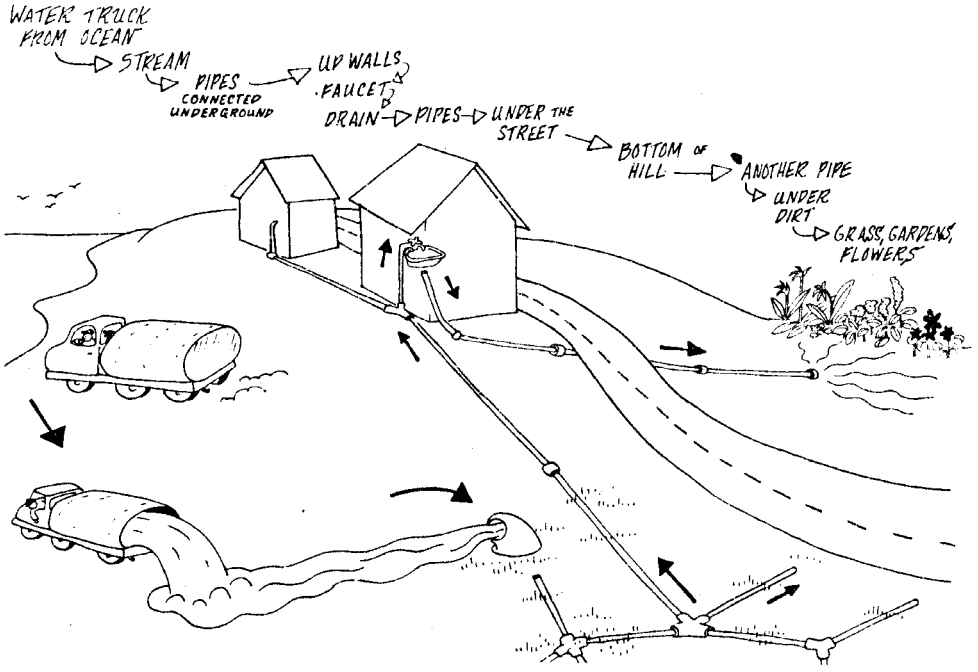

FIG. 4—Five-year-olds' conception of the hydrologic cycle.

evaporation in discussing what happens to snow in the sun: "It melts and then it goes way up in the sky and in the night we get clouds."

The two five-year-old groups participated in another aspect of our inquiry, a field trip to a nearby park and pond. The swings, ducks, and leaky pipes in the bathroom were generally more interesting than the pond and its origins. Both groups independently concluded that the pond got its water from a pipe, which is visible and overhangs the pond, although one child added that a little bit comes from the ground.

There was no connection between the cloud and rain/snow discussions, the water tap discussion, or the one inspired by the pond. No child made the connection between rain that falls into rivers or ponds and water that flows from their taps. Even when they were asked where it rained most, children did not discuss rain falling into or running off into a body of water. They stated only that it went into the ground, made mud, or made puddles. When they were asked about drinking rainwater, the children invariably responded that the only way to do this was by filling vessels or opening one's mouth in the rain. No one considered that tap water was linked with rain. It is as if the children conceive of two separate cycles—the more tangible domestic water cycle and the harder to grasp cloud-rain cycle. The two rarely meet in the world of the preschooler.

RESOURCE APPRAISAL

Individual interviews were conducted with childen of all three age groups in which they assessed the comparative utility of three resources: blocks, water, and sand. Four rectangular wooden blocks, a gallon-sized plastic container of water, and a small box of sand were arranged on a child-level counter top and served as tangible objects of discussion. No favorite choice emerged from our sample of eight children, although

