Being scientifically literate is more than knowing a set of science facts or having a set of science skills. It includes a way of thinking, a way of seeing, and having a set of values and perspectives. In Tailors' Alley in West Africa, learning the curriculum of tailoring and learning to be a tailor are inseparable: the learning takes place in the context of doing real tailors' work within the community of tailors. Apprentices are surrounded by journeymen and master tailors—from whom they learn their skills and among whom they live—picking up their values and perspectives as well. These values and perspectives are not part of the formal curriculum of tailoring, but they are a central defining feature of the environment and of what the apprentices learn. The novice tailors apprentice themselves into a *community,* and when they succeed in doing so, they possess a point of view as well as a set of skills—both of which define them as tailors (Lave, 1994).

# Communities of Practice

Dr. Lawrence F. Lowery

Compare the process by which one becomes a tailor in West Africa, to the process by which one becomes an expert at something in any field of endeavor. You cannot become an expert lawyer, doctor, automobile salesman, teacher, or a wise citizen without meaningful involvement within a particular "community of practice." You cannot become an expert at learning something, such as science, without involvement in a community in which such learning is inherent in what that community does.

The sense people make of what they experience is culturally determined. This holds true for all members of communities of practice and groups of people engaged in common endeavors within their own culture. In each case, the habits and dispositions of community members are culturally defined and have great weight in shaping individual behavior. Even in school, the culture of the classroom shapes what sense students make of what they experience.

The cultural perspective for learning is well grounded anthropologically, but it is relatively new to educational practice. The main idea, that a point of view is a fundamental determinant of cognition and that the community to which one belongs shapes the development of one's point of view, is significant (Geertz, 1983).

In classrooms, the science that students experience is broadly cultural. What is learned by the students extends far beyond the content and procedures of the science that is studied (the curriculum). Whether or not the teacher is explicit about his/her epistemological stance, what the teacher thinks science is shapes the kinds of science environments made available to students and thus the kinds of science understanding that students develop. Recognizing that the teaching of science is done within a cultural setting provides an important perspective to what teachers do when they teach.

The cultural assumptions about science that today's students are acquiring are of great concern to educators (National Commission on Excellence in Education, 1983). Studies show that in most schools the community of practice (the culture of the classroom in action) does not reflect or represent in any way a science community at practice. For decades, textbooks have perpetuated an incorrect point of view—both in terms of what science is and the way by which it is taught and learned. In most classrooms, *doing science* means reading a textbook and following the rules laid down by the teacher; *knowing science* means remembering and applying the correct answer when a question is asked; and *scientific truth* is determined when the answer is ratified by the teacher or the textbook. These ideas do not reflect the nature of science, and repeated experience with this incorrect view has led to several serious consequences.

One consequence is that most students come to accept a passive role in the learning process[1]. Another is that they come to think of science as content that is handed down by experts for them to memorize. Still another is that they come to believe that there is one right way to solve a problem—the way that is shown by the text and that the answers to problems are already known and will be provided[2].

Perhaps the most unfortunate consequence is that many beliefs that today's teachers hold about the nature of science—how to do science and what it means to teach it in school—were acquired when they were students in settings where they were passive and where content was delivered for them to memorize. Through many years of watching, listening, and participating in such practice, most teachers develop an inappropriate point of view concerning science and how it is best taught. The result is that they inculcate an inappropriate point of view to future generations, and the problem is perpetuated (Lampert, 1990, p. 31).

> *"It takes a whole village to educate a child."*
>
> — Ancient African Proverb

Students' primary experience with science—the grounds upon which they build their understanding of the discipline—is their exposure to it in the classroom. If that exposure is not culturally true to the discipline, then the students (and ultimately this country) will be ill prepared to participate in the highly scientific world of the future.

Today, with access to appropriate resources and opportunities to practice teaching science in a different way, some teachers have found that they can change the culture of the classroom—from one in which students are passive and receive information from authorities to one in which the classroom is a dynamic community of learners engaged in the practice of science.

Guided by the goal to create communities of learners in practice within the context of science as a domain, developers of the FOSS curriculum invented and tested activities that were designed to establish the cultural change in the classroom. Often, this was done by making use of small communities of practice (what FOSS calls *collaborative* groups) whose activities reflect the active nature of the scientific enterprise or other selected aspects representative of the science community. For example, some activities provide experiences in which students interact with each other and the science in ways that promote effective scientific thinking. Other activities allow students to exchange ideas and support different interpretations of results. Within this setting the teacher is expected to be a part of the community of practice and not separate from it.

