Journal of Materials Education 24 (1-3): 23-30 (2002)

MATERIALS TECHNOLOGY EDUCATION PROGRAM IMPACT ON SECONDARY TEACHERS AND STUDENTS

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ABSTRACT

The clear impact on teachers and students of a teacher educational program in materials technology is clearly shown. Surveys of the impact of this program on secondary teachers and students shows significant enhancement in the students' self concept, problem solving, and hands-on skills. Their perception of science was changed and the career opportunities in science and technology were made clear to the students. Enthusiasm for science and technology was evident in the students and in their teachers. This type of program, which is aligned with National Science Standards, provides a means for motivating teachers to engage students more in real science and to motivate students toward more understanding of science and engineering.

Keywords: *Materials education; secondary level; technology; student-centered; lab- oriented*

INTRODUCTION

This Materials Technology Educational Program, an NSF-sponsored project begun in 1997, is aimed at training Secondary School teachers to teach the subject of Materials Science and Technology. The goal is to provide the teachers with the background and curriculum needed to set up courses in this subject for students at their respective schools. As a result of this program, Materials Science and Technology is now taught in about 30 secondary schools in the State of Washington, and in at least this number in other parts of the country.

The long term goal of the course is to encourage young people to extend their studies in the areas of science and technology. This is accomplished by providing students with a hands-on look at the world of materials, and by showing them the many different career possibilities in the sciences and technology related to manufacturing. The program teaches materials science and technology as a hands-on applied science/technology course, with over 75% of the class time being laboratory and project work. The program uses the Materials Science and Technology (MST)[1] curricular materials developed at Pacific Northwest National Laboratory under Department of Energy sponsorship, along with the Materials World Modules (MWM)[2] developed at Northwestern University under NSF sponsorship. These units, which actualize science standards[3], include collaborative learning activities related to all classes of materials and focus on materials as used in day-to-day life.

This project, funded under the Advanced Technology Education program of the National Science Foundation, was a continuation of a program first started at Pacific Northwest National Labs (PNNL) in Richland, WA. In this program, experienced MST teachers and outside professionals train the teacher-participants at intensive summer workshops (80 to 120 hours), with follow-up weekends where possible. Subjects covered include basics of structure, properties and processing of materials, applied to metals, ceramics, polymers and composites. As in the course, 75% of the instruction is laboratory-based, to ensure that the teachers can implement the curriculum with their students.

Following the workshops, participants then go back into their districts to share their knowledge and to develop Materials Science and Technology programs in their own schools. Others have incorporate the materials curriculum into existing classes such as Chemistry, Physical Science and Art. Quite often teachers from prior workshops, after several years of experience, will become trainers of new teachers.

Teachers selected for the program are recommended by their schools, and encouraged to apply in teams of one science educator and one technology teacher. Although the course is not always taught this manner, this provides a useful partnership of skills. Some of the participating educators are just beginning to set up a facility to teach the program, while others have full facilities at their disposal. Experience ranges from just a few years to twenty years. The educators have varied academic backgrounds, and help each understand the concepts from different perspectives. Over 120 teachers have been trained in this program, in addition to nearly 100 trained earlier at PNNL.

This program gives the educators background knowledge in all areas of Materials Science and allows them to actually carry out a wide variety of the hands-on laboratory exercises in the program. This allows them to understand better what the students will experience, and gives them the chance to trouble-shoot labs with experienced staff nearby. This process is also encouraged in the actual classroom with students. A mistake during an MST session is an opportunity for critical thinking and problem solving, two of the most highly sought after skills in today's job market.

Materials Science and Technology in high schools in Washington State is taught as both a vocational and a science class, and most districts provide science credit for the course. The curriculum is divided into five areas: Solids (an introductory unit), Metals, Ceramics, Polymers and Composites. Within each main unit there from ten to thirty hands-on experiences for the students, and sufficient material in included for a full year's course if desired. Each experience adds to a set of skills the student will develop over the course. Many of these skills have never been introduced before in any other class. All the skills fit with the Washington State Essential Learning's for students, which is patterned after the National Science Standards. Table I shows the outline course; the teachers handbook for the course is available for interested parties[1], while a commercial version is also available.[4]

Table I.
Materials Science and Technology Curriculum

Solids:

1. Safety and Familiarization
2. Introduction to Materials
3. Characteristics of Solids
4. Mechanical Properties and Reactivity

Metals:

1. What are Metals
2. History of Metals
3. Alloys
4. Altering Mechanical Properties of Metals
5. Testing and Manufacturing Processes

Ceramics:

1. Ceramics and Their Characteristics
2. Glass- The Special Ceramic
3. Properties of Glass
4. Ceramic Manufacturing Processes

Polymers:

1. Chemistry of Polymers
2. Copolymers and Elastomers
3. Manufacturing Polymers

Composites:

1. What is a Composite
2. Wood and Concrete
3. Fiber Reinforced Composites
4. Manufacturing Processes

Our evaluation of the MST program includes two parts. First we present an evaluation of the educational program for the teachers, then an evaluation by the students taking the Materials Science and Technology course from the participants in the program. These evaluations were carried out after the 1997 and 1998 programs. The teachers were asked to fill out an exit survey at the end of the summer program. Students were surveyed after they had completed the yearlong course. All surveys were anonymous and used rating scales and specific comments to assess different areas of the program. These results were tabulated and averages assessed for each question. The raw data for both the student evaluations and the teacher evaluations is available on request. Figure 1 depicts the results of the student survey (N=221) for their responses to six of the questions asked.

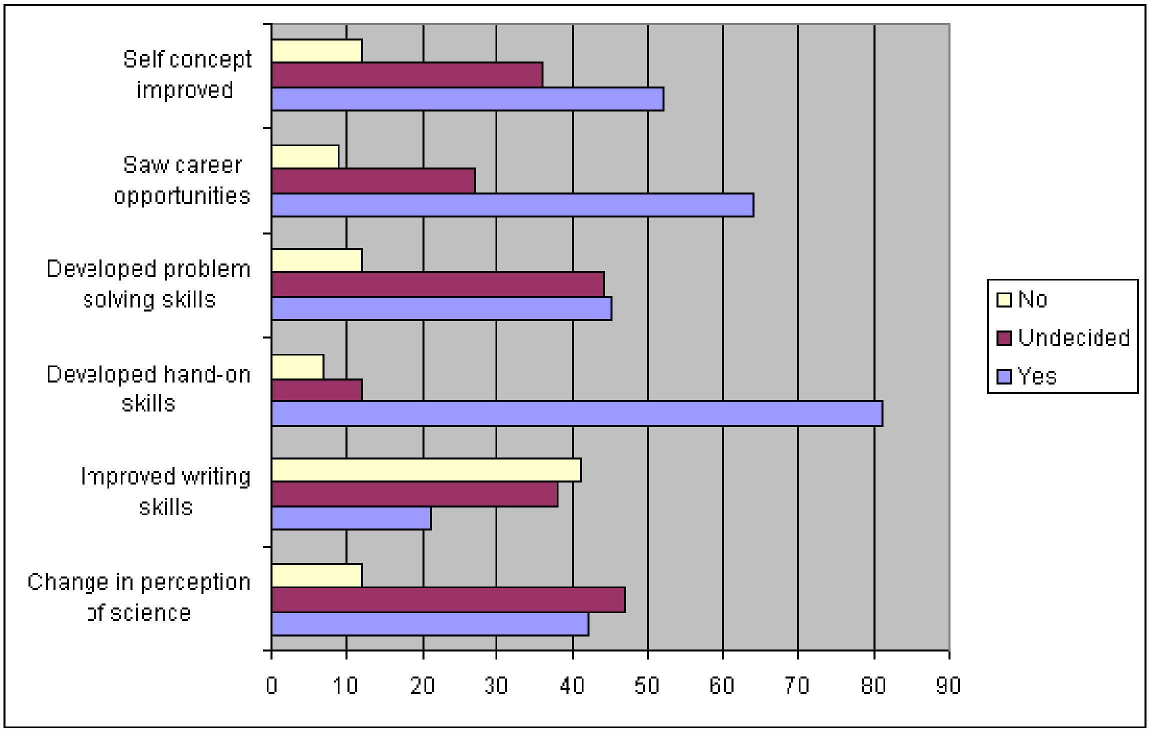

Figure 1. Results for selected responses to student survey

BACKGROUND

The evaluation of this program must take into account (1) the status of science, mathematics, and technology education; (2) perspectives on staff development; and (3) methods of investigation. Three focuses are needed because the MST program challenges some methods currently used to teach science, mathematics, and technology. The MST format addresses the interrelationship between teachers, students, trainers, and how science in learned.

Regarding the status of science education in the U.S., the National Center for Improving Science Education (NCISE) reports that "at least two-thirds of the nation's high school students typically do not select science courses or achieve well in those courses they are required to complete.[5]" From *A Nation at Risk*[6] to findings of numerous authors,[7 - 13] the reports have reemphasized the need for reform in mathematics, science, and technology education. Methods of instruction appear and reappear as the single most important cause for student problems. According to Tobias[7], "what makes science hard may not be the science itself or the unpreparedness or prior knowledge of high school and college-level students, but rather how science is packaged and purveyed--something we can all do a great deal to change."