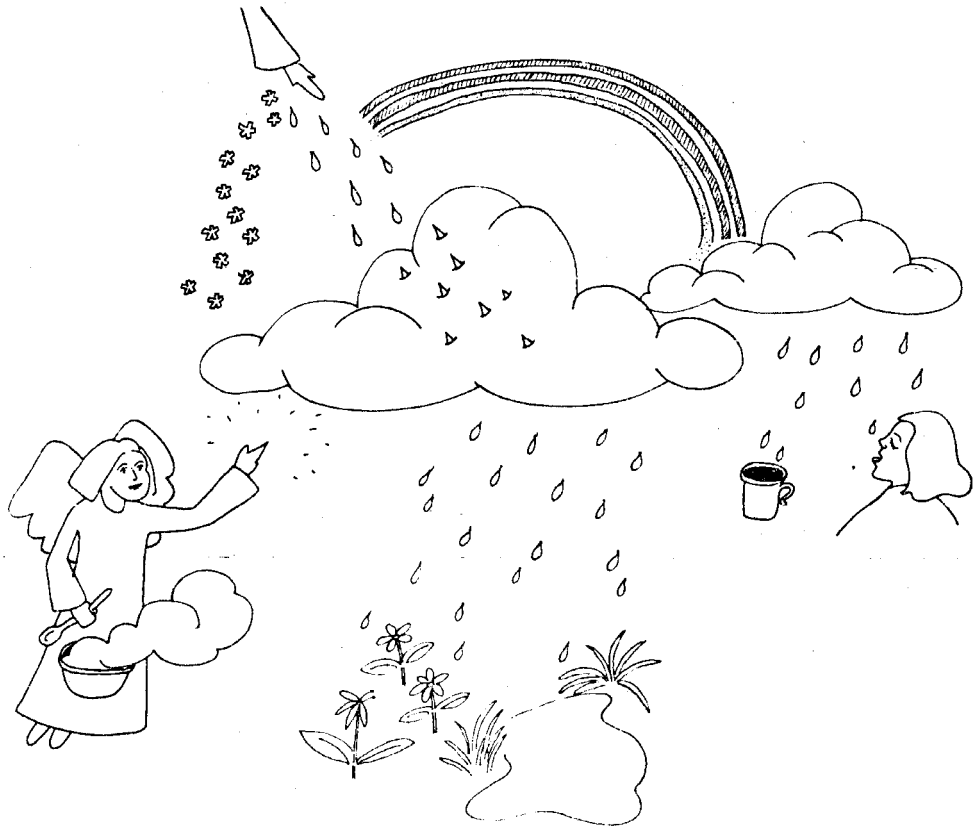

FIG. 5—Four-year-olds' conception of snow and cloud making. Snow and clouds are made by God and angels. Rain falls into clouds from "the top" and falls to the ground, making mud or watering flowers. Rainwater can only be drunk directly.

water and sand were a combined favorite. Most children who cited either water or sand noted that it was best used in making mud. Indeed, as we spoke, the children often dropped handfuls of sand into the water or poured water into the sandbox.

All three resources are most commonly used in the construction of small-scale environments. Sand and water together make "mountains," "volcanoes," "castles," "buildings," "people," and "messes." Blocks are useful for building "houses," "buildings," "parking places," "people," and "block sand castles." The next most common usage of water and sand is domestically oriented. Mud is made into "pies," "cakes," "coffee," and other "things when you're playing house." Water alone is "stirred and cooked" into "soup," and other times used just for drinking. Water was recognized by the four- and five-year-olds as a good cleanser of "dishes," "blocks," "windows," "hands," and even "cows." Children, like adults, show a disparity between what they say and what they do. Only one child, a three-year-old, mentioned filling vessels or pouring as a use of water, precisely the form of play that was most often observed indoors. One four-year-old went so far as to say that she did not like water at all except when added to sand, yet she plays with water, especially indoors, more than almost any other child.

When asked about adult use of these resources, every child could cite at least one

example of parental water use. The most commonly mentioned uses for water were washing, drinking, and cooking. Some children mentioned watering plants and another mentioned making paint. One child summed it up by saying that "water's really special." When asked why, he responded that "it do good . . . it feels good and it really cleans things up."

Sand had more limited utility. One child's father uses sand to clean wood, and another child's mother uses it to make the steps less slippery. Most children, however, agreed that adults do not generally use sand.

There was unanimous agreement that "mommies and daddies" never use blocks, although they do use wood. Blocks had the narrowest scope as a child's resource as well. They were not credited with having any nonplay function, and they were the only resource that some children felt were not good for anything. Only two children, both three-year-olds, chose blocks as a favorite or a cofavorite resource. The consensus on blocks might be, in the words of one five-year-old, "Ehhh, not so good. I say they're all right."

To understand the affective or sensory quality of the three items, the children were asked how each of them felt. In this category most of the children were at a loss for words. Without a myriad of adjectives at their disposal, most children opted for "good" when asked how any of the resources felt. Water was the most easily described by means of its thermal qualities, hence after "good" several children added "warm," "hot," "ice cold," or "frozen." Sand if not "good" or "great" was described by a few children as "squishy" or "muddy." Blocks were seen as "good" or "dry."

Each increasing age group recognized a greater array of activities and possible uses from each resource. However, their assessments of blocks, sand, and water were limited in light of our naturalistic observations. During the hours of observed play, children of all ages were more creative than they credited themselves to be; they engaged in a much wider range of activities, both domestic and engineering, than they mentioned.

