National Capstone Design Course Conference

13 – 15 June 2007

University of Colorado – Boulder

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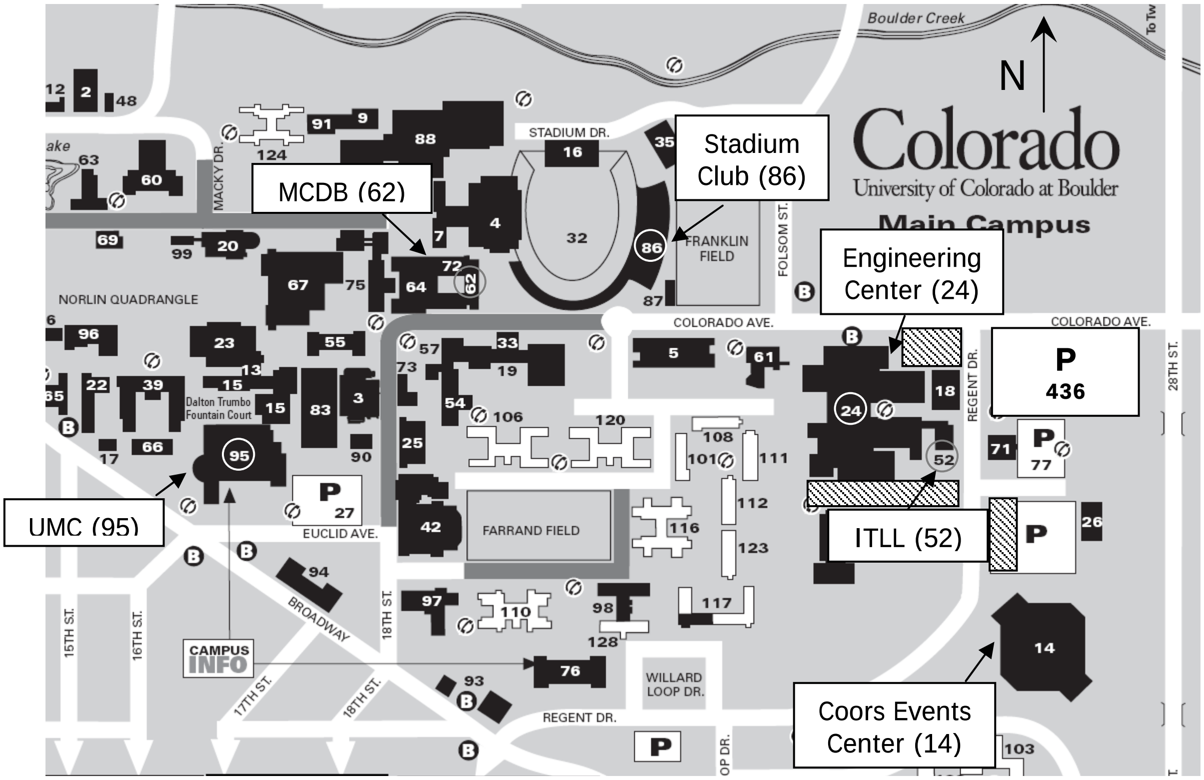
Campus Map



