MST Curriculum Philosophy/Rationale

The philosophy that underlies this introductory materials science and technology (MST) curriculum has as much to do with how things are taught as with what is taught. The instructional approach is based on the idea that students cannot learn through talk or textbooks alone. To understand materials, they must experiment with them, work with their hands to discover their nature and properties, and apply the scientific concepts they learn by "doing" to designing and creating products of their own choosing.

Learning comes, as it has for humankind for generations, from the active pursuit of solving problems. In this case, students learn from solving problems using the scientific process, which is speeded by scientific knowledge. Students get a chance to use and build their mechanical skills as well as mind skills. We call this approach hands-on/minds-on learning.*

"A combined emphasis on "know-how" and "ability to do" in carrying out technological work transforms mathematical and scientific principles into reality."

—International Technology Education Association

Learning by doing is not a new or complicated idea, but it is not common in today's classrooms. Unlike many mathematics and science classes, students enrolled in MST classes are excited instead of bored. They ask "What happens if ...?" instead of "What's the right answer...?" Instead of sitting at a desk reading about science and technology, they work on science and technology activities. They're not memorizing facts about mathematics and science, but using the thinking processes of scientists and mathematicians to become better reasoners, and learning facts and concepts while solving problems relevant to them as they create their projects.

The MST course can only be fostered by good teachers, those who are a regular part of the school system and community members who have mastered their skills and are willing to pass on what they have learned. Teachers must create a learning environment where students are willing to risk and are willing to learn from mistakes they make.

Beyond MST's basic project approach, other fundamental elements of the program include fostering student creativity, developing journal writing skills, and teaching in teams (science and technology teachers). Peer teaching also plays an important role. Students who have just mastered a skill or gained an idea can be the most convincing teachers.

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* "Hands on/minds-on": this phrase originated with Herb Thier, Lawrence Hall of Science, and refers to experiential learning that physically and intellectually engages the student.

When scientific concepts, thinking skills, and mechanical skills are combined, then science and technology are truly combined, and an atmosphere exists that appeals to a broad range of students. Not just "science smart" students, but also the so-called average students not usually reached by traditional science, mathematics, and technology curricula and also young women and traditionally underrepresented students.

Working with materials appeals to all students because materials are the medium for art, handicrafts, and the myriad of things that surround them. Students enrolled in honors science courses find that MST focuses the science knowledge they have learned in other courses and gives them a chance to use mathematics skills in concrete ways. Other students, more oriented toward applied technology than traditional science, who are not usually adept at memorizing or doing mathematics, often shine in the MST course as they discover how to connect subjects usually taught in isolation. They can apply their abilities and strengths in areas of problem solving in which they do well.

Through the process of working with materials, students begin to understand science as a highly socialized activity. They discover that science is not just facts and figures, but a process that relies on people's visions and imaginations, as well as their abilities to follow through a step-by-step process. The degree of "handiness"* MST students develop goes a long way toward instilling in them a sense of self confidence. Although few students take advanced materials classes in college, most say MST has changed the way they look at the world.

"Do not try to satisfy your vanity by teaching a great many things. Awaken people's curiosity. It is enough to open minds, do not overload them. Put there just a spark. If there is some good inflammable stuff, it will catch fire."

—Anatole France

* "Handiness": a term contributed by Eugene Eschbach, Manager of Innovation and Technology at Battelle, refers to the ability to solve materials-related problems with available or limited resources (see page 2.15)

MST Multi-Instructional Approach

- Solving Problems
- Creating Student Projects
- Using the Laboratory Journal
- Working in Small Groups
- Developing Handiness
- Fostering Creativity
- Teaching in Teams
- Using Community Resources

Multi-Instructional Approach

Because this MST course is designed to be taught to a wide range of students, we use a multi-instructional approach that includes elements to appeal to many learning styles. In general, we describe the instructional process shown in Figure 2.1 as "observe, correct, and create." It works something like this: Students ponder, plan, experiment, GOOF UP, correct, discover, and learn in a laboratory setting. These concepts are the principles of the scientific process.* As part of the process, students experiment individually or in groups, record their observations in a journal, and discuss the experiments and their observations in class or small groups. In addition, students read and research, using periodicals and other library resources in relation to the unit of study or their selected project. Students are encouraged to gather information by interviewing or working with those who are familiar with the materials or are experts in the field of study.

