Sometimes when I am working with teachers to resolve educational problems, I'll suggest that they think about the educational enterprise as a metaphor. Metaphors provide powerful insights into the perceived workings of complex systems. They can explain the source of problems and suggest ideas for solutions (Lakoff and Johnson, 1980; Turner, 1991).

Changing the Metaphor

Dr. Lawrence F. Lowery

"I think my school is a three-ring circus," one teacher told me. "The principal is the ringmaster, and he cracks a mean whip. There are days when I am a performing juggler, trying to keep many important things going at the same time. Other days I am the high-wire performer who walks the tightrope—the sensitive political lines between parents, the school system, and what I believe is important for children. And some days my classroom is the tiny Volkswagen from which, when its doors open, there escape more than 30 hyper, highly individualistic clowns."

Another teacher said, "My school is a sanctuary. It is the only place where the children can come to be safe from the tragedies, dangers, and temptations in their neighborhood." Over the years I've collected a large number of metaphors that educators generate when they think of their schools and how they operate: the school is a prison, a nursery, a hospital, a military base, or a fortress. No metaphor ever captures all of a situation, but each metaphor provides some clarification of the operation of a system.

The metaphor that is most frequently used to describe what goes on in education is the industrial metaphor. American schooling grew during the industrial revolution and naturally incorporated many of the accouterments of that revolution. Thus, schools often resemble factories in which classrooms are workplaces. Sometimes students are treated like products to which the teacher (assembly line worker) adds some qualities. But more frequently students are treated like workers to whom the teacher (supervisor, manager) assigns "seat work," "homework," and commands students to "get back to work." (Marshall, 1988). A typical workplace-classroom is one in which the teacher might say, "My students are well trained. When the bell rings, they get right to work on their assignments."

Changing the Curriculum

For more than two decades, most science curricula have been designed to fit the workplace metaphor. Because of the fit, implementation has been easy, efficient, and there has been *no improvement* in the teaching of science—districts or schools select and buy textbooks, deliver them to schools, and the implementation process ends as teachers pass out the books and continue to teach in much the way they have always taught.

Today forceful movements are underway to change the way science is taught. Funding agencies are supporting the development of "new" curricula. National standards are being established. Fresh ways to assess learning are being developed.

FOSS is one of the several newly funded curricula, and it was deliberately designed to establish the classroom as a *learning place,* rather than a workplace. To accomplish this, FOSS incorporated qualities unique to learning settings and differentiated from work settings. These qualities were gleaned from cognitive and social constructivist views of learning as well as from research on work-oriented and learning-oriented classrooms.

The Cognitive Constructivist Perspective

Drawing upon the cognitive perspective, FOSS activities implement changes in the classroom by engaging the learner in the process of actively constructing and restructuring knowledge. This is done within developmentally appropriate complex networks that progressively increase in conceptual depth and consistency as students advance through the grades. This cognitive perspective contrasts sharply to the behaviorist perspective that is associated with the workplace setting, wherein discrete facts are delivered from external sources (textbooks, teachers), and students react to gain external rewards (do work for a grade). There is little continuity from one experience to another (experiences are eclectic and unrelated) (Shuell, 1986).

Contrast this workplace model to a cognitive constructivist model. For example, in the *Making Connections* activity from the **Magnetism and Electricity Module,** groups of students collaborate to determine how to organize a set of batteries, wires, switches, and motors to make the motors run. The goal of the experience is for the students to discover the principles that will allow them to construct understanding of circuitry. In a workplace classroom students read about circuitry or following directions that show how the parts of a circuit are to be connected. Showing that the parts are hooked up correctly is the goal of the lesson.

In a cognitive constructivist classroom the role of the teacher changes as well. No longer a workplace manager, the teacher is free to be a guide or facilitator with an expertise in recognizing misconceptions and assessing learning. To implement this change, FOSS provides the tools that enable teachers to develop and use this expertise. FOSS assessment procedures include learning tasks in a variety of formats that can determine a student's current level of development as well as the cognitive processes a student uses in an activity.

