

## **2007: MULTIDISCIPLINARY TEAMING THROUGH STUDENT DESIGN COMPETITIONS**

### **Dan Dolan, SD School of Mines**

Dan has been actively involved in teaching for over 25 years. He has taught courses in thermodynamics, dynamics, controls and manufacturing. He enjoys teaching in all of these areas, but especially in vehicle development courses such as *IC Engines* and *Vehicle Dynamics*. He has worked in industry for General Motors and Onan on engine development and at MTS on manufacturing control system development.

### **Mike Batchelder, SD School of Mines**

Mike, a professor in the Electrical and Computer Engineering Department, has enjoyed teaching for over 30 years. In addition, he has experience with administrative duties as past chair and interim dean and has worked with the Governor's Office of Economic Development on many projects including two startup companies. His interests include the hardware and software of embedded computer systems.

### **Jim McReynolds, SD School of Mines**

Jim has developed the *Teams and Teaming* course that supports the competition teams and capstone design teams. He also teaches Industrial and Organizational Psychology. The contents of this course have been adapted to the needs of engineering graduates to better understand and work in environments where reciprocal, cooperative relationships provide an atmosphere conducive to flexibility and innovation.

## MULTIDISCIPLINARY TEAMING THROUGH STUDENT DESIGN COMPETITIONS

*“I don’t know why people are so frightened by new ideas. It’s the old ones that frighten me.”* John Cage American composer

Our “new idea,” evolving for the past ten years, is to enhance engineering education by giving students the opportunity to work on real engineering projects in multidisciplinary teams through a campus-wide program focusing on intercollegiate engineering competitions. Teams consist of students at all levels, from freshmen through graduate students, together with faculty and industry advisors and are open to students from all disciplines. The program is tied to the curriculum through the capstone design, and capstone design students are typically the team leaders. Participation in the competition projects is not required, and approximately half of the capstone design students choose to participate.

The Center for Advanced Manufacturing and Production (CAMP) was formed in fall 1997 as a campus-wide program to develop students’ ability to excel in multidisciplinary teams, using industry sponsored projects and national engineering competitions as a means to grow engineering skills<sup>abc</sup>. Students are generally well prepared technically; however, projects often falter and fall short of their potential due to non-technical issues. Most students major in engineering because they are interested in designing, building, and testing. They do not enjoy documenting, developing (and sticking with) schedules, and being required to coordinate with other groups; however, these are the skills that the Accreditation Board for Engineering and Technology (ABET) and industry want developed. Work on significant projects soon shows the importance of developing these abilities. CAMP strives to aid students to learn goal setting, scheduling, fulfilling commitments, establishing priorities, problem solving, and resolving conflicts in an environment that works to develop open communication, trust, commitment, cooperation, and responsibility to others.

With this campus-wide approach, students from mechanical, electrical, computer, industrial, civil, metallurgical engineering and other majors choose to participate. Although each department has its own capstone design criteria, a common approach of a preliminary design review and a critical design review helps achieve consistent results and helps maintain faculty and institutional support:

- Faculty Skill Development for Capstone – ongoing competitions allow faculty to develop expertise over time.
- Team Selection – self-selected and often recruited by team members.
- Project Selection – capstone design students can choose among multiple ongoing competitions or other projects.
- Communication, writing, oral presentation - most competitions require a report and presentation.

- Assessments/measurements for Capstone – a common approach of preliminary design review and critical design review by faculty and peers.
- Capstone-Curricula improvement in department – competition drives improvement in both competition projects and non-competition projects.
- What skills to impart to students – weekly seminar open to all team members provides topics on project management, scheduling, documentation, teamwork, conflict resolution, and setting priorities. Sophomore Design, a newly developed course, covers many of the topics early in their curriculum to help prepare them for the capstone design experience. The presence of a psychology professor on the faculty of CAMP aids greatly in understanding team dynamics and in guiding the teams to positive teaming behaviors.
- Grading projects – each department has its own criteria.
- Publishing project results – some competitions require posting of competition reports.

Our competitions are: Formula SAE, SAE Mini-Baja, SAE Aero Design, ASME Human Powered Vehicle, IEEE Robotics, ASCE Concrete Canoe, ASCE Steel Bridge, SAE Electric Snowmobile competition (recently switching from American Solar Challenge /Formula Sun Grand Prix), International Aerial Robotics Competition, and the ChemE Car Competition. Although education is the primary goal, placing well in the competitions provides motivation for students. Results include over 10 first place regional and four national first place finishes.

Figure One shows the campus context for capstone design combining the curriculum, the co-curriculum, research facilities whose labs may assist student projects, and project support that includes a manufacturing specialist, an electronics specialist, a CNC machining center, a rapid prototyper, and a circuit board prototyping center. Formal activity in some departments is now cohering the capstone design work with classroom learning<sup>d</sup>. For example, students in the CAD/CAM course normally design, analyze and manufacture parts for their senior design projects as a part of the required homework of the course. Students in the Finite Elements course often choose to analyze a component of their capstone design project as a project within the course. The engine system for the Formula SAE vehicle is studied in the Thermal Systems Design course. Similar activities occur in several other courses.

Each department has a required capstone design sequence in the curriculum. Two courses have been developed with the aid of Bush Foundation Summer Workshops: Psyc 292 -- Teams and Teaming, and EE/ME 292 -- Sophomore Design. These courses were developed with a team of students, a psychology professor, civil, electrical, mechanical engineering professors, and student affairs personnel. These courses are designed to support capstone design as well as other student projects.

