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MATERIALS WORLD MODULES: A VIEW FROM THE SCIENCE CLASSROOM

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ABSTRACT

This article describes the experiences of a high school science teacher who was an early collaborator in the Materials World Modules (MWM) program. He attended the first organizational meeting in 1991 and he has remained deeply involved ever since. In this article, he looks back over these many years and reflects on his increased use of MWM, discussing the ways in which his classroom teaching style has changed for the better, the ways in which his students have learned to produce design projects with increased sophistication, and above all, the ways in which he has become an active participant in making science education a more exciting and rewarding field.

INTRODUCTION

At what point does one allow high school students to experience science? When are they considered to have a sufficient knowledge foundation to design and execute their own experiment? Is it appropriate for them to attempt to design something of their own that might require background research, significant testing and re-design? Is there a type of learning, or of motivation, that requires a deeper assessment than a standardized test? Against the backdrop of developing National Science Education Standards[1], and more recently of the No Child Left Behind Act (2001)[2], the MWM program initiated a unique collaborative effort between university researchers and high school science teachers to bring cutting-edge, hands-on, student-centered units to the classroom while placing the student in the role of scientist/engineer.

BEGINNINGS

In 1991, R.P.H. Chang, Director of the Materials Research Institute at Northwestern University invited Chicago area science teachers to attend an informational meeting on the MWM project. Chang expressed concern for the direction of education - too few students were enjoying science and choosing science and engineering fields. He proposed increasing student excitement by demonstrating the relevance of doing science and asked for our help to develop instructional materials that would transfer the latest *materials science and engineering* concepts from Northwestern laboratories into high school science classrooms. Much of that meeting escapes my memory now, but two distinct themes will always be with me: (1) What is *materials science?* and (2) Chang's desire to partner with high school teachers.

Like the vast majority of high school teachers in 1991, I had never heard of materials science but as Chang explained this new initiative, I wanted to learn more. As for the partnership, he used this analogy: We want to bake you (meaning us science teachers) cookies, but we don't want to make you sugar cookies, if what you really want is chocolate chip cookies. Chang made it clear that he wanted science teachers to provide input right from the start. That was an unusual statement for a scientist to make! More meetings followed.

Early on, it was decided that we would create supplemental materials for high school. Interdisciplinary materials science concepts would be taught through inquiry-based learning activities that culminated in a team-based design project. We agreed that these materials should be versatile and adaptable, so that teachers could readily use them in a wide variety of courses and content areas. The first supplement would be based on composite materials.

EARLY MODULE DEVELOPMENT

A fellow teacher and I volunteered to work with Matthew Hsu, a materials scientist from Northwestern, to create the first module. The composite module began with a quick lab that demonstrated the strength of paper-reinforced ice. After developing a few other possible module activities, I recall the students making fiberglass reinforced epoxy beams that were tested in a complex three-point bend apparatus. When enough water for weight had been added to break the beam, a circuit was completed and the water flow was shut off automatically. Although innovative, and worthy of study, the epoxy resin created havoc with the ventilation systems of most high schools; and the testing, while very accurate, was not suited for high school students or budgets, The 3-point bend apparatus was too expensive for most schools to purchase. A good beginning had been made, but it was time for re-design.

REDESIGN

The redesign phase is one of the continuing threads of each module. Students design, build, and test something, and then improve upon it through re-design. Re-design occurs in all facets of the modern world. Gates did not stop at Windows version 1. Skis, airplanes, car engines, telephones, hip replacements, etc. - it would be hard to imagine a product that has not undergone almost continuous re-design. As it is in the real-world, so it was with our first efforts. We kept the original ice/fiber composite demo and followed it with guided activities illustrating concepts such as "What is a composite?" and "How are strength and stiffness related?" We also added guided research on composites and the culminating design project: a fishing pole prototype. The fiberglass-reinforced epoxy was scrapped in favor of more student-friendly and cheaper designs of fishing poles or other composite structures. In my experience, once students have seen examples of designs developed by other teams, they seem more eager to go back to the drawing board and give it another try. Their new designs invariably eclipse the marks set by their first designs. So it was with our new *Composites* module. We achieved a highly adaptable set of activities that fit easily into many courses. It was easy to lead, easy to use, easy to adapt, and the materials were inexpensive. I am very proud of the work we did with that module.