The multi-instructional approach focuses on solving problems, creating student projects, working in small groups on open-ended experiments, writing as a means of learning, participating in high-interest demonstrations and activities, using community experts in materials, showing videos, and using a host of written resources. These approaches reach many minds and learning styles, and can interest many students in the learning process.

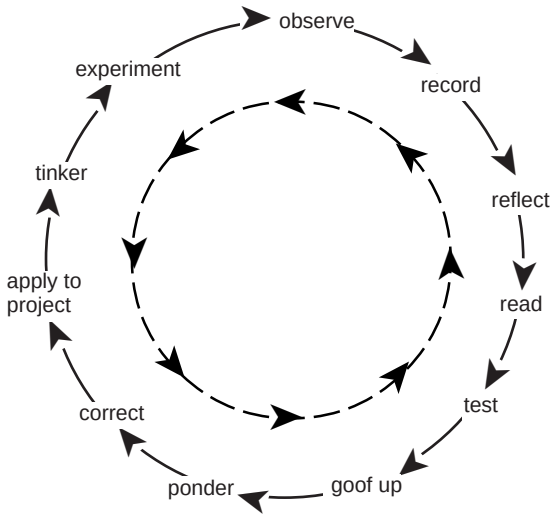

Figure 2.1. MST Learning Process

* The process may be recursive, allowing students to cycle back to gain additional information, even as they move forward.

"As children we were fascinated with 'tearing' things apart. As we matured and went through the educational system, the desire or fascination somehow died or was stuffed until only those who could memorize written data and regurgitate it were recognized as being smart or gifted. The so called 'handy' student was lost or ran out of places where their skills could be evaluated and appreciated."

—Andy Nydam, MST Teacher
River Ridge High Schol

Course of Study

Four major units of study form the basis of the MST curriculum. Each unit typically includes the following activities as shown in Figure 2.2. *Note the approximate percentage of time required for each activity.*

Student Experiments—Students conduct experiments individually and in groups (35%). The experiments feed student projects.

Student Projects—Students design, research, create, and build individual or group projects (35%).

Instructor Demonstrations and Presentations—One day per week (20%).

Films, Videos, Guest Speakers, and Visits to Industries and Laboratories—Fostering creativity, developing handiness, and using community resources are also major elements of the MST multi-instructional approach. These elements are integrated into the curriculum through student projects and the instructor's ability to promote these concepts (10%).

Reading, Writing, and Discussion—These activities are integrated throughout. Students 1) write and sketch in a journal to record observations, procedures, experiments, and progress on projects (information from presentations, guest speakers, tours, readings, and films also is recorded); 2) read and research (through interviews, periodicals, and library resources) in relation to the unit of study or the students' selected projects; 3) participate in journal writing activities to practice and enhance student writing skills; 4) explore through discussion, writing, and applying the process of creativity, innovation, and scientific inquiry; and 5) study specific occupations that require a special understanding of material characteristics and how these occupations can change as a result of technological change in materials.

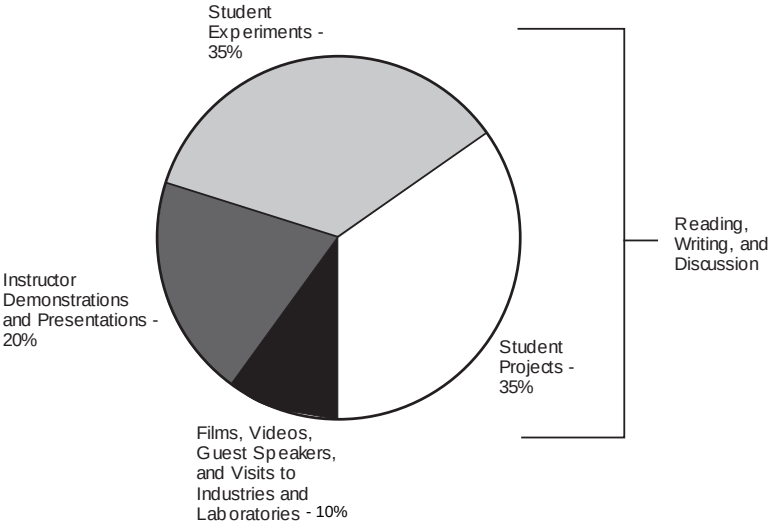

Figure 2.2. MST Activities