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Educational Modules for High School Teachers on Materials Engineering

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Abstract
Effective outreach to high school students, as prospective engineering students, starts by training their teachers. One of the goals of our Partnership for Research and Education in Materials (PREM) program is to facilitate the preparation of those teachers in Materials Science and Engineering (MSE). During five weeks in the summer, teachers are trained in the laboratories while simultaneously preparing related educational modules based on their experiences. These content of these modules is dictated both by economic restrictions common in public schools and by educational regulations from the local school district. This article summarizes these teacher professional development activities and the accompanying logistics coordinated under the PREM umbrella.

Keywords
High school teacher training, high school modules

1. Introduction

Several strategies have been shown to be effective in motivating high-school students to pursue engineering careers, including contests (Verner and Ahlgren, 2002), partnerships (DeGrazia et al., 2001), one-day programs, summer programs (Symans, 2000), teaching teachers (Conley et al., 2000), etc. All of these initiatives aim at increasing the pool of qualified engineers needed to satisfy the demand of this profession in the near future and to prevent a future shortage of these professionals, a fear raised by such institutions as the National Science Foundation (NSF). This potential shortage is particularly unsettling when materials engineers are considered. To address this issue, the approach discussed here intends to increase student awareness of and appreciation for the potential career opportunities in materials engineering. However, rather than focusing our efforts on the student population, we propose a professional development program that introduces teachers to material science and engineering (MSE) issues. The preparation of teachers is a strategy for continual and lasting impact on students. This paper describes one of such projects carried out at the University of Puerto Rico-Mayagüez (UPRM).

In April 2004, UPRM established a collaboration with the University of Wisconsin-Madison (UW) via a Partnership for Research and Education in Materials (PREM) program sponsored by NSF. A main participant of the partnership is UW's NSF-funded Materials Research Science and Engineering Center (MRSEC) on Nanostructured Interfaces. In particular, one of the undertakings of MRSEC, the Research Experiences for Teachers (RET) program, focuses on preparation of teachers in MSE. This RET program has served as a model for the Summer Research Experience for public high-school teachers from the Mayagüez School District, a program run by the PREM Office of Education and Outreach. The experience accumulated by the UW MRSEC group provided a first-class resource for the success of this UPRM initiative.

RET programs are common in many universities and have proven to be a practical strategy in helping to prepare teachers in emerging sciences and technologies. New and rapid developments in science and technology make such teacher professional development programs an urgent necessity.

Several initiatives are being carried out in the University of Puerto Rico System with parallel goals, i.e. to facilitate the professional development of the teachers. The largest of such programs is AlaCima, an island-wide program. Their description can be found in the given reference (AlaCima, 2006). AlaCima works with teachers at all levels and has also established Resource Centers in some of the participating schools. These centers facilitate the incorporation of new modules and material into the classroom. Another program is AFAMaC, which works with the professional development of middle-school teachers in mathematics and science (AFAMaC, 2006). The Summer Research Experience program for teachers presented here broadens the impact of pre-existing initiatives by incorporating a rapidly-expanding area of knowledge: materials science and engineering.

2. Scope of the Summer Research Experience Program

The primary goal of the UPRM Summer Research Experience program is to provide teachers with research practice. Participants learn about a number of MSE topics, develop a project, produce presentations as progress reports, and create an instruction module. The individual project themes all relate to material science and engineering. We have found that this program structure is effective in facilitating teacher understanding of a new and challenging topic and in providing immediate feedback on the teachers' understanding of their topics. If a teacher fully understands a concept, s/he will be able to talk clearly about it, create effective analogies, design content assessment, and plan related classroom and laboratory activities. In addition, the high number of presentations the teachers have to give on their topics and the related educational module they need to develop cause the teachers to become very conversant on their specific research topic. To spread the enthusiasm for and interest in MSE, the teachers are asked to design their instruction module in such a way as to foster interest and enthusiasm among school students and other teachers about the subject matter. It is also required that the module be constructed at minimum cost to accommodate common budget restrictions in public schools.

3. Details of Summer Research Experience Program

A series of activities are important for establishing the Summer Research Experience program, including announcing and advertising the program; selecting the participants; creating a program calendar; choosing professional development activities (such as the development of basic knowledge, scientific knowledge, and the project itself); and managing the personnel involved.

A call for the prospective teacher participants was distributed among the high schools of the Mayagüez area. The application required basic information, such as past experience and the normal contact information, from the prospective participant. Due to time constraints, all teachers were personally invited for the summer of 2005, the initial phase of the project. A full selection process will be carried out when the number of applicants so required. The proposed selection process is to choose each teacher through a selection committee that will evaluate and interview the candidates.

A full agenda of the first day and a schedule of the entire five-week program are given to the teachers. The first day, an important one, is used for orientation and administrative paperwork, such as parking arrangement, keys acquisition, and any other necessary paperwork.

