Engineering Education by An Application Oriented Design

Ron K. Bhada, Abbas Ghassemi, J. Derald Morgan
New Mexico State University
Waste-management Education & Research Consortium

Introduction:

Efficient and safe management of a sustainable environment is an increasingly critical national goal. It is a broad issue which cannot be addressed by any one entity and requires a multi-disciplinary, multi-organizational approach. In 1990, the U.S. Department of Energy approved a cooperative agreement to establish the Waste-management. Education and Research Consortium (WERC) of New Mexico. The program partners include New Mexico State University, the University of New Mexico, the New Mexico Institute of Mining and Technology and Navajo Community College in collaboration with Los Alamos and Sandia National Laboratories and over 40 industrial organizations. The mission of the consortium is to expand the nation's human and technology resources to address all types of environmental issues through unique education, technology development/technology transfer and public outreach programs.

WERC has developed and implemented a unique method of providing design education by providing a real-life solution of a site problem. The WERC has innovated a way in which a real problem is provided to university teams that work on this and develop a total solution for this problem. The WERC consortium provides a problem statement of a real issue on either a Department of Energy site or an industrial site to universities in August of each year. This coincides with the start of the academic year at most universities. Universities then form teams which work on this issue not only from a technical viewpoint, but also considering economics, public policy, regulations, public outreach and all other aspects that affect the application of a solution to a site issue. Top universities from throughout the country form teams made up of technical, as well as other department individuals, and work on this through the year. In April of the subsequent year, they provide a written solution to the WERC consortium judges. The judges are made up of top experts from government, industry and academia. The university teams from throughout the U.S. then travel to a central site in New Mexico where they make a presentation of their solution to the judges and demonstrate the solution concept on a bench scale. Again, the judges pay attention not only to the technical solution, but also to how these teams have addressed the other issues, i.e., economics, public policy, regulations, etc.

Education Through Practical Design:

The Design Contest problem statement is prepared each year with assistance from government and industry representatives in order to identify a real-life environmental challenge. In addition to developing the problem statement, government and industry also provide financial support and judges for the competition. The interaction with government and industry has provided additional avenues of dialogue which have led, in some cases, to offers of permanent employment to the students involved in the competition.

Problem statements have addressed clean up of contaminated water, contaminated soil, pollution from a printed wiring board manufacturing plant, a combined soil remediation and water reclamation problem, transport of contaminated slurry from underground storage tanks and sludge pond remediation. The 1996 competition features three site-specific environmental problems. Student teams will address the problem of 1) mixed radioactive and hazardous waste in storage tanks, 2) fiber wound filters contaminated with plutonium and solvents, and 3) contamination of vegetation from seepage basins.

The past participating teams have represented the premier environmental education programs in the country. Past competitions have included MIT, Purdue, Michigan State, West Virginia University, Cal Poly, University of Illinois at Chicago, SUNY-Buffalo, University of Oklahoma, Villanova, Widener University, University of Alabama, Texas A&M University, University of New Mexico, Wayne State University, New Mexico State University, University of Akron, University of Maryland, Florida International University, and the New Mexico Institute of Mining and Technology (Figure 1 shows the diversity of the university participants). Several two-year colleges and a team from Mexico have also competed in past contests. More than 500 students have been involved in the competition since 1991.

In 1995, the student teams received the problem statement at the beginning of the academic year and worked on their control process through the fall and spring semesters. They presented their findings at a national competition which was held in New Mexico in April. The teams developed a full-scale process design and prepared a written technical report which addresses all aspects for site implementation including: technical, economics, regulations and stakeholder communications. Solutions were presented to a team of judges from government, industry and academic organizations. The teams also proved the concept on a bench-scale model. In addition to trophies, the students competed for substantial cash awards in several categories, i.e., best overall design concept, bench scale process, paper and presentation. A corporate sponsor has also contributed a traveling trophy which is awarded to the best overall concept each year.

Education Through On-Site Applications:

In 1995, the Design Contest took on a new direction through the WERC/FAST initiative. This initiative (The Fast-track Advancement of Significant Technologies) promotes the concept of technology development being used for site demonstration. It represents a true technology development/technology transfer component. The FAST initiative, sponsored by the Department of Energy, provides funding to advance promising technologies to a more field implementable level. Through the FAST

initiative, WERC is able to strengthen the Design Contest concept and make it a complete process of identification-development-application.