Work and Play

Water is a special part of the play world of a child. The children used water primarily in their dramatic play, which was often domestically oriented, and in more functionally oriented engineering projects. Their curiosity about the properties of water led them to experiment with it, and the sensory qualities led to a variety of other experiences. Outdoors, the children were primarily involved with engineering projects, although there was a substantial amount of other dramatic play. Volcanoes and rivers were the most frequently built civil engineering works. The volcanoes were similar to the one described earlier. River construction projects involved digging a trench in the sandbox and providing enough water to fill it in a continuous flow.

Engineering projects most frequently involved a group effort, and for each volcano or river construction, different sets of children divided the work among themselves. Although each engineering project was open to outsiders and although no one was excluded from any projects, there was a core group of mostly four- and five-year-old boys. When the girls joined in, their role was mainly as water carriers.

More common than engineering was domestic play. Children filled vessels and arranged them on the sandbox ledge for cooking. They poured water back and forth between their various pots, pans, and cups, and fed it to an assortment of dirty dolls.

In this play, as with the engineering, dirt was an important element, but sex role differentiation was less prominent. In warm weather, getting wet became as much a function as the play itself. One day in August the following experience was observed:

> Several of the children pretended there was a fire and rode make-believe fire engines to the scene. "The car's on fire! It ran into a tree in New York City!" they said. The fire seems to be a big blaze and C asks the teacher for some water. He has a bucket, gets the water and pours it on the fire. Now J needs some water. He has a little cup for it and holds it close to the faucet and the teacher fills it. JO needs some as well. He has a teapot which he pours onto the fire. J pours his cup on the ground but not on the fire. He repeats this. They keep taking turns filling the teapots, coffeepots, and cups; C and JO pour theirs on the fire and J pours his on the driveway. C likes pouring his on the fire and on his feet. JO likes flinging it in the air toward the fire.

Indoor water play is more constrained, though less so than in the average home. The play area consists of a large tub (three feet in diameter) that is filled with water at the start of the day, a child-level sink and counter top, cups and plastic bottles of all sizes and shapes, and several dolls and water toys. Children take objects from the box of water play toys and play with them in the tub of water. They swirl them, soap them and rinse them several times, and often end by dipping a vessel in the water, filling it, and pouring it back into the tub. Play in the area also includes "cooking" and the filling of large containers by using small ones. The names that the children assigned to their brews indicated that their activity was another replication of the adult world. These names included "axlerax" "florax," "castor," "wallpaper paste," and simply "lemon-orange juice."

The dramatic play both indoors and outdoors involved primarily three- and four-year-olds of both sexes. The three-year-olds were occupied mostly in replicating indoor cooking and washing. The four-year-olds, though involved in this play, initiated and were involved in the more exotic episodes of water play. Most of the five-year-olds rarely participated in dramatic water play. The four- and five-year-old children experimented with water:

> J (aged five) put dirt in the funnel, poured the water, and watched it go out of the funnel into the tube. Then he watched the water come out of the tube. Using a pot, he covered the opening at the bottom of the tube and tried pouring water in the tube. He was surprised to see the water flowing out from under the pot because he had not only covered the opening with dirt but with a pot as well. He secured the pot by burying the edges in the sand and said, "It can't go in there now." He got more water and poured it down the tube a little at a time. At first the water did not flow through the sand and pot, and he said, "It's not coming." He poured more, and it still didn't come out. He asked me to watch the opening. When it finally flowed through, he responded happily but was surprised. Next, he filled the funnel with sand and said, "It won't go through." He tried pouring the water through the clogged funnel and said, "Look, it's not going through." I asked, "Why?" and J replied, "Because there is sand in it."

Another time some children poured colored water into the large tub to see what would happen, and they watched its diffusion. Sometimes children experimented with floating and nonfloating objects, trying to hold, for example, a cork at the bottom of the tub.

For a short time the staff kept listening for children's spontaneous comments about water. Children, like adults, had much to say about the weather. Most of the spontaneous comments concerned weather processes. One five-year-old walked by the window on a rainy day and said to no one in particular, "It's a tornado." Another

child, a four-year-old, heard a loud noise in the distance on a clear day, looked up, and said, "What a storm it is here! You know what I think? I think it's the ocean!"

The sensual and affective qualities of water are important to the three-year-olds. Watching water was a serious activity. Some children sat on the window seat looking at the rain, and others watched the water flow out of the taps. Children stood with their hands under running water, poured it over their hands, swirled the tub water with their hands making waves, or stood soaking their hands in the tub for quiet minutes. They enjoyed pouring water back and forth between two vessels, or between the large tub and a cup, for long periods of time. Most of this play was purely abstract; there was no end product or set line of play to follow. Water was enjoyed for its unique qualities.

