FOSS Introduction

The Full Option Science System® springs from a philosophy of learning at the Lawrence Hall of Science that has guided the development of successful active-learning science curricula for more than 25 years. The FOSS® developers are dedicated to the proposition that elementary students learn science best by doing science. Teachers and students do science together when they open the FOSS kits, engaging in enduring experiences that lead to deeper understanding of the natural world.

Science is an active enterprise, made active by our human capacity to think. Scientific knowledge advances when scientists observe objects and events, think about how they relate to what is known, test their ideas in logical ways, and generate explanations that integrate the new information into the established order. Thus the scientific enterprise is both what we know (content) and how we come to know it (process).

Because science is a discovery activity, it is fundamentally a process for producing new knowledge. Although many of us tend to think of scientists as special people, the processes they use are quite natural to all people. We all continually make careful observations of phenomena and create explanations that make sense out of those observations. Science is a wonderful, natural human enterprise through which we all find out about things.

The best way for students to appreciate the scientific enterprise, learn important scientific concepts, and develop the ability to think well is to actively construct ideas through their own inquiries, investigations, and analyses. The Full Option Science System was created to engage students in these processes as they explore the natural world.

GOALS OF THE FOSS PROGRAM

FOSS has set out to achieve three important goals.

1. SCIENTIFIC LITERACY. Provide all students with science experiences that

a. are appropriate to their cognitive development and

b. serve as a foundation for more advanced ideas that prepare them for life in an increasingly complex scientific and technological world.

Because the quality of life will be significantly influenced by science and technology in the 21st century, it is important for all citizens to be scientifically literate. They should be able to make thoughtful, informed decisions.

Project 2061 of the American Association for the Advancement of Science characterizes scientific literacy as

- Familiarity with the natural world, its diversity and interdependence.
- Understanding the big ideas of science such as energy, patterns of change, variation, systems and interactions, and scale and structure.
- Knowing that science, technology, and mathematics are interdependent human enterprises and, as such, have implied strengths and limitations.
- Ability to think scientifically.
- Using scientific knowledge and thinking patterns for personal and social purposes.

The FOSS program design is based on cognitive theory that suggests that learners advance through increasingly complex levels of thinking over time. The ability to organize new information and relate it to established knowledge increases in depth and sophistication. Through internally regulated and social processes, students construct understanding of the natural world and their relationship to it.

Second graders understand the natural world and its diversity by observing and comparing objects, organisms, and natural systems. They organize this information into simple conceptual structures that define scientifically literate second graders.

As fifth graders, students are able to interpret natural phenomena in terms of cause and effect, and tackle concepts that call for understanding relationships among variables. Students can formulate testable questions, conduct experiments, and build explanations based on data. This more complex, but still developing, knowledge of the natural world is characteristic of scientifically literate fifth graders.

Middle schoolers start to grapple with inferential subjects, encountering the intellectual constructs that give form and meaning to dimensions of the natural world that we can't know as a result of direct experience. Starting to fold these deep abstractions into understanding of science is characteristic of scientifically literate middle schoolers.

2. INSTRUCTIONAL EFFICIENCY. Provide all teachers with a complete, flexible, easy-to-use science program that

a. reflects current research on learning, including collaborative learning, student discourse, and embedded assessment, and

b. uses effective instructional methodologies, including hands-on active learning, inquiry, integration of disciplines and content areas, and multisensory methods.

Hands-on science is intrinsically fun and interesting for students. And most teachers can be superb science teachers when they are provided with effective instructional materials. FOSS is designed to make hands-on science engaging for teachers as well as students.

- Complete equipment kits with durable materials.
- Science background for the teacher.
- Detailed lessons that are easy to follow and adaptable to many teaching styles.
- Teacher preparation videos showing extensive classroom interaction (K–6), and teacher video clips demonstrating specific techniques (6–8).
- Embedded (formative) assessments.
- End-of-module (summative) assessments for grades 1–8, including performance assessments.
- Student sheets, in English and Spanish, including a letter home to parents for grades K–6.
- *FOSS Science Stories*—module-specific readings for grades K–6.
- FOSS *Resources* book—course-specific readings for grades 6–8.
- Lab notebook for organizing data for grades 6–8.
- Interdisciplinary activities, including math and language extensions (K–6).
- Specific activities to do at home (K–6).
- Suggestions for extending experiences through reading, videos, and software.
- FOSSweb website with interactive multimedia activities for use in school or at home (K–6), and course specific multimedia (for 6–8).

3. SYSTEMIC REFORM. Meet the community science-achievement standards and societal expectations for the next generation of citizens, prepared with the knowledge and thinking capacities to manage the 21st century.