BUILDING ON *COMPOSITES*

Composites became the successful template for all subsequent MWM modules, including *Biodegradable Materials, Biosensors, Ceramics, Food Packaging, Concrete, Polymers, and Smart Sensors*. Each module follows the organizational pattern and scaffolding that was first laid out in Composites. One begins with a captivating demonstration or "hook" – something that piques the interest of the students and encourages them to ask questions. Activities and labs help students to gain new content and see how the concepts being presented connect with the opening “hook” activity and relate to the culminating design project. Activities and labs include pre-lab and post-lab reading assignments and questions for students, as most will have no experience with these materials. Fortunately, MWM has developed more elaborate guides for the teachers, as they, too, may have little experience with the topic.

CLASSROOM EFFECTS OF MWM

I place a little MWM in my curriculum every year because from start, I have liked the difference that it makes in my classroom. Students enjoy the freedom to ask questions and seek answers to their questions. Students see the relevance of the topics and are curious about them. With its focus on hands-on activities, cutting edge technologies, and student design, MWM makes my classroom more “team” focused. Instead of being the boss at the front of the room, I become a collaborator. I ask questions, I direct, I probe, I check- these are still things that I do as a teacher. But my students are so much more active; asking their own questions, proposing to continue a lab in a new direction, seeking further information on a topic on their own, without any direction from me. In a short two week period, students gain enough insight into a new material to design/build/test/present/ redesign something with that material. Rather than simply memorizing some organized step system of scientific method, they have engaged in authentic scientific inquiry and technological design.

Every year, MWM helps a few more kids get excited about being in Science class. Have all my students decided to become engineers and scientists? No. But I can say that all of them have had a positive experience with a novel, relevant material that has made them consider–a little more thoughtfully–how the world is put together. The next time a new plasma TV, fuel cell car, or graphite bike comes along they will be better able to evaluate the design and appreciate the research and engineering that brought it about. Using MWM has helped me to keep my classroom a learning community; where students have freedom to ask, to seek, to discover, to grow. This impact, this orientation to student learning, this change in perspective is important to my students and me.

OPPORTUNITIES FOR OUTREACH AND PROFESSIONAL DEVELOPMENT

MWM was designed to be teacher friendly and very adaptable. Teachers may choose to use a single 15-minute demonstration or an entire module that lasts two weeks or more. Teachers have used it with virtual every secondary science class currently being offered. It has also been adapted for the middle school and college levels. I was part of the original presentation team that brought MWM to many National Science Teacher Association (NSTA) conferences, from one coast to the other. Teachers began to use our materials all over the country. Our team presented many times regionally, and ran workshops in many states. Department of Defense schools sponsored a workshop to train their teachers to use our materials. Today, MWM modules are used in many states across this country and states in Mexico.

MWM has also gotten me very excited about materials science. I spent two summers performing research at Northwestern, where Chang designed the first Research Experience for Teachers (RET) program. Although high school science teachers teach *about* research, most have little or no experience *in* research. RET is designed to give teachers a taste of the research experience so that they can teach from an experiential framework. Imagine a science teacher who can answer questions about what a scientist does from the perspective of a scientist! It is no wonder that the RET program has become a staple outreach program at nearly all research institutions.

As my love of materials science grew, I pursued all sorts of topics in my readings. Eventually, I won grant support from Toyota Tapestry to simultaneously launch several research topics in various classes at our high school. Students were experimenting with composites, dendrimers, piezoelectrics, memory alloys, high temperature superconductors, diamond thin-film, humidity sensing polymers, lighter than air biodegradables, and more. Some of these continue in my classes to this day. My perspective on the teaching/learning relationship that was so influenced by MWM also helped me to earn my National Board Certification, the highest certification a teacher can earn.

CONCLUSION

My students and I have gained much from my relationship with MWM. The program has given me insight into materials science - a field that I did not know existed, an ongoing, collaborative relationship with materials and education researchers, and a real taste of scientific research and the role it plays in society. Most importantly, it has provided the ultimate in professional development and made me a much better teacher. My students have greatly enjoyed learning exciting materials science content and the opportunity to do the work of researchers, designers, and engineers in the classroom.

REFERENCES

1. National Research Council, *National science education standards,* National Academy Press, Washington, DC, (1996), pp. 173-207.
2. No Child Left Behind Act of 2001, Pub.L.No.107-110 (2001).