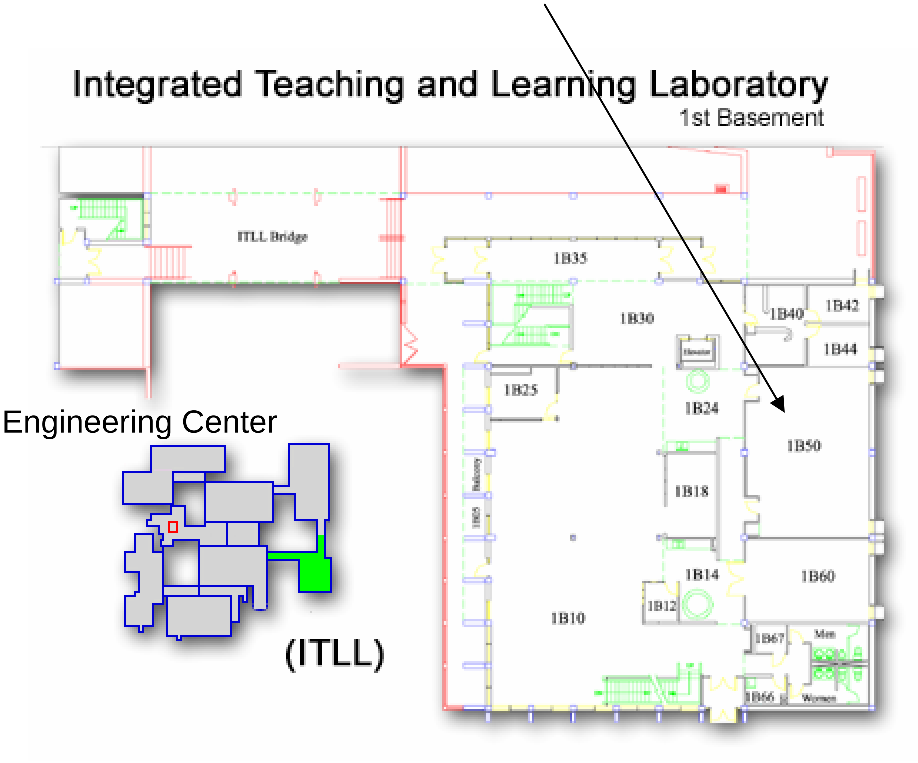
- Metered parking (denoted by the hashed areas) is available in the lots north of the Coors events center (building 14), north of the Discovery Learning Center (building 18) or south of the ITLL (building 52). If you use the metered parking, park your car in a numbered spot and then continue to the kiosk to pay for the day. The kiosk will accept cash or credit cards.
- If you have purchased a parking pass available for the duration of the conference. Park your car in lot 436, on the southeast corner of Colorado Ave. and Regent Ave, entering the lot from Regent Ave. Proceed to the registration table located on the first floor of the engineering center (building 24) to register and receive your parking pass. Then fill out the parking pass as required, return to your car and hang it from your rear view mirror. This pass will allow you to park in lot 436 for the duration of the conference.
- Registration and all conference sessions, excluding the plenary sessions, will be held in the engineering center (building 24) and the Integrated Teaching and Learning Laboratory (ITLL – building 52). The registration desk is located on the first floor of the engineering center near the revolving doors and elevators. If approaching from the east (parking lots or walking from hotels), cross Regent Ave. at the marked cross walk and enter the engineering complex between the ITLL (building 52) and the Discovery Learning Center (DLC-building 18). Continue to the west and enter the engineering center through the double doors on the 1B level of the complex. Proceed up the stairs and head towards the revolving doors on the west side of the building. The registration desk will be located on your right as you head through the lobby.
- The Wednesday afternoon, Thursday and Friday morning keynote talks will be held in the Molecular, Cellular and Developmental Biology building (MCDB-building 62) located west of Folsom stadium and east of Colorado Ave. It is about a 10 minute walk from the engineering center.
- The banquet will be held in the stadium club (building 86) located directly east of Folsom stadium. Access to the club level is via the elevators located on the east side of the stadium.