In the research and development phase of the FOSS modules we critically examined whether and how it might be possible to bring the practice of knowing science in school closer to what it means to know science within the community of scholars who practice the discipline. We did this not for the purpose of preparing people to be scientists, but rather to enable people to develop important understandings and capacities that would serve them in many ways. By deliberately altering the roles and responsibilities of the teacher and students in the classroom, we were able to change the meaning of knowing and learning within the school setting. The FOSS Teacher Guide provides ideas for initiating and supporting social interactions appropriate to doing some aspect of science such as conjecturing (e.g., guessing, hypothesizing, predicting) and making scientific arguments in response to conjectures. Through many of FOSS's extensively-tested activities students find patterns, make definitions, reason about their claims, and ultimately defend them. Two examples follow. Both are derived from transcripts taken during the development phase of the activities: *Carbon Printing* from the **Ideas and Inventions Module** and *Stream Tables* from the **Landforms Module.**

[1] Whenever science textbooks include activities, the text is written so that students can "read around" the activities, thus bypassing them altogether, or the activities are structured like a recipe that is to be followed step-by-step. From such experiences students come to believe that ready methods are available to solve all problems, the method for the solution of a given problem must be memorized, and the method will always produce an answer to the problem (Carpenter et al., 1983). The result of this belief is that students (1) seldom attempt to solve problems for which they have no ready procedure to follow, (2) curtail their efforts after only a few minutes of working without success on a problem.

[2] Studies have found that students consider textbook problems to be exercises of little meaning; thus they often come to believe that the topic is not something they can make sense of, but rather that it is something that is arbitrary or at least whose meaningfulness is inaccessible to them and which must thus be memorized without looking for meaning (Lampert, 1990).

### Ideas and Inventions Module: Carbon Printing Folio

At one point during the Carbon Printing activity, some students expressed the idea that if their right-hand thumb pattern was of a particular type, then the rest of the patterns on the other fingers of that hand should be of the same type. Other students did not think so. The students agreed that to find out they would have to get pattern samples of all five fingers on their right hands. They divided themselves into two groups—a group that thought the prints would be the same and a group that thought the prints would be different. Each group took samples of themselves and other students in the classroom. When the samples were examined, the group that thought the patterns would be the same abandoned their hypothesis, and the group that thought the patterns would be different were able to provide evidence in support of their idea. But almost immediately, new questions came to mind to the students. One student wanted to know if it was *ever* possible to have all fingers of the same type. Several others wondered if their left-hand patterns would match their right-hand patterns. Another wondered if his toes had prints. Another wondered if her mother had prints like hers. The conjectures were varied and in many cases individualized. All were testable, so students gathered evidence that supported or did not support the idea they had.

Note that in the activity described above, the teacher seems to be invisible. Actually the teacher entered the dialogue from time to time as a knowledgeable participant—a representative of the classroom science community who is not an all-knowing authority but rather one who could ask pointed questions to enable students to arrive at reasonable conclusions. Within a community of learners, this pedagogical practice of deflecting undue authority places the responsibility of scientific conclusions on

*Continued on page 8*

the shoulders of the students. They do not turn to the teacher for answers. They gain confidence that they can derive answers for themselves.

### Landforms Module: Stream Tables Folio

The introduction of the use of stream tables began somewhat formally so that students would recognize important procedures in the preparation and use of the apparatus (e.g., there needs to be a container for collecting runoff water and newspapers for sopping up spillage; thought must be given to the preparation of the earth materials and the positioning of the water source, and so on). The apparatus familiarity experience was followed by small groups of learners working independently of other groups but on the same task—running water through the earth material for a certain amount of time and observing the results. There was no prior problem or question to be solved. The experience was open-ended and allowed for the generation of hypotheses. When finished, the different groups were asked to compare and contrast their results. Commonalities and variances in results immediately become apparent. Because students knew they all began with the same set up, variances caused an interesting positive tension that led students to naturally raise questions. Such tensions within and across groups and the discussions that resulted in the resolutions of conflicting ideas made the relevant earth science issues salient and meaningful to the students. In the stream table settings, different students had different ideas regarding what they thought might happen in a situation. The materials were sufficient to provide ways by which students could derive evidence that did or did not support their ideas. On subsequent observations, the students appeared to be intellectually well-prepared (through their prior experiences) and thus entered into more advanced discussions.

Note again that the teacher's role is not one of a "fact teller" but one of a "facilitator." The teacher is visibly active in the management phase of the activity, but she quickly disappears to become free to roam from group to group, engaging as a participant when it is appropriate to do so.

In the preceding examples, the classroom environments were consonant with the idea that science is an ongoing, dynamic discipline of sense making, achieved through the dialectic of conjecture and argumentation. Our early work in developing FOSS found that experiences of these types consistently resulted in the students' coming to grips with some fundamental science notions and that self confidence in problem solving developed. To sense the difference between these experiences and traditional ones, simply compare the same content topics with those in a text-driven program.

For FOSS, the content domains of science (biology, physics, earth science, and so on) provide opportunities for distinctive modes of thought to be used and developed. The modes, which FOSS calls the *Scientific Thinking Processes,* are natural, versatile, and powerful (Lowery, 1990). They underpin the ways by which humans observe and communicate, ways they make order through comparing, grouping, seriating, and classifying, ways they discover cause and effect patterns by seeing relationships between and among objects, ways they infer about what cannot be seen by hypothesizing, predicting, modeling, and experimenting, and ways they apply what they have learned by model building and theorizing. Experience with these thinking processes within a science community of practice moves novices of all cultures toward expertise.

Scientific literacy is a level of expertise of increasing value in the current and future technological age. That expertise will enable individuals to read critically to identify fallacies, to detect bias, to assess risk, and to suggest alternatives. A person who comes to possess such capacities of mind is a scientifically literate person. That person will be empowered to understand better and make effective use of the scientifically information-laden world of the 21st century.

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