The FOSS program design makes it appropriate for reform efforts on all scales. It has met with the approval of science and technology companies working in collaboration with school systems, and has demonstrated its effectiveness with diverse student and teacher populations in major urban reform efforts. FOSS continues to respond to the needs of systems moving away from passive exposure to scientific concepts toward real experiences for students that reflect the vision of a scientifically literate America.

THE THINKING BEHIND FOSS

THE HUMAN MIND

The FOSS program is guided by research on human cognitive development. The activities and intellectual demands are matched to the ways students think at different times in their lives. The research indicates that the human mind is wonderfully flexible and capable of engaging increasingly complex ideas as it matures, acquires experience, and exercises.

As powerful as it is, the human mind is not fully formed at birth, ready to tackle all cognitive challenges. The mind grows continually from kindergarten through high school and beyond. It is important to remember that young students typically are not able to engage all subjects or to apply advanced levels of relational, mathematical, and logical thinking. The challenge facing science program designers is to create learning experiences that are developmentally appropriate, intellectually challenging, and scientifically rigorous, and to do so throughout a student's academic career.

In their early elementary years, students learn science best from direct experiences in which they observe, describe, sort, and organize objects, organisms, materials, and simple systems. Using their senses to acquire data, and their emerging language and mathematics skills to process and communicate their observations, is appropriate and authentic engagement with science for early learners. The foundation concepts about the natural world and the basic inquiry skills that are established in the early years form the anchor concepts on which students will construct more advanced understanding in the years to come.

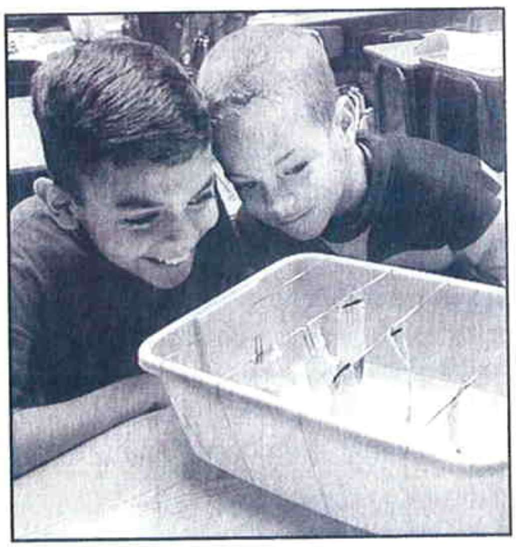
Upper elementary students construct more advanced concepts by classifying, testing, experimenting, and determining cause-and-effect relationships among objects, organisms, and systems. Effective learning is still based on direct experience, but should be enhanced and extended with information from print and other media. At this time in their lives, students make significant advances in their ability to incorporate logical-mathematical thinking into their scientific inquiries, such as formal measurement, the concept of variability, and relational logic. Students' ideas are based on evidence, and their advancing language skills allow them to explain and defend their intellectual constructs effectively.

In their middle school years, students tackle inferential subjects, like force, energy, cosmology, atomic theory, and chemical interactions. At this time students are required to think about things that cannot be experienced directly. Models replace objects, and symbols represent powerful abstractions. Students actively construct, revise, and extend basic models about the structure and function of the natural world that will affect everything they have learned so far about science.

LEARNING WITH UNDERSTANDING

This model of human cognition, in which cognitive development is incremental and continuous, has implications for curriculum and instruction. If there are characteristics of learners that we can understand, there should be characteristics of instruction that will take maximum advantage of those learner attributes.

Research suggests that understanding moves from concrete experience to abstract conception. Direct firsthand interactions provide a foundation for concepts that cannot be experienced



directly. FOSS instruction begins with hands-on investigations, then moves students toward abstract ideas related to those investigations, using simulations, models, and readings.

Research emphasizes that fewer topics experienced in depth produces much better learning than many topics briefly visited. FOSS affirms this research. FOSS modules provide long-term engagement (8–10 weeks) with important science topics. Furthermore, modules build upon each other within and across each strand, progressively moving students toward the grand ideas of science. The grand ideas of science are difficult and complex, never learned in one lesson or in one class year.

Merging the ideas of deep engagement and cognitive development gives rise to the concept of a horizontal curriculum design. The FOSS methodology does not push students to learn more complex, cognitively inappropriate subject matter earlier in their academic careers, but rather pushes students to explore widely at their cognitive level. The horizontal curriculum is exciting for students and a joy for teachers.

Research has shown that when language arts experiences are embedded within the context of learning science, students improve in their ability to use their language skills. Students are eager to read to find out information, and to share their experiences both verbally and in writing.