Staff development program evaluation has been an elusive and tenuous goal of curriculum developers for many years. As Orlich[14] wrote on program evaluation, "if schools are to succeed in their many goals, then school personnel must continuously expand their knowledge and skills; be made aware of new challenges, and be encouraged to solve problems--especially those related to student achievement" (p. xi). Authors focusing on staff development indicate that the guiding principles for effective staff development should include such questions as:[15-18]

how clearly new ideas and practices are presented

how well new practices align with a teacher's philosophy

how much time the teacher feels the new practice will require, compared to the benefits attained

how the new practice impacts a teacher's current vision of what teaching should be

is the new practice presented and practiced by teachers with experience in the field

is there time for reflection, practice, and critique during the training, and finally,

will there be follow-up activities to reinforce and discuss the new practice?

Using this information from effective staff development, the MST program has focused its training on these ideas. Once teachers had completed training and are teaching a materials science and technology class, they were asked to give students a survey to determine the impact the class had on student perceptions of the class. It was the impact on students, the real driving force for effective staff development, that was of interest to the MST trainers.

Evaluating a program such as the MST is a difficult task. There are no standardized tests to be given, and no easy ways to put quantitative data into a survey form. Thus, specific questions were developed by us and a Rickert scale was used to differentiate opinions on MST effectiveness. Using this method it can be seen that the program received positive responses in most areas. The averages were consistently in the higher score, or positive region of the scaling assessment. It is obvious from the increase in overall scoring that changes were made to the program between the 1997 program and the 1998 program, which resulted in generally higher scores.

SUMMARY OF STUDENT SURVEY RESULTS

The typical Materials Science and Technology student in this evaluation is a high school student in the eleventh grade (44%), male (65%), with a grade point average of between 2.1 and 3.0(54%). The next closest categories that these students fit into are tenth graders

(27%) followed by twelfth grade students (25%). Girls were outnumbered by boys 2:1, and all students had above a 1.0 GPA, 31% a 3.1 of higher.

The survey was given to students at the end of the 1998 school year. The students in the survey were those students that were currently enrolled in the materials science class in the schools involved. Surveys returned were from 221 students at 7 high schools. The survey instrument is shown in Table II.

Table II. Student Evaluation Instrument

Circle the number to best complete each statement concerning your beliefs about the Materials Science class that you are currently taking.

1. I am a: 1) Freshman 2) Sophomore 3) Junior 4) Senior

2. I am: 1) Female 2) Male

3. My GPA (grade point average) is between: 1) 0.1 and 1.0 2) 1.1 and 2.0 3) 2.1 and 3.0 4) 3.1 and 4.0

4. I like science and am probably going to seek a career in science. 1) True 2) False

5. I did not like science but because of MST, I am now interested in a science career. 1) True 2) False 3) Maybe

6. My favorite unit in MST was: 1) Metals 2) Ceramics 3) Polymers 4) Composites

7. MST helped me to develop better writing skills through the use of the journal.

   1) I agree 2) I am not sure 3) I disagree

8. My favorite part of the MST class was: 1) lab activities 2) journal writing 3) projects 4) reading articles

9. MST helped me to develop skills in using tools and equipment that I did not know how to use before.

   1) I agree 2) I am not sure 3) I disagree

10. Because of the MST course, I have greater self confidence in my abilities to work on solving problems.

   1) I agree 2) I am not sure 3) I disagree

11. The MST course has helped me develop skills in working cooperatively in a group.

   1) I agree 2) I am not sure 3) I disagree

12. The MST course has allowed me to have a better understanding of career opportunities (jobs) in science fields.

1) I agree 2) I am not sure 3) I disagree

13. The MST class has allowed me to develop skills in expressing myself artistically.

1) I agree 2) I am not sure 3) I disagree

14. MST has helped me to develop a better self concept through the work I accomplished.

1) I agree 2) I am not sure 3) I disagree

15. I would/will recommend this class to other students. 1) Yes 2) Probably 3) No

16. I found out about this course through:

1)other students 2) the teacher 3) the counselor 4) course offerings booklet 5) other

17. Complete the following in your own words: MST is

18. Complete the following in your own words: I like MST because

19.The part of MST that I dislike is

20. If there is anything that you would like to say about the MST class, use the rest of this page.

Thank you for taking the time to complete this survey.

Survey highlights include:

Of the students responding, only 25% had some initial potential interest in seeking a career in the sciences, but after taking the MST class 47% said that they had some interest in a science career, and 9% said they were definitely interested.

Of the units taught in the MST class, 44% liked the metals unit the most, followed by ceramics and polymers, each with 24%, and composites 8.5%. The students enjoyed lab activities predominantly (67%) and projects (32%).

