

THE MATERIALS WORLD MODULES PROGRAM

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ABSTRACT

This article presents an overview of the philosophy, development, evaluation and assessment of the Materials World Module (MWM) program. Launched at Northwestern University in 1991, MWM develops modular instructional content to supplement pre-college STEM curricula. Thirteen modules have been published to date on materials-related topics ranging from Composites to Sports Materials and Nanotechnology. MWM modules employ the methodology of inquiry and design, which enables students to perform the work of scientists and engineers in their classrooms. The next four articles in this issue of the Journal of Materials Education describe the quantitative assessment of data gathered from a large field test of the program (Pellegrini), a detailed study of the classroom-based technology (engineering) design process (Heroux et al.), the personal experience of a veteran teacher who has participated in the program since the very beginning (Turner), and a report on MWM in Mexico (Fuentes et al.).

BACKGROUND

In 1991, when the author was serving as the director of the NSF-funded Materials Research Laboratory at Northwestern University, an NSF program director posed a challenging question: "How have the activities of your Center benefited U.S. society?" This question is clearly relevant today and, I believe, should be asked of any research center or institution. At that time, it was not yet obvious that those working in universities should help to improve pre-college science education. However, there were several factors that drove us in that direction: 1) Our materials science and engineering department was not getting any direct freshman applications; 2) Our own children were not interested in pursuing science or engineering as

a career choice; and 3) We noticed a large communication gap between university faculty and precollege science teachers – two communities that should be cooperating closely in the interest of national science and technology education.

Based on these initial observations and the challenge set forth by NSF, we launched two NSF-funded programs in 1993. Both were designed to quickly transfer the latest multi-disciplinary research content from our laboratories into precollege STEM classrooms. The first - Research Experience for Teachers (RET) invited science teachers to perform research at Northwestern laboratories, which equipped them first-hand research experience to carry back to their classrooms. The second program-

Materials World Modules (MWM) set out to develop supplemental modular instructional content that would enable students to perform research and design projects related to their STEM coursework. Today, both programs have become national in scope. The following is a historical perspective of MWM and its future vision for improving STEM education in the U.S. and around the world.

THE MWM PHILOSOPHY

MWM is designed to supplement existing STEM curricula with short, easy-to-use modules that are pre-aligned with national learning standards and benchmarks. Each module lasts about 2 weeks and consists of a series of inquiry-based learning activities culminating in a design project. Modules are designed for a wide range of school districts and teacher experience levels.

In our experience as materials researchers, interesting science usually occurs where disciplines intersect. Materials science and nanotechnology are excellent examples. Both fields are inherently transdisciplinary and have direct relevance to industrial, societal, and global needs. Research knowledge in these areas has been expanding exponentially in recent years, and it has become imperative to bring these ideas into the classroom as quickly as possible. MWM module topics are selected with a view to preparing students for future careers in industries and technologies that will be relevant 10 or 20 years from now. Therefore modules address materials and nanotechnology-based applications to industry, society and global challenges such as energy, environment, health/medicine, and security.

Modules published to date include:

- Ceramics
- Composites
- Concrete
- Polymers
- Sports Materials

- Biodegradable Materials
- Biosensors
- Environmental Catalysis
- Food Packaging Materials
- Smart Sensors
- Introduction to the Nanoscale
- Manipulation of Light in the Nanoworld
- Nanotechnology

For ease of use by teachers and students, modules include a teacher edition, a student edition, and a kit of supplies for 24 students, a user's guide, minipedia and links to useful websites. Recent modules also include web-based animations, simulations, and games. Workshops and webcasts are available to prepare teachers to use the modules effectively.

The program website (www.materialsworldmodules.org) includes an introduction of each module, videos illustrating how the modules are being used, an online store where modules and classroom kits can be purchased, and a MWM community where teachers and students can share their MWM experiences, design projects, discussion and collaborations.