Speculations

For small children, water is an object of curiosity, exploration, appraisal, and use. Their conceptualization and manipulation of water tells us something about their talent as environmental managers, about their developing thought processes, and a little about the development of knowledge itself.

In the child's play, as in the adult's work, water is a multipurpose resource centered mainly on domestic, engineering, and recreational pursuits. For most purposes, the play is imitative, re-creating the worlds of kitchen and nature in order to understand them. But in one case, children originate and do not imitate. Indeed, in the world of adult play with water, their roles are reversed. Watch a child trail her or his hands through a tub of water, intently pour water from container to container, frolic through an early morning snowfall, or splash in a summer wading pool. Are these not the forerunners of a quiet morning's fishing, of sitting by a waterfall, of skiing on fresh powder, or of riding the waves on an ocean shore? The most joyful of adult play resonates to the spontaneous joy of our youthful years. Thus children as managers share in adult resource use by imitating the purposeful, exploring their own relationship with it, and exemplifying the playful.

Piaget and his colleagues were interested in children's knowledge and conceptions of the world as stepping stones more for studying their developing mental powers than for studying their actual thoughts. This goal is clear in his categorization of seventeen types of causality that are divided into stages in the development of causal thinking. The first stage includes phenomenistic, magical, or finalistic conceptions; the second includes animistic, artificialistic, and dynamic explanations; and the third stage, reached at age eleven or twelve, represents true causality. Jean Marquis Deutsche, along with others, has raised several criticisms of Piaget's classification: "The types of causality as defined are vague and indefinite making it difficult to distinguish clearly what is implied by each type, and to distinguish clearly between types, some of the answers fall outside the seventeen types as outlined by Piaget, and the interpretation of what a child really means by his answer is largely a matter of individual judgment."[8]

Some of what we have learned differs from Piaget's pioneering inquiry into how children think about the physical world. The most obvious difference is that our children know so much more so much earlier. In one of the few places that we can

[8] Jean Marquis Deutsche: The Development of Children's Concepts of Causal Relations (Univ. of Minnesota Press, Minneapolis, 1937), pp. 92–93. In her own studies Deutsche used three judges for each response to make the interpretations less subjective.

make a substantive comparison, the differences in our responses and those received by Piaget are striking. In "The Child's Conception of the World," Piaget describes the evolution of explanation concerning the origin of clouds:

> During the first stage (average age 5–6 for Geneva), the cloud which is usually regarded as solid (of stone, earth, etc.) is conceived as made entirely by men or by God. During the second stage (average age 6–9 for Geneva and Paris) the child explains the clouds by the smoke from the roofs and maintains that if there were no houses there would be no clouds. The artificialism is thus more indirect than in the first stage but is still very systematic. Finally, during the third stage (from 9–10 on the average), the clouds are of entirely natural origin: the cloud is condensed air or moisture, or steam or heat, etc.[9]

In contrast, our four-year-olds are both artificial and naturalistic. They believe that clouds are made out of water and gas, or water and snow, but never solids (Fig. 5). God makes the rain and snow, and angels make the clouds, but out of natural ingredients. Our five-year-olds never invoke a deity; they believe that clouds mean rain and, at least in part, are made up of evaporated water. It is clear that these four- and five-year-old children offer the more advanced explanations of the six-to-nine-year-olds studied by Piaget in the early part of the century. In our study, the lack of clear evidence of stages in causal thinking is not unique. Nor are our findings that the children know more at an earlier age than those studied by Piaget. There is a substantial body of psychological literature written over the past fifty years that differs with Piaget's conclusions on precisely these questions. Piaget's studies have been criticized by psychologists and educators who, in repeating his experiments, have arrived at different conclusions.[10] Their studies presented no clear-cut evidence of stages in the development of causal thinking and substantially fewer non-materialistic, prelogical responses than Piaget obtained using the same or similar questions and experiments.

These differences should be explored more fully. Edwin C. Johnson and Charles C. Josey postulated that the difference might be accounted for in language, with English being better for logical thinking than French.[11] Other studies have revealed little evidence that intelligence, class, or sex is a factor. Perhaps the problem is one common to all analyses of thought—the questioner's bias. This factor is particularly hazardous in analyzing children's thought because in using our adult logic and philosophy to study children, we are placing it in a framework that includes implications not present in the child's mind.

"Understanding what goes on in children can shed light on the history of science,

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[9] Piaget, The Child's Conception of the World [see footnote 3 above], pp. 298–299.

