

## **A NEAT (New Engineering and Applied Technology) Workshop for Secondary Teachers**

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### Abstract

In the summer of 2000, CSM hosted a weeklong workshop for secondary mathematics and science teachers. The NEAT (New Engineering and Applied Technology) workshop had a mission of providing *information about* and *experience with* engineering for teachers in primary and secondary schools. The teachers, who attended, participated in a combination of presentations, laboratory experiments, pedagogical discussions and field trips to engineering companies. Post workshop evaluations and interviews established that this pilot workshop was viewed as a strong success by the teachers who attended. Expansion of the program is planned for 2001. A description of the program is given here in hopes of aiding others in their development of similar activities.

### Introduction

The objectives of the workshop were threefold:

- First, we hoped to develop, among the teachers who attended a better understanding of what engineers do.
- Second, we wanted to provide these teachers with an in-depth exposure to some aspects of our engineering curriculum at CSM.
- Third, the workshop wanted to provide materials and experiences from the workshop that would be taken, by these teachers, back to their classrooms and shared with their students.

The purpose of these objectives is to make teachers better equipped to

- have a good appreciation for the engineering profession,
- be able to describe engineering careers to their students,
- provide their students with better information about possible future career paths that include engineering, mathematics and science and be able to describe the type of preparation the students will need to be successful in engineering school.

As indicated in the exit survey given the participants, the workshop was very successful in enhancing their understanding of the engineering profession. In addition, they voiced a strong approval for the workshop and indicated that they would all recommend it to their colleagues. It seems clear that we had a positive impact on their view of

engineering and we believe this will translate into a stronger communication, to their students, of the opportunities and challenges available in engineering. In this paper, we describe the activities that were included in the workshop, give some examples of the types of materials and activities that were undertaken during the workshop, provide an assessment of the value of the workshop, and discuss the benefits of the workshop.

## Activities

The workshop was held over a five-day period (July 17-21, 2000). Each day was broken into two half-day sessions and each session was a combination of presentation and hands-on-experience activity (labs). In addition, each day included a tour of a working engineering facility.

The workshop week began with introductions of faculty involved in the workshop and the Engineering Division, including the Engineering Division director, Dr. Joan Gosink. Dr. Gosink talked about the opportunities for collaboration between the Colorado School of Mines and high school math and science teachers, offering to act as a facilitator for collaborations involving the National Science Foundation. The rest of Monday was devoted to working with a modern exemplar robot that is being used in courses at CSM to introduce students to mechatronics. Mechatronics can be defined as the integration of mechanics, electronics, and computer software into a single system. The workshop participants were given their own robot to assemble. This involved disassembly and reconfiguration of a RC servo, to make it a velocity-based device. Once the alterations to system had been made, the servos were reassembled and the robot construction was completed. The teachers were then given an opportunity to develop code to command the motion of the robot. This involved writing programs in BASIC and downloading those programs to their robots. The participants were then asked to develop software that would guide the robots around a given trajectory.

On Tuesday, Professor David Munoz gave a special lecture on heat transfer and the teaching of heat transfer at the college level. Professor Munoz discussed some of the history of heat transfer engineering and the personalities who pioneered the field. He also introduced two LabVIEW-based experiments that the participants were to complete. The experimental activities involved doing a heat transfer study of an aluminum rod bent into the shape of a U, with one leg placed in hot water and the other end in room temperature water. Each of the bars had three thermistors attached, and using a LabVIEW program, (previously written) the teachers were able to collect data including both dynamic and steady-state responses of the aluminum bar. A second experiment involving the use of a modern solar cell was conducted. The teachers were asked to measure the response of the solar cells at different angles of incidents relative to the energy source.

Later in the morning, Professor Chris Debrunner and his graduate student Mark Whitehorn presented the fundamentals of computer vision processing and image understanding, as well as current research. The workshop participants were introduced to work being done at CSM involving stereovision and the development of 3D models for

underground mining. This was in preparation for a tour to the CSM experimental mine that afternoon.

On Wednesday, the participants continued work on their robots and then participated in another LabVIEW-based experiment in which accelerometers were mounted on the front fork and frame of a mountain bike and data were collected for both the sprung mass (the frame of the bike), and the unsprung mass, i.e., the fork and wheel of the bike. The data were then analyzed using Matlab, to produce the frequency response of the system. The results were presented using PowerPoint.

This experiment was followed by discussions of curriculum development and how materials from the workshop could be integrated into the high school classroom. This led to a lively discussion of the need for hands-on materials and activities that allow the students to be participants in the learning process.

Wednesday afternoon was used to introduce another research project called the Batmobile. Professor King talked about the use of such vehicles in the investigation and mapping of abandoned uranium mines in Colorado.

Thursday was devoted to an introduction to Finite Element Analysis (FEA) and its use as an engineering design tool, for understanding stress and deformation in mechanical and structural systems. Professor Graham Mustoe conducted a lively discussion of the use of finite element programs to understand the stress distribution within an engineering system. In addition, using a program called Working Model 2D, Dr. Mustoe presented models of the bicycle suspension that had been used in the experiments on the previous day and showed that mathematical models could give good results when compared with the actual experiment.