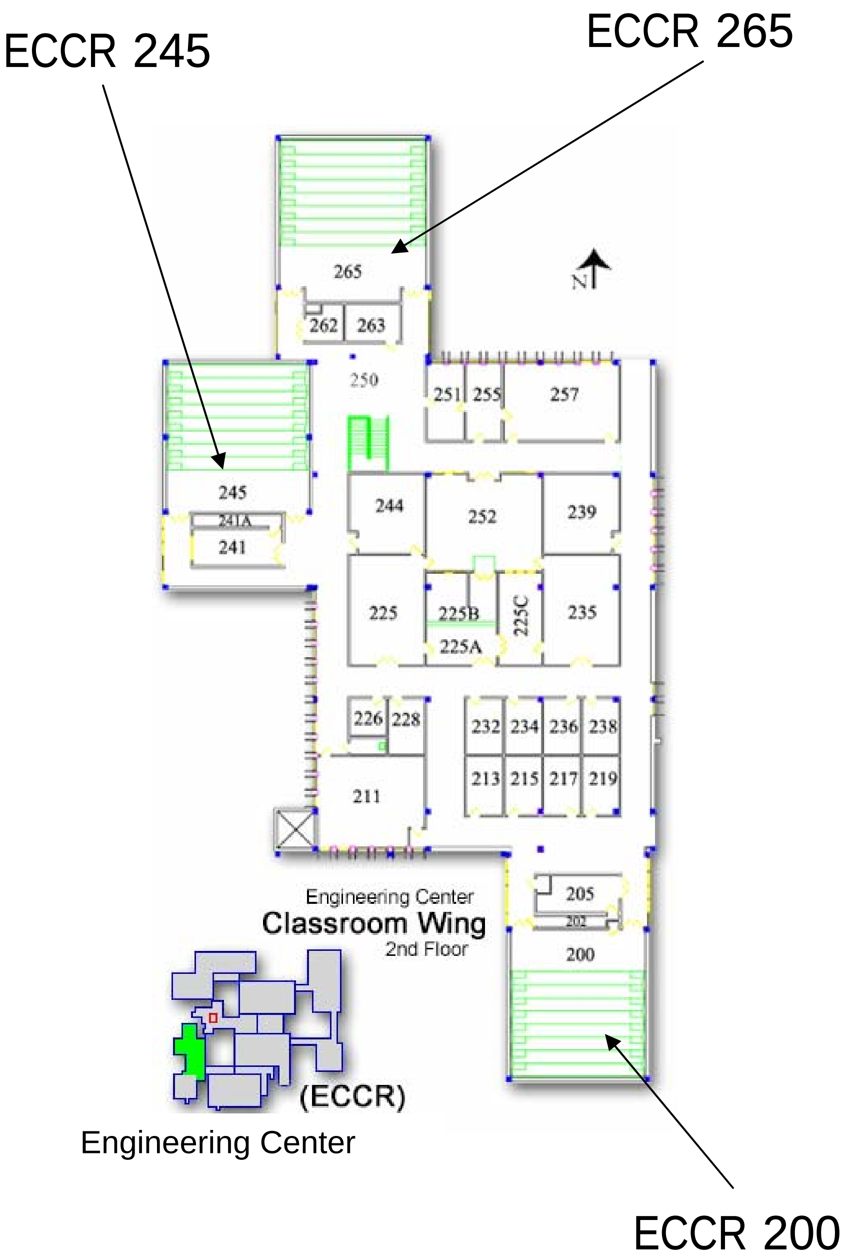
Campus Vicinity Map

- All hotels shown are within a 10 to 15 minute walk from the Engineering Center.
- If walking from the Best Western or Outlook hotels, head north on the frontage road then head west through the second pedestrian underpass. Continue following the path west across Regent Ave. and into the engineering complex.
- If walking from the Millennium Harvest House hotel, head south on the sidewalk that runs along 28th street then turn west on Colorado Ave at the light. Continue west on Colorado until the light at Regent Ave. where you will turn south, crossing Colorado Ave., and continue walking along the west side of Regent Ave. At the pedestrian crosswalk turn west into the engineering complex. An alternate path from the Millennium Harvest House hotel can be taken by heading west along the creek path and then south up Folsom Hill to the engineering complex. With current construction on the west side of the engineering center it is best to enter from the east off Regent Ave. This second option adds about 5 minutes to the walk.

Classroom Maps

ITLL 1B50





ECCR 245

ECCR 265

ECCR 200

Conference Sponsors

NSF

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ASEE

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Conference Goals

The 2007 National Capstone Design Conference is the first national conference focused on engineering capstone design courses. Held at the University of Colorado at Boulder, the conference includes papers, panels, and workshops from a wide range of capstone faculty.

Capstone design courses have become an important factor in receiving ABET accreditation at many institutions. In addition, capstone courses exist in many different forms and states of maturity. The focus of this conference is on moving a capstone design program to the next level. The conference aims (1) to build and strengthen the community of professors involved with capstone design courses and (2) to exchange and disseminate information about getting started, sustaining best practices, and pursuing future directions in capstone design curricula.

The conference is geared toward department chairs, capstone design faculty, capstone design coordinators, industry sponsors, and other interested parties. Papers, panels, and workshops were accepted in three broad categories to accommodate programs at all levels of maturity:

1. Starting a program featuring externally sponsored projects – **Mark Steiner, Chair**
2. Institutionalizing a capstone design program – **Keith Stanfill, Chair**
3. Improving and enhancing existing programs – **Spencer Magleby, Chair**

Conference Organizing Committee

Chair:
Jack Zable (U. of Colorado, Boulder)