[10] A partial list of authors whose conclusions differ from those of Piaget includes the following: Isaacs, *op. cit.* [see footnote 3 above]; Victoria Hazlitt: Children's Thinking, *British Journ. Psychol.*, Vol. 20, 1930, pp. 354–361; Margaret Mead: An Investigation into the Thought of Primitive Children, *Journ. Royal Anthropol. Inst. of Great Britain and Ireland*, Vol. 62, 1932, pp. 173–190; Deutsche, *op. cit.* [see footnote 8 above]; I. Huang: Children's Conception of Physical Causality: A Critical Summary, *Journ. Genetic Psychol.*, Vol. 63, 1943, pp. 71–121; I. Huang and H. W. Lee: Experimental Analysis of Child Animism, *Journ. Genetic Psychol.*, Vol. 66, 1945, pp. 69–74; Mervin E. Oakes: Children's Explanations of Natural Phenomena, *Teachers College Contributions to Education*, Vol. 6, 1947; Nass, *op. cit.* [see footnote 5 above]; Betsy Worth Estes: Some Mathematical and Logical Concepts in Children, *Journ. Genetic Psychol.*, Vol. 88, 1956, pp. 219–222; Gustav Jahoda: Child Animism: A Critical Survey of Cross-Cultural Research, *Journ. Soc. Psychol.*, Vol. 47, 1958, pp. 197–212; and Lee C. Lee: Conceptualization in Pre-school Children, *Child Development*, Vol. 36, 1965, pp. 221–227.

[11] Edwin C. Johnson and Charles C. Josey: A Note on the Development of the Thought Forms of Children as Described by Piaget, *Journ. Abnormal and Soc. Psychol.*, Vol. 26, 1931, pp. 338–339.

and vice versa," Jean Piaget told a recent conference convened in his honor.[12] For many years Piaget has explored the "tight resemblances" between child development and the history of science. This resemblance was also noted in 1973 by J. M. Jacquemin, who studied children's conceptions of the process of respiration and found four stages of understanding, which correspond with the development of the scientific knowledge of respiration.[13] Do we find parallels between our children's limited conceptions of the hydrologic cycle and earlier conceptualizations? If we use Aristotle as archetype, the way Piaget does, we would find in "Meteorologica": "The moisture surrounding it [the earth] is made to evaporate by the sun's rays and the other heat from above, and rises. But when the heat which is raising it leaves . . . then the vapour cools because its heat is gone and because the place is cold, and condenses again and turns from air into water. And after the water has formed, it falls down again to the earth."[14] Compare this with what T, a five-year-old, said: "The sun shines on it [water] and it gets hot. Some of it goes to the sky and it is clouds . . . Rain comes from clouds." And with four-year-old E's explanation: [It doesn't rain] " 'cause it's too hot and the rain doesn't want to get too hot 'cause it would burn the rain."

Again Aristotle on transformations: "We maintain that fire, air, water and earth are transformed one into another and that each is potentially latent in the others."[15] And from the people of the Elm Park Center:

T: Snow is made out of milk.
Teacher: Do you think it is really made out of milk?
T: No, it's made out of water.
R: Yes, it is made out of water.
A: Water and clouds.
A: Water and snow.
R: Water and milk.
A: It's white ice with milk.
A: Milk drops down from the cow and goes into the ground. It gets indivisible [*sic*] and it goes up in the air, then it turns back into milk and it turns into snow.

These comparisons require caution in interpretation. Aristotle knows much more and says it better than our five-year-olds. (Piaget is usually comparing Aristotle's thoughts with those of an eight-year-old.) Although Aristotle was demonstrably wrong in many of his scientific explanations of the origin of hydrologic phenomena, Anaxagoras, a century before, "was basically right within the geographic and geologic limitations of his observations."[16] Therefore, using Aristotle may be unfair to the state of Greek science.

Thus, while it may give delight to imagine that ontogeny recapitulates epistemology, it may be only a form of adult intellectual play, a kind of "romancing" that Piaget warns about when it appears in children, but from which he might also be suffering.[17] After all, romancing may be the prime occupational hazard of exploring the geographical world of small children.

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[12] Jean Piaget at SUNY Conference, Ellenville, New York, cited in *New York Times*, June 15, 1975, p. 45.
[13] Jacquemin, *op. cit.* [see footnote 3 above].
[14] E. W. Webster: Aristotle Meteorologica (Oxford Univ. Press, London, 1923), p. 346.
[15] H. D. P. Lee: Aristotle Meteorologica (Harvard Univ. Press, Cambridge, Mass., 1962), p. 11.
[16] Raymond L. Nace: The Hydrological Cycle: Historical Evolution of the Concept, *Water International*, Vol. 1, July, 1975, pp. 15–21.
[17] Piaget, The Child's Conception of the World [see footnote 3 above], p. 10.