MWM METHODOLOGY AND DEVELOPMENT

Module development is driven by the needs of students and teachers. Students need modules to enhance their learning of science and engineering concepts, build their confidence in applying these concepts, and prepare and inspire them to enter science and technology-related careers. Teachers need modules to be safe for use in the classrooms, inexpensive, relevant to concepts taught in physical and biological curricula and closely linked to state and national science standards and benchmarks. Modules must also be designed for use in incremental classroom sessions, not to exceed a total of two week period.

The inquiry and design methodology has proven very effective in meeting these needs.

Students gain exciting hands-on experience working as scientists (inquiry) and engineers (design) that stirs their natural curiosity and motivates them to learn. Teachers receive help in linking science and engineering concepts to real-world applications that students can appreciate.

The module development process is very rigorous. Great care is taken to ensure that content is relevant and up-to-date, and that students have a “wow” experience. All modules start with a demonstration of an intriguing phenomenon that piques the interest of the students, followed by a series of inquiry-based activities that teach the concepts emphasized in the module. At the end of the module, students team-up to do a design project to show how much the students have really grasped the concepts. Students work in teams and communicate their findings through written and oral presentations. All elements of the module are thoroughly tested in classrooms before the module enters final development. Small scale classroom assessments are performed during the development phase to ensure maximum classroom impact.

A unique aspect of MWM development is its emphasis on vertically-integrated development teams. University research faculty and their students work closely with pre-college science teachers in physics, chemistry, biology, and technology to ensure that modules are appealing to students, properly aligned with standards, and used effectively in the classroom. The program also provides professional development for teachers in the form of workshops and summer research. This close partnership with teachers has been very effective in vertically integrating STEM learning across levels.

In 1999, the MWM program launched the MWM-2002 project for the purpose of performing nationwide field tests. Eight cross-cutting modules (e.g. bonding and polarity; motions and forces; properties of solutions; conductivity, light and color; etc.) were developed using content from various prior modules. Each module was offered in three

levels of difficulties. Teachers across the country were able to go online to download files for use in their classrooms and upload assessment questions and evaluation comments for analysis by our external evaluator and assessor. A detailed report is presented in the following article by Pellegrini. This nationwide study showed significant impact of MWM on student knowledge gain despite the fact that the amount of time spent was very limited - no more than ten percent per semester in most cases.

In 2005, researchers at the Centro de Investigación en Materiales Avanzados (CIMAV) in Chihuahua, Mexico began working with local teachers and the State of Chihuahua to translate and adapt MWM modules for use in Mexican high schools. Mexican developers worked closely with Northwestern and followed the same content development and professional training process described above. This effort is described in the article by Luis Fuentes.

CONCLUSIONS AND FUTURE VISION

Investment in science and engineering education is the key to a nation's economic development. This investment is long-term and requires at least 16 years before it pays dividends. A well planned strategy is essential to save time and resources. We must ask ourselves how we can prepare students for lives and careers that will change with new technological and economical developments and how can we provide opportunities for all citizens to learn about the exciting fields of STEM?

To date the MWM program has reached more than forty thousand students in 48 U.S. states and thousands more in Mexico. The program has demonstrated that the insertion of trans-disciplinary materials science and nanotechnology concepts can positively impact national STEM education. It is also clear that supplemental modular approach and inquiry and design methodology employed by MWM significantly benefits school teachers and students alike.

The four new MWM modules for publication: “Drug Delivery at the Nanoscale”, “Dye-Sensitized Solar Cells,” “Nanopatterning,” and “Nano Surfaces” address a range of exciting nanoscale science and engineering concepts with applications to global needs. Going forward, MWM is encouraging school districts around the country to adopt MWM as an integral part of their STEM curricula. The adoption of MWM by each state will do much to address the urgent need for improving the US STEM education and its global economic strength and leadership. The articles that follow in this issue of the Journal of Materials Education provide additional perspective on MWM activities in the US and Mexico.



MWM Teachers attend a professional development workshop in Puerto Rico



MWM Teachers attend a professional development workshop at Aberdeen New Jersey.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the sustaining support of the MWM program by the National Science Foundation.



MWM Teachers attend a professional development workshop in Puerto Rico



Design Project for the X module: Students design an Atomic force microscope.



MWM module stimulates inquiry in a high school Chemistry class