Practical experience shows that all children can learn science, that there is no differentiation between genders in interest or ability to understand science concepts, that students with learning difficulties often shine in solving science problems, that English language learners have success alongside their fellow students, that gifted students are often inspired to "run with the topic" beyond the interests of other students. FOSS is a great way for *all* students to learn science.

INSTRUCTIONAL PEDAGOGIES

The FOSS program uses several instructional pedagogies to make science more efficient for teachers and more productive for students.

Inquiry. FOSS investigations are guided by questions. The overarching questions of science are "what's in this world?" and "how does it work?" In FOSS we break them down into discrete subquestions, as scientists must, that can be explored effectively. In pursuing answers, students usually start with free exploration of materials, followed by a discussion of their discoveries. Often new questions arise while students seek answers, leading to additional student-motivated inquiries with materials to reinforce and extend concepts.

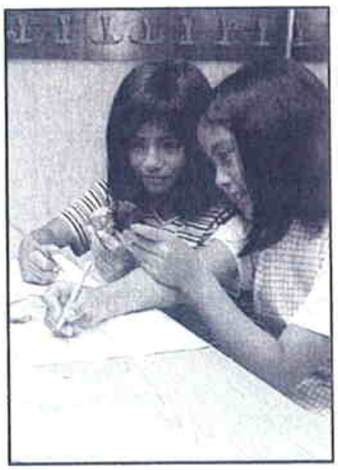
Hands-on Active Learning. It is widely accepted that children learn science concepts best by doing science. Doing science means hands-on experiences with objects, organisms, and systems. Hands-on activities are motivating for students, and they stimulate inquiry and curiosity. For these reasons FOSS is committed to providing the best possible materials and the most effective procedures for getting students deep into scientific concepts. FOSS students investigate, experiment, gather data, organize results, and draw conclusions based on their own actions. The information gathered in such activities enhances the development of scientific ways of thinking.

Multisensory Methods. Observing is often equated with seeing, but in the FOSS program all five senses are used to promote greater understanding. FOSS evolved from pioneering work done in the 1970s with students with physical disabilities. The legacy of that work is that FOSS investigations naturally use multisensory methods, not only to accommodate students with physical and learning disabilities, but also to maximize information gathering for all students. A number of tools used in the FOSS program, such as the FOSS balance, were originally designed to serve the needs of students with disabilities.

Student-to-Student Interaction. Collaboration is central to the enterprise of science. In FOSS investigations for grades 3–8, students work in groups of four with each member contributing to management, data collection, data analysis, and reporting of results. Individual students' observations and ideas are always incorporated into group decisions. Hands-on science, where students collaborate in planning, action, and information processing, gives students opportunities to develop deep understanding and rich, thoughtful interactions with other points of view.

Students in the early grades are just beginning to work cooperatively toward group goals. They do not always share materials gracefully. We have found that in grades K–2 it is usually best for each student at a table to have his or her own materials to work with. But working in close proximity to other students is important; it allows for easy interchange of ideas and communication of discoveries. We refer to this early elementary organization as working alone...together.

Discourse and Reflective Thinking. Discourse is tremendous exercise for the mind. Have you considered the immense complexity of converting experiences and ideas into words to be spoken or written? An idea or concept must be synthesized from the innumerable bits of stored information, and that concept must then go through the language center, where it is deconstructed into a string of symbols we call words, and output in a sequence that conveys information. An awesome cognitive process.



This is the essence of discourse—putting ideas and experiences into words. The process requires a tremendous amount of information processing, internal verification, and validation of what is known. This dimension of science education is sometimes referred to as the minds-on approach to science. It simply means that it is not enough just to work with materials—you have to think about what the experience with materials tells you about the world.

Discourse takes several forms in FOSS.

- Focused discussions take place in collaborative groups.
- Traditional whole-class question-and-answer sessions summarize a lesson and put important points in front of the class.
- Content/inquiry sessions wrap up each part of each investigation.
- Student sheets help students collect and organize data and discuss the results in thoughtful ways. Student-sheet discourse may be an individual or a group effort.
- Response sheets elicit individual discourse on specific topics for assessment purposes.

Reading and Research. In science, reading adds power to the curriculum. Through the printed word students can extend their experience beyond the limits of the classroom and the FOSS kit; they can enhance their understanding of concepts by exposure to related ideas; and they can share in the lives of people who played roles in scientific discovery or applied scientific ideas to life situations. *FOSS Science Stories* (K–6) and FOSS *Resources* books (6–8) were written to add this dimension to the FOSS program.

However, we believe strongly that reading should not be the primary source of science information in the curriculum. The primary source should be personal experience. Carefully selected reading materials, provided after an activity-based foundation is in place, can add a very effective dimension to science learning.

Other research tools recommended in the context of the hands-on activities for students include video excursions, computer software, and the World Wide Web.