Organizing Committee:
Jeff Gilles (Seattle University)
Susannah Howe (Smith College)
Bob Fogoros (IBM)
John Lamancusa (Penn State)
Mark Lehto (Purdue University)
Pat Little (Harvey Mudd College)
Spencer Magleby (Brigham Young)
Jennifer Miskimins (Colorado School of Mines)
Scott Palo (U. of Colorado, Boulder)
Gary Pawlas (U. of Colorado, Boulder)
Keith Stanfill (U. of Florida)
Mark Steiner (RPI)

Conference Attendees

Ackerman, Mark (University of Alberta)
Aidoo, John (Rose-Hulman Inst. of Technology)
Alexander, Suraj (University of Louisville)
Almstrum, Vicki (The Univ of Texas at Austin)
Anderson, Max (Univ of Wisconsin-Platteville)
Arthur, Howard (Virginia Military Institute)
Bailey, Ronald (University of Tennessee)
Bannerot, Richard (University of Houston)
Barber, Thomas (University of Connecticut)
Bergquist, Marcelo (University of Colorado)
Berkey, Rick (Michigan Technological Univ)
Beyerlein, Steven (University of Idaho)
Bielefeldt, Angela (University of Colorado)
Bowles, John (University of South Carolina)
Broadhead, Kelly (University of Utah)
Brown, Jennifer (Purdue University)
Burczyk, Richard (Colorado School of Mines)
Burger, Nicolaas D L (University of Pretoria)
Campbell, Scott (Washington State University)
Chen, Chiou (Miami University)
Chen, Jie
Chudyk, Wayne (Tufts University)
Cohen, Richard (Temple University)
Cohn, Louis (University of Louisville)
Crain, Jerry (University of Oklahoma)
Crittenden, Kelly (Louisiana Tech)
Cundy, Vic (Montana State University)
Dee, Kay C (Rose-Hulman Inst of Technology)
Dekker, Don
Dinehart, David (Villanova University)
Dixon, Gene (East Carolina University)
Dumas, Theodore (Southern Methodist Univ)
Dunphy, Terri Franklin (Olin College of Engr)
Eggermont, Marjan (University of Calgary)
Eichfeld, William
Emanuel, Joe (Bradley University)
Engel, Leland (Penn State)
Fitzmorris, Cliff (University of Oklahoma)
Fogoros, Bob (IBM)*
Ford, Ralph (Penn State Erie, Behrend College)
Fuh, Jerry Y.H. (National Univ of Singapore)
Gerlick, Robert (Washington State University)
Gibbs, Steve (Unive of Texas at Arlington)
Gilles, Jeff (Seattle University)*
Gnanapragasam, Nirmala (Seattle Univ)
Goff, Richard (Virginia Tech)
Goldberg, Jay (Marquette University)
Goncharoff, Vladimir (University of Illinois at Chicago)
Gorga, Russell (North Carolina State University)
Greene, Christopher (University of St. Thomas)
Gremillion, Paul
Grisso, Robert (Virginia Tech)
Haedt, Amy (Seattle University)
Hanningan, Mike (University of Colorado)
Harder, Robert (George Fox University)
Hitchcock, Robert (University of Utah)
Holger, David (Iowa State University)
Howe, Susannah (Smith College)*
Hsiao, J Kent (Southern Illinois Univ)
Jiang, Ruinian (new mexico state university)
Johnson, Peter (Valparaiso University)
Jones, Paul (Corp. and Univ. Relations Group)
Kanai, Junichi (Rensselaer Polytechnic Institute)
King, Paul (Vanderbilt)
Kisenwether, Elizabeth (Penn State University)
Klappholz, David
Knight, Daniel (University of Colorado)
Kotys-Schwartz, Dana (University of Colorado)
Kruzic, Andrew (University of Texas at Arlington)
Kurinec, Santosh (Rochester Inst. Of Tech)
Laferty, Matt (Binghamton University)
Lalk, Thomas (Texas A&M)
Lamancusa, John (Penn State)*
Lasher, William (Penn St. Erie, Behrend College)
Lasser, Ronald (Tufts University)
Latcha, Michael (Oakland University)
Lau, Mark
Lehto, Mark (Purdue University)*
Leininger, James (Univ of Texas at Arlington)
Lewis, William (Arizona State University)
Lillevik, Sig (University of Portland)
Lim, Seh-Chun (National Univ of Singapore)
Limb, Deborah (Boeing)
Little, Patrick (Harvey Mudd College)*
Livesay, Glen (Rose-Hulman Inst of Technology)
Looft, Fred (Worcester Polytechnic Institute)
Luongo, Cesar (FAMU-FSU)
Magleby, Spencer (Brigham Young University)*
Mahmud, Syed (Wayne State University)
Mandayam, Shreekanth (Rowan University)
Marchese, Anthony (Rowan University)
Martin, M. Hogan E. (Iowa State University)
Mayer, Robert (U.S. Naval Academy)
McDonald, Robert (Calif Polytechnic St Univ)
McGrann, Roy (Binghamton University)
Miskimins, Jennifer (Colorado School of Mines)*
Morgan, Mike (Olivet Nazarene University)
Morrison, John (Montana Tech of the U of M)
Munoz, David (Colorado School of Mines)
Nassersharif, Bahram (Univ of Rhode Island)
Ochs, John (Lehigh University)
Olsen, Greg (Mississippi State University)
Palo, Scott (University of Colorado)*
Park, Young Ho (New Mexico State Univ)
Parmigiani, John (Oregon State University)