The survey demonstrated the students' almost unanimous dislike for paper work, journal writing and reading articles. The students did agree (19%) that the journal writing helped with their general writing skills, with (43%) unsure and the rest (37%) did not think the journal helped with writing skills. (Most instructors of Materials Science require students to keep a journal. This journal is a place to express their feelings about the experiences they have in the class. They are encouraged to take many observations, answer questions, ask questions, and explore the subject matter, make drawings and discuss any problems they encountered.)

Developing a high level of competence in lab skills is an integral part of the class, as are problem solving and cooperating in small groups. The students agreed

(76%) that the course had helped them develop their skills for working with equipment and in the laboratory setting. Sixty nine percent of the students agreed that taking this class had enhanced their skills in working in a group, and forty five percent agreed that the class had helped them develop problem-solving skills. In this last area, problem solving, 44% were unsure, but only 10% disagreed.

About 54% of the students said the class helped them develop in the area of artistic expression, 27% were unsure, and 19% didn't think the class helped them in this area. Although it is always desirable to produce artistically beautiful pieces, this is not an art class, and aesthetics are not stresses as much as the techniques and processes used to make the various materials involved.

One of the most exciting responses to come from the student survey was the fact that 96% of the students would recommend, or would probably recommend, this class to their peers.

Students' comments fell into several distinct categories: activity related comments, overall expressions, and negative comments. Comments, which stood out, include:

"I love working with materials. I learn so much easier by working with my hands."

"It was a nonstop action class. Almost every day we are doing something new. I got to make a lot of cool stuff that I can keep forever."

"My friends used this class as a stepping stone to get into the Boeing Manufacturing Internship in Auburn, WA."

The most prevalent negative comment was a dislike of journal writing, followed by a dislike of any written work at all.

SUMMARY OF MST TEACHER-PARTICIPANT EVALUATIONS

These surveys used a scale response technique. Participants were asked to rate various parts of the course with 4 being the highest rating and 0 the lowest. The scores from all the participants were then averaged for each question. The class of 1998 completed this evaluation. A copy of the evaluation form is shown in Table III.

In general, the course received very high commendations from the participants. Responses to most questions averaged between 3.3 and 3.8. Comments included statements such as:

I increased my knowledge in science, technology and mathematics.

I increased my knowledge of applications of science/technology/mathematics

I gained new perspectives on how science/technology/mathematics should be taught

I learned activities I can use in my classroom

I learned laboratory skills I can teach to my student

When asked to comment on individual parts of the program, the responses were very positive, noting especially the use of hands on/ manipulative laboratory activities.

Table III. Teacher Evaluation Instrument
Materials Technology Institute

(Date here)

(Place here)

Your Position ____________________

Area and grade level(s) ______________________

School _________________________

Workshop evaluation

Please rate each statement below using the following scale:

4=strongly agree, 3=agree, 2=undecided, 1=strongly disagree, 0=not applicable

1. The workshop met the stated objectives. 4 3 2 1 0

2. The content of the workshop was valuable. 4 3 2 1 0

3. The content helped me to understand the value of MST. 4 3 2 1 0

4. The printed materials were suitable to the workshop. 4 3 2 1 0

5. The opportunities for interaction were appropriate. 4 3 2 1 0

6. The activities presented were informative. 4 3 2 1 0

7. The workshop was well organized. 4 3 2 1 0

8. The activities helped develop an understanding of MST. 4 3 2 1 0

9. The presenters were helpful and knowledgeable. 4 3 2 1 0

10. The workshop developed interest in the MST program. 4 3 2 1 0

Additional comments:

CONCLUSION

The evaluations of this program are very positive from both students taking the course and from teachers participating in the workshop. Areas showing greatest strength for students are the lab experiences and projects. The same results were evident with the teacher-participants, who also included the development of background knowledge as strong. Dislikes for students were anything that required writing; for teachers it seemed to be content background [what does this mean?]. All participants agreed they had learned a great deal about Materials Science and Technology.

The goals for this program were to increase student awareness of careers in science and to provide them with hands-on experiences to develop their understanding of science. The MST program and its predecessor at Pacific Northwest National Laboratory have trained the teachers who are now teaching the course in many areas across the country, and in many schools teachers teach multiple sections due to the popularity of the course. If every school has only forty students per year, it would mean 1200 students in the state of WA alone would have had this opportunity. If each teacher has a class each year for only five years, 6000 students would be impacted by the MST training. Consider that if each teacher taught Materials Science for twenty years, the huge impact the MST training will have had on science and technology education. The MST program works.

ACKNOWLEDGMENTS

This program was sponsored by the National Science Foundation under Advanced Technology Education grant 9602360 at the University of Washington and continuing ATE grant 0070835 at Edmond Community College. The authors wish to thank Ms. Karen Wieda at Pacific Northwest National Laboratories for her assistance in developing these programs. We also thank Dr. John Rusin for his work in expanding this project through the new program at Edmonds Community College, and our master teachers and participants for making this program a success.

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