Available to students working on their capstone design projects are research labs such as the Composite and Polymer Engineering Lab (CAPE), the Additive Manufacturing Lab, and the Advanced Materials Processing and Joining Lab. For example, Photo One has

the Human Powered Vehicle team showing their composite design manufactured in the CAPE Lab. As another example, the Formula SAE team has manufactured titanium suspension uprights using a laser additive manufacturing process in the Additive Manufacturing Lab.



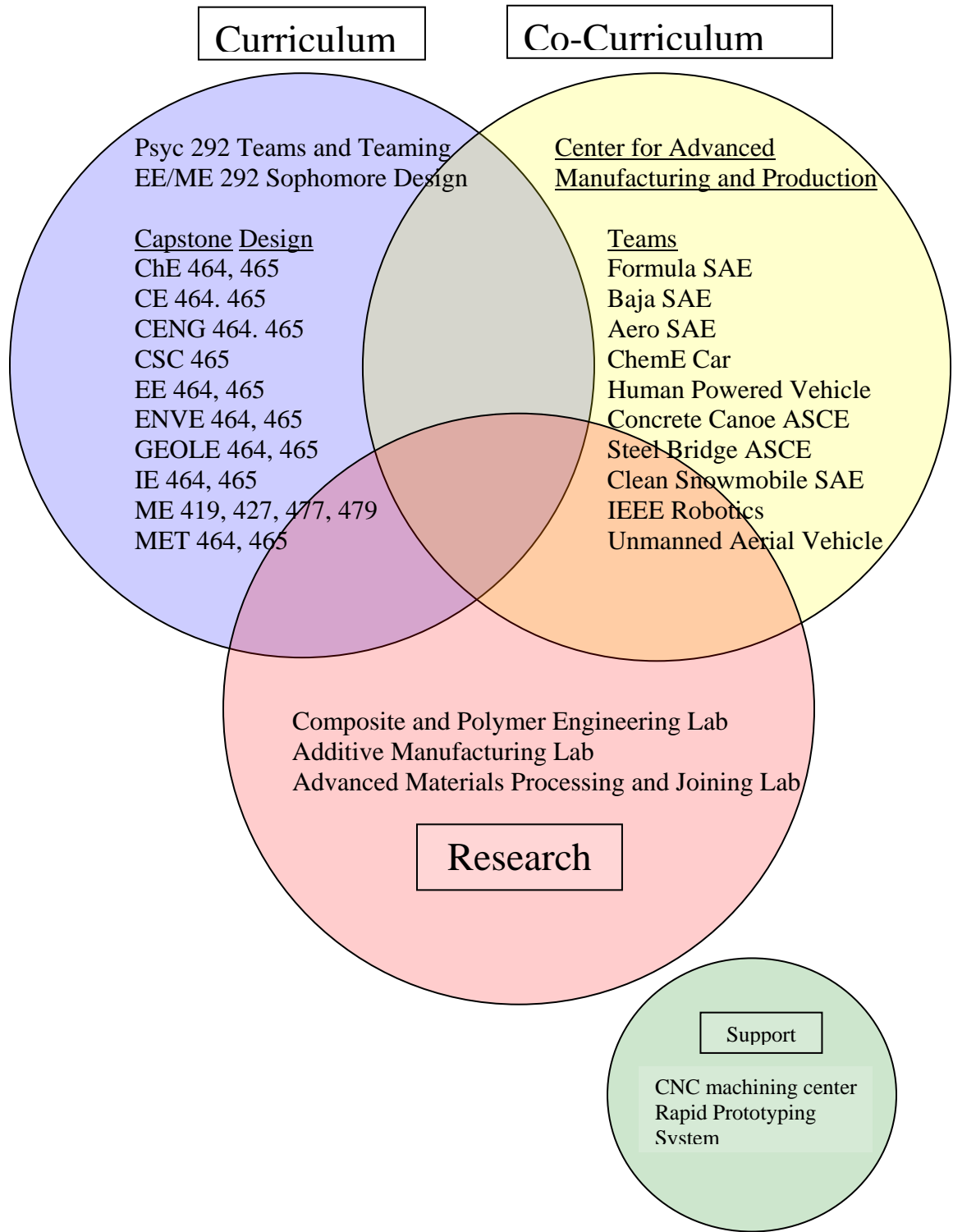
Photo One Human Powered Vehicle

At the end of spring semester all departments and student projects are presented to the campus and the public in a campus-wide design fair as shown in Photo Two.



Photo Two Design Fair

**Figure One Capstone Design in the Campus Context**



Other components of the campus-wide approach to student design projects include:

- Project unveiling – in the spring the competition teams have an unveiling of their projects to the campus and the public. This is coordinated with other events that include K-12 students.
- Dinner at president’s house – the president invites competition teams to his home for a BBQ.
- Student fee allocation- elected students allocate student fee funds based on proposals and presentations by student organizations including competition teams. These funds provide seed money for the teams to use with their fund raising to pay for project costs and travel to competition.
- Project Expo at Rushmore Mall – over a weekend each February the teams display their projects as illustrated in Photo Three..
- Workspace for teams – Photo Four shows the Caterpillar Student Excellence Center that provides space for teams to work on their projects.



Photo Three Projects Expo at the Rushmore Mall



Photo Four Caterpillar Student Excellence Center

The combination of curricular, co-curricular, and research components plus the support of the administration and faculty provides for a campus-wide integration for student projects and capstone design projects. Support from industry for multidisciplinary project-based teams has contributed significantly to institutionalizing of student projects across the campus.

### **Bibliography**

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