Twisting the Dragon's Tail

Students in the Materials Science and Technology (MST) course at Richland High School in Washington state are willing to take risks, to chance a mistake by trying something new. They know that a so-called mistake in the execution of a materials project may actually be an opportunity to learn, to extend the dimensions of the original design, or to create something new.

A hands-on, minds-on approach to the MST content, coupled with direct guidance from their teachers and community mentors, releases students from apprehension about making mistakes. They have the courage to risk disaster, to "twist the dragon's tail" so to speak.

This classroom approach mirrors that of real scientists and technologists as they experiment, create, design, and build in their laboratories. This approach is the heart of the MST course developed jointly by teachers in Northwest schools and the Pacific Northwest Laboratory, a U.S. Department of Energy Laboratory operated by Battelle Memorial Institute. Acknowledging unexpected results or unpredicted outcomes is key to the process in both lab and classroom.

One MST student designed and built a sterling silver ring. She made a wax model, formed a rigid plaster mold around it, and programmed the furnace to "burn out" the wax slowly and leave a reservoir for the silver. Next she calculated the silver density needed, alloyed the silver with copper, and cast the ring in a centrifugal casting machine. She then set a cubic zirconium stone in it and finished and polished the piece, which she planned to give to a friend. While examining the ring, a teacher dropped it on the concrete floor. The student thought the ring was ruined and was ready to discard it when local goldsmith and artisan Paul Howard stepped in. One of the community mentors in the Richland High School MST course, he engaged the student in looking for ways to transform the compressed and fractured corner into a modification and an improvement to the design.

In the MST classroom, students are encouraged to ask "What happens if...?" instead of "What's the right answer...?" Scientists and engineers learn to reason this way in their work. It also removes the pressure of students thinking they always have to be right. Battelle's Eugene Eschbach tells students how he learned:

"That it's okay to err during an investigation or during a learning process was brought home to me again and again by my most illustrious mentor, Dr. Lloyd Preston Garner of RCA. One day Dr. Garner found in a wastebasket a damaged part from an experiment. He grabbed the part, called everyone to an informal meeting, and asked who had thrown the part away and why? Then he asked why the rest of our group was not made aware of the error. Dr. Garner went on to say that an error was, first, an opportunity to learn and, second, an indication of a possible shortcoming. From then on, Dr. Garner said it would be an honor to err because 'our errors are our greatest teachers.'"

A 20-foot-long trophy case was placed in his office to exhibit all errors and surprises after they were analyzed. I was privileged to be with Dr. Garner for four and one-half years. And during that time I filled four of the five shelves with errors, unusual events, and an occasional triumph.

The Education Exchange highlights the experiences of scientists and engineers with local schools, along with helpful hints and resources. If you would like to share your own involvement in science education, contact: Finley Shapiro, Department of Electrical and Computer Engineering, Drexel University, Philadelphia, PA 19104, U.S.A. Phone (215) 895-6749; fax (215) 895-1695; e-mail: shapiro@ece.drexel.edu

As Battelle materials research scientist, Mary Bliss, reminds us: "Glass-ceramics were an accident. An annealing furnace did not turn off as programmed. Instead of throwing away the resulting material, Donald Stookey asked himself, 'What is this stuff anyway?' This led to a whole new field within glassmaking."

Profiting from mistakes in the MST course does not mean tolerating sloppy experimentation or poor safety practices, or ignoring materials or processes that would lead to injury, fire, or explosion. Students are rigorously trained in how to safely perform laboratory procedures and operate tools and equipment used to conduct experiments and complete projects. This very training in itself fosters confidence and courage. Prior to taking MST, many students have studied science and technology only from textbooks. Learning how to safely operate the equipment and machinery in the MST laboratory often frees them from long-held inhibitions or fears.

Learning to use tools safely can also lead to "handiness," an important component of the MST course. "Handiness," as we define it, is the ability to solve materials-related problems with available or limited resources or with alternative methods. Today, many people are not handy. They lack ability to solve problems because they don't understand how to use alternative materials or methods if what they need is not available. When "handy" people are presented with a problem, they use their creativity, imagination, and problem-solving skills to come up with a solution that allows them to get the job done.

Designing and creating a project is often what draws students to the MST course. But the project work builds on concepts and skills students learn in MST while experimenting with each of four materials groups: metals, glass/ceramics, polymers, and composites. These experiments feed the student projects. Understanding the nature, states, properties, and behaviors of the materials presents students with a wide range of possible projects to design.

Students experiment individually or in groups, record their observations in a journal, and discuss the experiments and their observations in class or small groups. Students read and do research by using periodicals and other library resources that relate to the unit of study. Students gather information by interviewing and working with those who are familiar with the materials or are experts in the field of study. Students apply what they have learned to their projects, but also continue experimenting, reflecting, reading, and writing.

This hands-on, minds-on approach can provide an entry point for average students not usually reached by the traditional science, mathematics, and technology curricula, and it can reach young women and minority students. The project approach can open the doors of science and technology to all students and can help close achievement gaps between ethnic and gender groups.

The course also appeals to the traditional high achievers. Tom Gannon, former associated student body president of Richland High School, said, "The class really opened my eyes to the exciting

world of materials. In chemistry I never really understood covalent or ionic bonding or what they had to with anything.... That all changed after I took the MST course. Numbers weren't just numbers anymore—they actually meant something! After annealing and batching my own glass in MST, what my physics teacher says about thermal shock in physics class takes on a whole new light because I've been there and I've seen that."

Under a project of the OSTP's Federal Coordinating Council for Science, Engineering, and Technology, the MST course is now being disseminated nationally through the DOE National Teacher Institute in Materials Science and Technology. The Institute features a 20-day program conducted each summer at the Pacific Northwest Laboratory in Richland, Washington. Teams from school districts across the country are invited to apply.

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Irene D. Hays is manager of the Science Education Center at the Pacific Northwest Laboratory, Richland, Washington. The materials science and technology program is one of several education programs she and her staff conduct for teachers and students in elementary, middle, high schools, and community colleges in the northwest and across the nation. The programs were featured in the September 1992 MRS Bulletin, *p. 27–31.*
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