(cont'd on next page)

Pawlas, Gary (University of Colorado)*
Peng, Jian (Southeast Missouri State University)
Pizziconi, Vincent (Arizona State University)
Pope, Glenn (John Deere Harvester Works)
Potts, Lee (University of Colorado)
Ray, Jeffrey (Grand Valley State University)
Reamon, Derek (University of Colorado)
Reising, James (University of Evansville)
Rethard, Tom (The Univ of Texas at Arlington)
Riley, Linda (Roger Williams University)
Rivin, Eugene (Wayne State University)
Rogge, Renee (Rose-Hulman Inst of Technology)
Rouch, Keith (University of Kentucky)
Rust, Jon (North Carolina State University)
Rutar, Shuman Teodora (Seattle University)
Sanders, Bruce (University of Colorado)
Santacroce, Rudy (University of Florida)
Selleck, Colin (Binghamton University)
Sheppard, Sheri (Stanford University)
Shooter, Steve (Bucknell University)
Siegenthaler, Kenneth (U.S. Air Force Academy)
Sieving, Allison (Purdue University)
Skokan, Catherine (Colorado School of Mines)
Smith, Raife (Southern University)
Snethen, Donald R. (Oklahoma State University)
Song, Dong Joo (Yeungnam University)
Spivey, Gary (George Fox University)
Stanfill, Keith (University of Florida)*
Steiner, Mark (RPI)*
Sunak, Harish (University of Rhode Island)
Sundarrao, Stephen (USF)
Terpenny, Janis (Virginia Tech)
Thorsen, Denise (Univ of Alaska Fairbanks)
Tongele, Tongele (S. Illinois Univ. Edwardsville)
Townsend, Jessica (Olin College)
Trombetta, Len (Univ. of Houston)
VanLaanen, Julie (Colorado School of Mines)
Venkat, Rama (University of Nevada Las Vegas)
Virkus, Annie (Rensselaer Polytechnic Institute)
Waggenspack, Jr. Warren (N. Louisiana St Univ)
Walrath, David (University of Wyoming)
Warnick, Gregg (Brigham Young University)
Weimer, Al (University of Colorado)
Widmann, James (Calif Polytechnic State Univ)
Wilczynski, David (Univ of Southern California)
Wildblood, Harry (Univ of Il. Urbana-Champaign)
Wilde, Douglass (M. E. Design Division)
Wilmot, Chester (Louisiana State University)
Wojahn, Patti (New Mexico State University)
Woodley, Michael (University of Illinois)
Zable, Jack (University of Colorado)*
Zahos, Steve (University of Illinois)

***Organizing Committee**
Registered as of 06/06/07

Logistics

Registration

Conference registration will be held on Wednesday, June 13th from 8:00 am through 1:00 pm in the Engineering Lobby.

Conference Parking

All CU parking areas are either permit or meter parking. Permit parking for the conference is located in Lot 436, on the corner of Regent Drive and Colorado. Parking passes for this lot cost $10 and can be picked up at the conference registration. However, all hotels suggested are within a 10-15 minute walking distance of the conference. The hotel “MILLENNIUM HARVEST HOUSE BOULDER” offers a free shuttle service.

Internet Access

Internet access is available to all conference participants at no cost. A username and password will be provided to participants when they check in at the registration desk.