Before the summer program began, all UPRM investigators participating in the PREM program provided a project title and a draft of a possible research topic. This allowed the teachers to have a brief description of the available projects on the first day. The investigators also gave a short, informal presentation to the teachers. It is planned to provide the list before the first day in order they may start to think which project fit their interest or background better. The second day all teachers provided their first three choices. A project was assigned to each teacher according to preference, the investigators' recommendations, and the demand of the project. The investigator becomes the teacher research advisor.

During the first week of the program, the teachers participated in several workshops on fundamental skills such as Word, Excel, Power Point, and the use of the library and Internet. This provided the teachers with the basic tools necessary for easily preparing a presentation every week and knowing how to present their data and communicate their progress. For this purpose, all teachers had an account in the Engineering Computer Laboratory where the necessary software and Internet access are available. There was a student in the computer lab ready to answer questions during regular operation hours, which meant that the teachers could go any time they wanted to process their data and start working on their modules, presentations, etc.

The teachers also participated in activities related to the scientific component of their program experience. They visited all PREM research laboratories, attended a weekly seminar, and had group meetings. The laboratory visits included a small presentation about what was done in those labs. The weekly seminar was a technical presentation by each PREM investigator. The teachers learned about most of the research on MSE conducted at UPRM through these two activities. During group meetings they presented their work and learned about other teachers' work.

The teachers also had to create an instructional module to teach the main concept of their project to their own students. The design of the module or activity should comply with the mandatory standards of the Department of Education of Puerto Rico. The teachers chose the structure of the module according to their background and interest.

Each research advisor met with the teacher assigned to his or her research group at least once a week. The teacher was also invited to the research group meeting where the advisor had the opportunity to make suggestions and openly discuss the teacher's progress with other research group members. Besides the advisor, the teacher also had several helpers such as an undergraduate or graduate student or both. All of them supported the teacher project by providing any necessary technical training on research equipment and by helping with in the construction of the instruction module.

The teachers gave a final presentation of their research and educational module on the last day of the Summer Research Experience. During this final presentation, the teachers specifically addressed school educational standards and any other pedagogical information that would help the audience to realize the requirements for integrating a new educational module into the schools.

4. Results

All teachers' projects were outstanding. Their weekly presentations made clear how much the teachers improved in knowledge and confidence. It was also interesting to see the different approaches the teachers used according to their own background and interests in the research context.

For example, one teacher learned how to synthesize nanoparticles of gold and study how synthesis parameters affected the particle size. The teacher chose to develop a demonstrative teaching module with her project. The reason for her choice was the impossibility to synthesize gold particle in the school due to the lack of necessary lab equipment and materials in her school. The module therefore consisted of an interactive animation of the procedure to produce gold nanoparticles. The teacher was assisted by an undergraduate student proficient in Macromedia Flash™. The teacher designed the structure and format of the module, and the student wrote the program with input from the teacher. Her objective was to produce a very instructive animation using language the most appropriate for facilitating communication with her own students. Figures 1a and 1b are two of the frames of the animation developed to show the synthesis of gold nanoparticles.

Another teacher studied the deformation of metallic materials, the role of dislocations in plastic deformation, and the subsequent strengthening mechanisms. She designed and prepared a physical model to represent how a dislocation moves on sliding atomic planes and how it interacts with obstacles. Students could use the physical model to study the characteristics of dislocation movement. Figure 2 shows the physical model of the dislocation movement.

a. b.

Figure 1: a) First page of the Flash™ animation introducing nanotechnology; b) Animation frame showing one step of gold nanoparticle synthesis

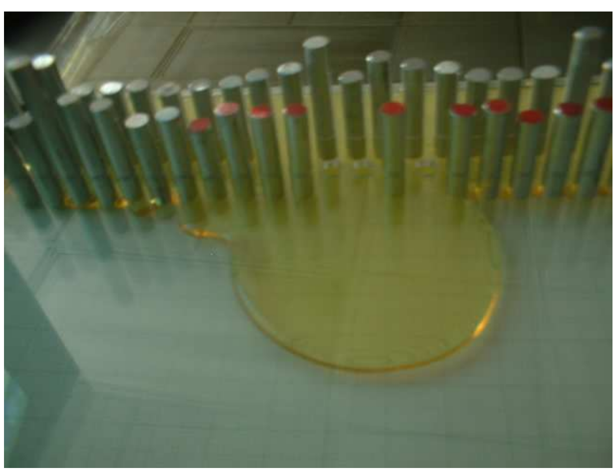

Figure 3: Physical model of a dislocation movement using an acrylic box, aluminum pegs, and glycerin.

5. Conclusions

Subsequent interviews by the coordinator of the Office of Education and Outreach indicated that the participating teachers felt extremely satisfied with their contribution to research. Their presentations showed their proficiency in the research themes and overall comprehension of the underlying concepts. The teachers also noted that their experience demonstrated to them how demanding the projects were and how time consuming research is. Nevertheless, they took on the challenge with enthusiasm and were highly motivated to learn new concepts.

6. Recommendations

The developed modules have to be tested in the classroom, including assessment of their content and satisfaction of the target audience (students). The long-term results could be seen in several years if an engineer says that he/she chose the career because of the experience he/she had with an MSE activity prepared by his/her teacher (a PREM-trained one) in high school.

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