A cell is a kind of energy machine. Inside there is a huge molecule that does the job. This molecule is called an ATP molecule. ATP stands for adenosine triphosphate (ad'e-no'sin tri'fos'fat). ATP is broken down to yield energy, then the ATP that has been broken down is built up again. The energy to build up the ATP comes from glucose and other food substances.

Cells are the building blocks of living things. Within a cell are chromosomes. Within each chromosome is the substance DNA. (Its chemical name is not really needed at this point). DNA has in it the pattern of that living thing. Because chromosomes and their DNA duplicate themselves, living things receive the characteristics carried by their parents.

The Importance of Understanding Child Development in Curriculum Development

Dr. Lawrence F. Lowery

The above excerpt is from a 5th grade science textbook. The excerpt exemplifies some of the reasons why current researchers and wise educators are emphasizing a move away from science textbooks at the elementary grade levels: The content is often beyond the cognitive capacity of the students; prerequisites (prior knowledge) needed for understanding are not part of earlier experiences; the number of new vocabulary words per chapter exceed the number in a foreign language text; the presentation is didactic and the student is passive; the instruction utilizes methods for teaching reading rather than methods for teaching science.

FOSS was created to provide a competitive, viable alternative to textbook-driven science programs at the elementary level. And from its beginning, FOSS, unlike textbook programs, has been grounded in knowledge gained from academic researched coupled with practical, tested classroom experience.

A major contribution from research is the evidence of developmental stages of learning (Piaget, 1969). If students are to learn science and become scientifically literate, both science content and science experiments must be appropriately chosen to match the cognitive capacities of students at different stages of their development. (Lowery, 1989, 1992). Research shows that to mismatch content (e.g., first grade instruction in atomic structures, the theory of evolution, or movements in the earth's crust) leads to little understanding, misconceptions, and frustration on the part of students and teachers. Mismatches cause teachers to resort to telling information because the content cannot be conceptualized by students even through hands-on experiences. (Cowan, 1978). At best, students learn a narrative or story rather than science. Their thinking is reduced to memorizing and accepting ideas because they are told, not because they are learned. The results are that students cannot extend, apply, or interpret deeper meanings of the content. Interest in and positive attitudes toward science diminishes. (Covington and Berry, 1976; Brophy, 1983).

Because the age ranges for the different stages are well known, FOSS has been able to match the cognitive demand of a concept to the appropriate capacity required to learn the concept. A benefit is that the content to be learned is *always* within the realm of possibility for the students to comprehend it. (Bruner and Kenny, 1966).

An example of how FOSS does this can be demonstrated in two ways. First, let's examine a sequence of FOSS modules throughout the grade levels. At grades 1-2, the **Pebbles, Sand, and Silt Module** lets students explore the properties of earth materials through activities that allow them to mix, pour, sift, and separate the materials. The developmental capacities utilized at this stage are the processes of observing, comparing, and communicating about what is observed and compared. At grades 3-4, the **Water** and **Earth Materials Modules** engage students in acting upon the materials, making transformations in them to see how the materials behave or of what they are made. This science content builds upon the earlier content of grades 1-2 and the activities utilize the additional cognitive capacity that appears at this stage—the ability to organize by sorting, grouping, or seriating materials on the basis of their properties. At grades 5-6, the **Landforms Module** provides new content (e.g., the properties of water and earth materials). Activities utilize the stage-related capacity to developing in students by challenging them to determine cause and effect relationships between water and earth materials. (Lowery, 1992).

A second example of how FOSS moves research into practice can be seen within the **Landforms Module**. For this module, two powerful, useful ideas from the field of geology were chosen—how some landforms are made and how these landforms can be depicted symbolically on a map. This content was placed at the 5-6 grade level because research on students' capacity to interpret and create maps consistently shows that these operations are difficult for students prior to the fifth grade. The reason is that younger students are highly egocentric. They have difficulty perceiving the world from a position other than their own.

If students are to learn science and become scientifically literate, both science content and science experiences must be appropriately chosen to match students' capacities.

If you ask a third grader to draw a map of her school yard, the student will consistently draw features from her own viewpoint (side view perspectives showing windows and doors on buildings). Even after hands-on instruction in model building and map making, third grade students, when given a "new" terrain to draw, revert back to depicting it from their own point of view.

