National Sponsored Design Project Initiatives for Mechanical Engineering Students

Alan K. Karplus
Western New England College

Over several years the second semester Junior Mechanical Engineering Laboratory program has emphasized formal team building activities. A project format is used which requires the completion of an entry into a National Design Competition. For the 1995/96 year the Student Safety Engineering Design Contest sponsored by the Safety Engineering and Risk Analysis Division of ASME, National Institute For Occupational Safety and Health, Bridgestone/Firestone Trust Fund and Factory Mutual Research (1) was chosen. Four suggested topics were offered:

1. Guarding of PTO's (Power Take Offs),
2. Guarding of infeeds of harvesting equipment,
3. Use of high strength composites in removable guards for equipment exposed to rugged field conditions; and,
4. Develop a system that permits a wider range of protected motion than conventional seat belts for operators of tractors equipped with ROPES (Rollover Protection Structures).

At the first meeting of the 1996 Spring Mechanical Engineering laboratory course an introduction to team and team member dynamics was presented following which each of the four teams was directed to select a topic. Outside the laboratory was a large industrial Ford tractor that was shown to the students. Then each team selected a topic and at the end of the first meeting submitted a plan of action listing the activities each team member would undertake. At the end of the semester each team presented its work orally to the Junior Laboratory class and faculty. Team written reports were received and assessed by an external engineer and the best two reports were forwarded to the competition. This realistic experience created novel solutions and several 'touchy' issues with respect to protection of ideas (as often the work was saved on a networked computer system).

The titles of the completed reports are:
Team A - Design of a Safety Device for a Power Take Off system (PTO's) on Farm Tractors
Team B - Power Take Off Design Alternative
Team C - Design of a Seat Belt Restraining System for Agricultural Farm Equipment
Team D - Design of a Safety Restraint System for an Agricultural Tractor

As an example Team C, developed a semester work plan that included 1. the preparation of a problem statement to address a discussion of current personal restraint systems and the safety problems associated with existing designs, 2. a methodology to include brainstorming, research, theoretical modeling, sketches of proposed solutions, and the possible fabrication of a proposed prototype, 3. Review of the feasibility of proposed design modifications, which entailed a cost analysis, manufacturability, comfort and effectiveness for the user, and 4. safety standards as dictated by state, federal and industrial guidelines. As the team departed from the first meeting, tractor, research of existing seating options, research on existing restraint systems, making sketches and drawings, research into current safety requirements, and an examination of after market safety harnesses. The laboratory faculty responded to each team with a written memo emphasizing expression and summarizing their understanding of the project and a list of items which would be covered in the mid-term progress report.

As the semester progressed each team met biweekly or as needed with one or more of the three laboratory/team advisors to secure new resources, present their collection of information (which often included antidotal information from current farmers operating tractors with various degrees of seatbelt restraining systems), request equipment to make models to test out ideas, and to present drawing of potential solutions. An important part of the project was to address team building and team work. Operational issues of team member interaction were often addressed and resolved when the team and an advisor(s) were acquainted with a situation. Many times the quality of interpersonal communication(s) was the centerpiece of working together. The midterm progress reports were reviewed by the faculty and comments made to assist with project closure during the next to the last week of the laboratory program. Emphasis was placed on preparing both the oral presentation and written report with emphasis on making figures and tables, for example, an integral part of each. Each member of each team spoke at the 12-15 minute oral presentation.

The time spent on the project was the equivalent of one three week laboratory project. Great depth in the project was not expected, rather an understanding of project scope was addressed as was teamwork. On this basis presented solutions were often concepts to be initiated.

A brief summary of the proposed solution offered by each team follows :

Team A
The development of an improved PTO guard system was prepared. System specifications include: weight, cost, number of parts, durability as the ability to withstand impact, safety, flexibility or ease of motion, interchangibility, accessibility or the ease of connecting PTO with guard in place, and texture.
Team research uncovered the need to keep debris from getting into the bearings at the connection points between the tractor and the power shaft and the power shaft and the equipment powered to minimize operator handling and cleaning of moving parts. To minimize operator "hands-on" activity alternatives selected were : 1. A transparent

plastic box, 2. Front and rear elastomer boots to cover joint parts , and 3. A hinged aluminum clamp at joints. The elastomer boots was selected as best in the decision matrix based selection.

Team B
An arrangement where the ignition key and engine are in a series circuit with three parallel items: a seat sensor, a floor of cab sensor, and an external PTO Overide switch. Any or all of theses latter items provided a possible solution. For the system to operate the specifications of cost, serviceability, durability, safety, convenience, reliability, marketability, and scaleability for size of user were assessed for pressure sensors for the floor and seat as alternative 1, an optical sensor as alternative 2, a motion sensor as alternative 3, a pressure plate for the chair alone as alternative 4, and an operator tether cord as alternative 5. Alternative 1 was selected as best by team A.