The Social Constructivist Perspective

Drawing upon the social constructivist view of learning, FOSS suggests ways to engineer the social context in which activities are presented. Although FOSS makes use of many types of classroom arrangements, the most frequently used arrangement is the *collaborative* group. Collaboration provides many benefits that enhance learning. When students work collaboratively, the multiple roles (GETTER, STARTER, READER/REPORTER,

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CHANGING THE METAPHOR

THE WORKPLACE SETTING	THE FOSS LEARNING SETTING
Goal	**Goal**
◆ The production of a tangible, externally visible product for the benefit of the employer (teacher) rather than the worker (student).	◆ The acquisition or construction of science knowledge and processes that are of benefit in terms of self-development or improved quality of life.
The Teacher	**The Teacher**
◆ Works independently and does not know how what he/she teaches in science fits or contributes to anything else that is taught.	◆ Works collaboratively with other teachers and knows how what is taught in science contributes to what students learned before and how it will contribute to what students will experience in later grades.
◆ Maintains authority.	◆ Delegates some authority and responsibility to students.
◆ Views errors as being costly and evidence of inefficiency.	◆ Views errors as misconceptions that can be a source of further learning.
◆ Gives and receives answers; expects correct answers.	◆ Asks and encourages questions; accepts first-draft thinking.
◆ Leads or shows.	◆ Guides or facilitates.
◆ Uses evaluation procedures; is judgmental; values right answers. Evaluations are usually given at the end of an experience and results are seldom used.	◆ Uses assessment procedures; is accepting and supporting; values thinking. Assessments are on-going and provide information for both the student and the teacher.
The Learner	**The Learner**
◆ Is taught; engages in compulsory activities; is an empty container to be filled; performs (e.g. repeats rote answers) or produces a product (fills in worksheets) to please others.	◆ Learns; explores a variety of interests; has varied prior experiences; constructs knowledge and understandings for him/herself.
◆ Proceeds at the same pace with others through the same text under the watchful eye of the teacher. The pattern of work is similar to that of large-batch processing in industry.	◆ Is involved with the thought processes and understandings of the tasks that mediate learning (adding and relating new information to what is already known, planning, goal setting, and so on).
◆ Is taught to perceive knowledge as absolute and seek truth from authority.	◆ Learns that knowledge is socially constructed and seeks understandings through evidence.
The Curriculum	**The Curriculum**
◆ Emphasizes the end product.	◆ Emphasizes the process/product relationship.
◆ Prepares students for the known.	◆ Prepares students for the unknown.
◆ Experiences are eclectic within a scope and sequence that may not be developmentally appropriate; many topics are covered superficially.	◆ Experiences are organized to be developmentally appropriate and progressive over years of time. A few carefully selected topics have real-world importance and are explored in depth.
◆ Experiences are recipes, always convergent (set, linear, rigid); relationships with other subjects are added on.	◆ Experiences vary, are divergent or convergent; relationships with other subjects are integrated.
◆ Experiences are memorizable.	◆ Experiences are memorable.

Metaphor continued

RECORDER) and varied cognitive functions required to carry out a task produce a complexity of information that is much greater than that produced by any one individual. Each individual provides a point of view and a set of interpretations from which others can learn. Each individual receives more than he or she contributes, enhancing the knowledge construction process for everyone (A. Brown and Reeve, 1987). Collaboration has a synergistic effect that improves insights and problem resolution for the participating individuals (J. Brown, Collins, and Duguid, 1989). Collaborative groups create group norms where effort and intention to learn are valued, thereby enhancing the motivation to learn by all members of the group (Ames and Ames, 1984).

To see the benefits of collaboration, observe the *Black Boxes* activity from the **Models and Designs Module.** In this activity, students begin by trying to conceptualize the interior of a sealed black box, working alone. They then move into collaborative groups to compare their ideas. At this point, watch and listen to students interacting—sharing ideas, building arguments to convince others of their models, giving evidence, adjusting their ideas as others provide different perspectives, and inventing tests they had not thought of before or could not think of alone. Notice that different perspectives are valued by the students—learning is valued, clear ideas are valued, and there is no need for a single correct answer to the problem.

Changing the Metaphor

The metaphors we use to conceptualize classrooms affect our teaching and practice. Altering the metaphor can lead to different insights into classroom processes and to significant improvements in educational practice (Greeno, 1989; Armstrong 1991). Changing the industrial metaphor is necessary if change in science education is to take place and be long lasting.

Although the industrial metaphor oversimplifies the educational enterprise, it remains at the center of many of the problems we face when we want to bring about change in schools. If educational materials continue to be designed to fit within the paradigm of the industrial metaphor, they will simply refine parts of the status quo, and no real change will take place. If new instructional materials demand a different paradigm, implementation of these materials will result in real change in the teaching of science (and perhaps all teaching). The curriculum must change, teaching must change to maintain the integrity of the curriculum, administrators' roles must change to mainstream and support the instructional changes, and university preparation of future teachers must change to produce a new kind of teacher. Once real change in the teaching of science has been implemented, new metaphors will emerge to replace the old ones. FOSS suggests that the new metaphors should begin with activities that develop autonomous learners, and with instruction that builds on a cognitive and social constructivist perspective.

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