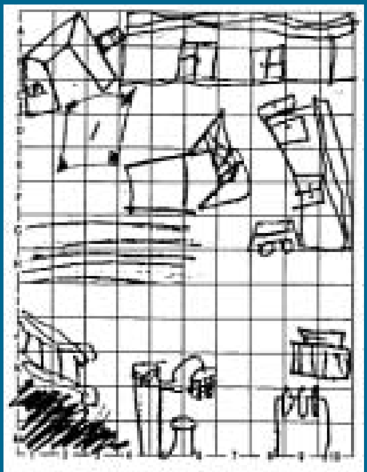
When the same topic is taught at fourth grade level, one finds many youngsters in transition. If you give a student the task, he will draw some features from his viewpoint and other features using symbols and a bird's-eye point of view.

And at fifth grade and beyond, virtually all children are able to interpret and construct typographic maps if the content is properly experienced.

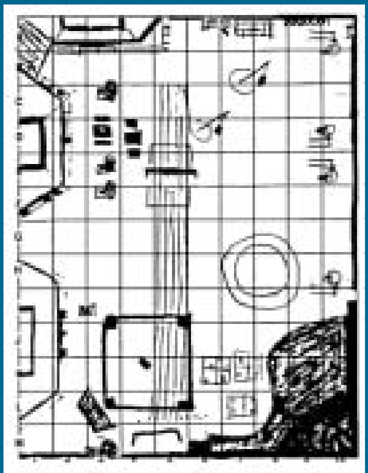
After selecting science content to match appropriate intellectual stages, FOSS designs and test activities and lessons that embed the content-first within concrete, relevant, hands-on experiences, then pictorial experiences, and finally symbolic experiences. Thus, instead of teaching a sequence of skills which increase vertically in cognitive complexity, a student is given the setting in which she can construct knowledge appropriate to her level of cognitive development. Through additional activities she experiences the content in a variety of circumstances and with a wealth of different materials (e.g., examine the **Landforms Module** activities involving materials to build a mountain {hands-on} that is scaled to an aerial photograph {pictorial} and a topographic map {symbolic}). Through such carefully crafted FOSS activities, the student is able to operate on a succession of progressively more difficult, challenging tasks while putting to use and extending cognitive capacities she already possesses.

For FOSS, there is no intent to "speed up" the students' development or to "move down" advanced concepts. Rather it is FOSS's intent to make what the student is capable of learning more useful, effective, relevant, and interesting, and to enable the student to progressively build, from grade level to grade level, an understanding of the grand ideas of science.

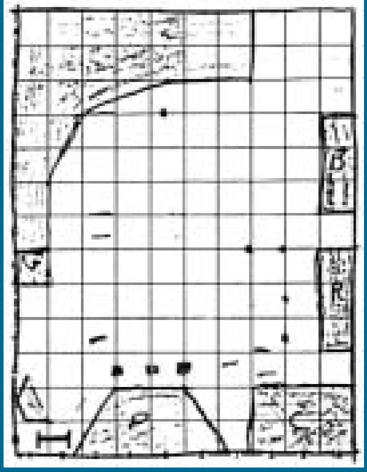
Sample Drawings:



EXAMPLE OF MAPPING A SCHOOL YARD: TYPICAL OF THIRD GRADE. (ILLUSTRATION FROM WEXLER, 1991)



EXAMPLE OF MAPPING A SCHOOL YARD: TYPICAL OF FOURTH GRADE. (ILLUSTRATION FROM WEXLER, 1991)



EXAMPLE OF MAPPING A SCHOOL YARD: TYPICAL OF FIFTH GRADE. (ILLUSTRATION FROM WEXLER, 1991)

References:

Brophy, J. (1983). "Conceptualizing Student Motivation." *Educational Psychologist*, Vol. 18, No. 3, pp. 200-215.

Bruner, J.S., and Kenny, M.J. (1966). *Studies in Cognitive Growth.* New York: Wiley.

Covington, M. and Berry, R. (1976). *Self-worth and School Learning.* New York: Holt, Rinehart and Winston, Inc.

Cowan, P.A. (1978). *Piaget with Feeling.* New York: Holt, Rinehart and Winston, Inc.

Lowery, L.F. (1992). *The Scientific Thinking Processes.* Berkeley, CA, Lawrence Hall of Science.

Lowery, L.F. (1989). *Thinking and Learning.* Pacific Grove, CA: Critical Thinking Press.

Piaget, J. (1969). *Psychology of Intelligence.* Totowa, New Jersey: Littlefield, Adams, and Company.

Welch, W.W. (1979). "Twenty Years of Science Curriculum Development: A Look Back." In D.C. Berliner, ed. *Review of Research in Education,* Washington DC: American Educational Research Association.

Wexler, D. (1991). *Development and Transfer of Map Making Concepts and Skills: FOSS Landforms Module.* Master's project. University of California at Berkeley.

This article was reprinted from the Spring 1993 *FOSS™ Newsletter,* pages 4-5
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