The Department of Energy, through the Office of Environmental Restoration, has tasked Rust Geotech with the responsibility to perform treatability studies and performance testing necessary to advance technologies to site application. Because the WERC International Environmental Design Contest represents real DOE waste problems and is sponsored by DOE sites that are actively seeking innovative approaches to solve their problems, Rust Geotech approached WERC with the FAST concept prior to the 1995 competition.

The criteria which was suggested for selection of potential technologies from the 1995 competition included:

- Ability of the technology to meet the performance specifications of the problems;
- Practicality of the technology and the feasibility of scale up to field application;
- Simplicity of approach;
- Commercially available components;
- Effort required to bring the technology to a level of readiness for implementation at a site;
- Perceived acceptability of the technology by the potential user, the public and the regulatory agencies;
- Relative cost of the system including capital expenditures and operation and maintenance costs;
- Ability of the system to be designed to meet health and safety concerns;
- Versatility and applicability to a variety of wastes, e.g., can the technology work on a more heterogeneous waste with large fluctuations in chemical compositions;
- Final waste form stability;
- Final waste form versus initial waste volume; and
- Secondary waste generation.

With the above criteria in mind, the judges for the 1995 competition were tasked with identifying one or more contest entries that provided very promising solutions to two specific DOE programs being addressed during the competition. With the concurrence of the DOE sites involved, financial support was provided to further refine the technologies to a more field-implementable level. Three technologies from that competition were selected for additional development and site demonstration. The processes selected were:

- The University of Oklahoma's modified bore hole mining system for use at the Hanford, Washington site

- The University of Alabama-Huntsville's steel pellet blaster material removal system for use at Hanford

- The University of Idaho's heavy metal immobilization through use of apatite for application at Rocky Flats, Colorado

The specific tasks to be performed for the FAST initiative included performance treatability studies or other performance testing as required to further advance the selected technologies. A site visit by the students was necessary to gain additional insight on the nature of the problems. During the visit, a testing plan was developed and agreed to by Rust Geotech, WERC and site representatives.

Another specific task was to identify issues relative to each of the technologies that needed resolution before full scale implementation occurred. The students were also asked to prepare information for Rust Geotech to generate a fact sheet on each of the technologies. In addition, they were required to provide a demonstration of the equipment at the Hanford site and an oral presentation to Rocky Flats.

The University of Oklahoma students performed initial scoping tests to determine a water temperature and jet cutter nozzle design for the bench scale tests of their bore hole mining system. In order to identify which parameters and values were most critical to material removal, additional quantitative data was obtained for parameters that affect the material removal rate for the hard salt cake waste simulant. Specifically, salt removal rate versus water temperature, nozzle orifice design, water pressure and velocity, water flow rate and distance between nozzle and salt were quantified over a range of parameters.

The University of Alabama in Huntsville demonstrated a steel shot blasting technique after the fashion of sand blasting which had the advantage of magnetic recovery of the shot from the waste stream.

The University of Idaho used a naturally occurring mineral "apatite" as an appropriate addition to stabilize mixes for immobilizing heavy metals. Testing included identification of the performance range for apatite at different ratios of salts and water and what effects apatite had on the radioactive components in the waste stream.

The student teams utilized the summer of 1995 to further investigate and develop their technologies and presented the results to site representatives during a subsequent visit in the fall. These demonstrations have been so successful that the sites will develop these technologies further internally, through sub-contractor services, for possible site applications at Hanford and Rocky Flats in the future. The educational benefits have been outstanding.

Conclusions:

The WERC International Environmental Design Contest has developed into a major educational and technology development experience, especially for undergraduate students who are not normally involved in innovative research activities. With the addition of the WERC/FAST initiative, this makes the design contest even more significant since it takes the laboratory experience beyond normal bounds and provides application practices for the undergraduate curriculum. Future design competitions are expected to include the FAST approach for post-competition technology demonstration.

Many of the participating schools use this as their capstone design course as well as a design course for graduate students. The students benefit not only from an actual real-life design, but also benefit by the process of making presentations and demonstrating their design. Furthermore, during the demonstration at the central site, over 300 of the top environmental students in the country are gathered at one site and develop a unique network which lasts them throughout their lifetime. In the four years since starting this contest, the program has progressed from seven teams in the first year to about 40 teams in the last year. We expect that in 1996 there will be between 40-60 teams participating.

Teams participating in WERC Design Contest 1990-1995