Team C
The objective of this solution was a tractor seat and seat belt restraining system that would provide adequate restraint of the operator during extreme situations, as team research uncovered the need for increased operator protection without completely restricting operator mobility. Specifications include: frame materials used, safety features, minimum restrained load, compatibility of design across tractors, driver mobility, driver comfort, adjustability of seat, head rest as an obstruction to view, seat belt type, and ease of seat belt use. Team solutions were phases of their final solution which is a reinforced welded frame with an adjustable head rest, a fixed arm rest, a universal mounting plate to which the seat is attached, and safety belts with automatic type style impact locking retractors.

Team D
Specifications selected were allowable operator size, degree of tipping until to loss of roll-over protection, operator comfort, maneuverability, safety effectiveness, ease of use, and ruggedness for three alternatives: Design 1. a standard lap belt, Design 2. a shoulder belt, and Design 3, Four point harness. All designs included an inertia sensor to lock the design upon impact. Alternative Design 3 was selected as best in a decision matrix analysis.

The Team reports were reviewed by an external registered professional engineer for submission to the competition. The reports of Team C and Team D were forwarded to the competition in June.

To show the range of topics considered by the competition, consider the subject matter supplied for the 1992/1993 year the Student Safety Engineering Design Contest sponsored by the Safety Engineering and Risk Analysis Division of the American Society of Mechanical Engineers and the National Institute for Occupational Safety and Health (1). That year the contest was to submit a paper describing an analysis, design or engineering study which will prevent occupational injuries, illness, and deaths by reducing the hazards in one of the following problem areas:

1. Consider the hazards of performing maintenance on machinery and design a system(s) to improve maintenance safety. A specific machine type is to be selected.
2. Aircraft waiting for takeoff clearance under freezing rain conditions can build up excessive ice resulting in the danger of a crash with possible casualties to crew and passengers. Design a self contained deicing system for commercial aircraft.
3. Ventilation of health-care facilities, transmission of airborne infections including tuberculosis is a major concern in all health-care settings. Search the literature including ASHRAE Standards for health-care facilities and develop a preliminary design of a system to properly ventilate and clean exhaust air.

Six teams selected on their own both team membership and topic. Four teams chose the airplane deicing challenge, and three of these teams had five persons each while one team had six persons. The other two teams, one with five persons and one with six persons, selected the ventilation of health care facilities challenge. The WNEC Mechanical Engineering laboratory program approach taken in the Spring 1993 semester was to address team building with the competition as the vehicle for involving the students an significant engineering oriented concerns. The procedure used in 1993 was upgraded in 1995 primarily with emphasis on teaming skills at the first class, more comprehensive use and integration of AutoCad coupled with Microsoft Office capability such as WORD, EXCEL, and POWERPOINT for team presentations, and extensive use of a digital camera for documentation and slides which were included in presentations.

Two other initiatives in which WNEC Mechanical engineers have participated are: 1) the 1994 Solar Splash (2) where the last of four student teams participated in the Lake Pewaukee, WI regatta and placed first in the all electric division and fifth overall, and 2) the preparation of an entry into the 1997 Propane Vehicle Challenge - pickup category sponsored by the US Department of Energy, Natural Resources, Canada, Chrysler Corporation, and the Texas Railroad Commission (3). The Solar Splash initiative was generated through WNEC ASME student section interest. The second initiative was generated out of Junior ME student interest prompted by a 1996 Engineer's Week visit to the Southern New England Society of Automotive Engineers meeting where SAE student built formulae cars were shown. Five students invited me to assist them in the preparation of a proposal which was forwarded to the competition. The W NEC team proposed to address changes to the pickup body along with engine modification integrated with a team developed fuel system, as the truck was to be delivered to the competing teams without a fuel system. The experience gained by the five students as well as the faculty and administrators at the college contacted for assistance was new and often rewarding. Much support was expressed for this initiative not only from the college community, but also from those industrial and private persons outside of the college who assisted the team.

Bibliography - Contest Contacts:
Roger Harvey, P.E., 25 Kinkel Street, Westbury, NY 11590, 516-333-2520
Gerorge Ettenheim, Solar Splash Headquarters, 403 N. Agassiz St., Flagstaff, AZ 86001, 520-773-0230 (phone and fax)
Carlos Buitrago, Argonne National Laboratory, 9700 S. Cass Ave, Bldg. 362-C264, Argonne, IL 604-4815, 708-252-7261

ALAN K. KARPLUS

Alan K. Karplus is Professor of Mechanical Engineering. He has a Bachelor's degree from Tufts College, a Master's degree from Iowa State University and a Ph.D. from Colorado State University. He has been involved with the freshman engineering program, coordinates the senior mechanical engineering laboratory program, teaches Materials Science and supervises M.E. Senior Projects. His interests include materials and design.