Friday morning began with a presentation on GPS technology and a discussion of the errors associated with GPS. This was followed by the workshop participants developing a map of part of the CSM campus by locating various points using GPS.

The rest of the morning was used to present information about motor encoders used on the wheels of the Batmobile, and to discuss delivery of workshop materials to the faculty for use in their classrooms. After lunch, there was assessment of the workshop including both written surveys and verbal feedback to the organizers. The comments and criticisms that were provided were useful in understanding what had been successful and what needed to be improved.

After a tour, the final part of the day was spent discussing the week's activities and developing plans for future get-togethers of the group, as graduates of the first NEAT workshop.

## Tours

An important part of the workshop was to show the application of engineering. This was

facilitated by tours to several local facilities where engineering work is being done. The first tour (Monday) was to Kevry Corporation, a provider of stainless steel kitchen equipment. The tour was hosted by two graduates of Colorado School of Mines who now work as engineers at Kevry. This visit included a presentation on Pro E, a 3D computer aided design (CAD) software package, and a visit to their state-of-the-art laser steel-cutting system.

Tuesday afternoon included a tour of the CSM experimental mine. Presentations included the history of mining in Colorado and a discussion of the development of technology applied to mining. The tour also included discussion of the relationship between environmental engineering and mining, and the use of environmental restoration as part of all modern mining projects.

On Wednesday, the participants went to Community Power Corporation, a young company involved in creating and marketing appropriate energy technology for developing countries. Some of their work includes the development of biomass as a local fuel source. Many of the teachers thought that projects involving Community Power would be a great way of getting their students interested in engineering.

Modern communication systems were the topic of Thursday's tour; at the AT&T media lab. This provided an opportunity for the teachers to see state-of-the-art facilities for new cable-based technologies. For example, the participants were able to see a mockup of a whole neighborhood of cable users that provided *On-Demand video* and teleconferencing. In addition, they were given a tour of a "modern home" of the 21st century, including video screen-based organizers (for the kitchen), as well as interactive television and dynamic photographs, both based on Internet technology.

Friday's tour was taken to a beverage making plant where high-speed equipment is used to make and fill containers. The applications of engineering were obvious throughout the facility, and showed the breath of engineering disciplines involved in a modern business.

#### Assessment

The participants were given a pre and post quiz on their knowledge of the engineering profession and the fundamentals of modern technology. Comparison of the results showed a 300% increase in their basic knowledge of engineering, and a more detailed understanding of modern engineering design techniques and tools.

A telephone interview was conducted three months after the teachers had returned to their classrooms, to investigate the level to which the workshop had influenced their teaching and assess how well the experience been integrated into their curriculum. The results of this interview showed that

- 1) teachers had used the contacts they made during the workshop to instigate student projects involving local companies (e.g., Community Power),
- 2) Others had developed new hands-on experiments, based on the labs they had done at CSM

- 3) Other faculty had been inspired to organize tours of other facilities for their students (e.g., Denver Federal Center, National Institute of Standards and Technology, and Waste Water Management Company)
- 4) They felt much more comfortable answering questions about what engineers do, and what their students could expect if they pursued a degree in engineering.
- 5) They have real-world examples of applications for the mathematics they are teaching, e.g., matrices.
- 6) Many of the participants said the tour of the mine had opened their eyes to the demands for technology that are required, as well as understanding that modern mining is quite different from its public perception.
- 7) They liked meeting and talking with university faculty. It helped them to understand the relationship and importance of their job to the future of their students.
- 8) They particularly enjoyed the mix of activities, having a chance to do hands-on experiments and then seeing application of similar technology in the field was very useful.

### Conclusions and Comments

As Professor Latanision<sup>1</sup> at MIT has said, “the educational process is a continuum”, and the seeds of our work at the post-secondary level are the fruit of the primary and secondary educational system. It is most gratifying to know that we are developing a stronger bond to and support for our faculty brethren who provide us with the stock for our education soup. The NEAT workshop offers an opportunity to build a stronger educational system. As can be seen in the results from the assessment interviews, the workshop has had a positive influence on these teachers and the inclusion of engineering topics in their classrooms. Knowledge about and facility with engineering topics has been improved.

Perhaps the biggest criticism from this first workshop was that it lacked specific deliverables in terms of projects and equipment that could be transported directly into the high school mathematics and science classroom. A search on the web shows that there are resources out there that can be gathered in to provide material for these activities<sup>2,3</sup>, and future workshops will exploit this avenue for providing materials. In addition, we believe that as the corps of NEAT graduates grows, the networking of these energetic, motivated, and highly talented faculty will result in a number of specific projects, based upon their workshop experience, and that these will then get communicated to others. A reunion of the graduates of the program is planned for this spring to facilitate just this development.

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