Presentation Information

Paper session presenters:

- Presentation length should be 10 - 15 minutes depending on session.
- Loading of presentation should be done via memory stick or CD on to laptop provided by the conference during one of breaks prior to your presentation session.
- Software on the laptops will be Windows XP running Microsoft Office 2003.
- Please contact your session chairman if you have questions.

Panel session presenters:

- Please see paper session presenter information.
- Presentation length will be approximately 8 minutes.
- Please contact your session chairman if you have questions.

Poster session presenters:

- The poster session will be from 3:15pm to 5:30pm in the engineering building lobby on Thursday, June 14th.
- The size of the poster boards will be 30" x 40". The poster boards, easels, and mounting materials will be supplied by the conference. Presenters must supply the poster.
- There will be awards given to the three best posters.
- If there are questions please contact the poster session chairman.

Workshop facilitators:

- Please let us know what special equipment, supplies, etc. are required for your workshop. There will be about 30 participants in each workshop. Please bring the workshop materials that you will need or we will make copies for you.
- If there are questions, please contact the conference chairman.

Wednesday, June 13, 2007

Time	Track A Event ECCR - 245	Track B Event ECCR - 265	Track C Event ITLL-1B50
8:30 AM	**Conference Registration** **Engineering Lobby** **8:00AM - 5:00PM**		
8:45 AM			
9:00 AM			
9:15 AM			
9:30 AM			
9:45 AM			
10:00 AM			
10:15 AM			
10:30 AM			
10:45 AM			
11:00 AM			
11:15 AM			
11:30 AM			
11:45 AM			
12:00 PM			
12:15 PM			
12:30 PM			
12:45 PM			
1:00 PM	**Keynote Speaker** **Susannah Howe (Smith College)** **Where are We Now? Statistics on Capstone Courses Nationwide** **MCDB A2B70**		
1:15 PM			
1:30 PM			
1:45 PM			
2:00 PM	**Walk to Engineering Center**		
2:15 PM	**Session 1A** **Papers** **Support and structure**	**Session 1B** **Panel** **Sharing Startup** **Experiences**	**Session 1C** **Workshop 1** **Obtaining Industry** **Sponsors** **(40 participants max)**
2:30 PM			
2:45 PM			
3:00 PM			
3:15 PM			
3:30 PM			
3:45 PM	**Coffee Break - Engineering Lobby**		
4:00 PM			
4:15 PM	**Session 2A** **Papers** **Managing Industry** **Sponsored projects**	**Session 2B** **Panel** **Toward a Common Standard** **Rubric for Capstone Projects**	**Session 2C** **Workshop 2** **Coaching Student Teams** **(40 participants max)**
4:30 PM			
4:45 PM			
5:00 PM			
5:15 PM			
5:30 PM			
5:45 PM			
6:00 PM	**Reception - Engineering Lobby**		
6:30 PM			
7:00 PM			

Thursday, June 14, 2007

	Track A	Track B	Track C
Time	Event ECCR - 245	Event ECCR - 265	Event ITLL-1B50
8:30 AM	Keynote Speaker Deborah Limb (Boeing Executive) Industry Sponsor Expectations of Capstone Design Team Deliverables MCDB A2B70		
8:45 AM			
9:00 AM			
9:15 AM			
9:30 AM			
9:45 AM	Session 3A Paper Project Evaluation	Session 3B Panel Improving Technical Communications	Session 3C Workshop 3 Effective Practices for Project Formation and Faculty Involvement (40 participants max)
10:00 AM			
10:15 AM			
10:30 AM			
10:45 AM			
11:00 AM			
11:15 AM	Coffee Break - Engineering Lobby		
11:30 AM	Session 4A Paper Non-Traditional Approaches	Session 4B Panel Service Learning	Session 4C Workshop 3 continued
11:45 AM			
12:00 PM			
12:15 PM			
12:30 PM	Lunch Engineering Lobby		
12:45 PM			
1:00 PM			
1:15 PM			
1:30 PM	Session 5A Paper Sponsor Involvement	Session 5B Panel Team Dynamics	Session 5C Workshop 4 Teaching Students to Give Oral Presentations (40 participants max)
1:45 PM			
2:00 PM			
2:15 PM			
2:30 PM			
2:45 PM			
3:00 PM	Coffee Break - Engineering Lobby		
3:15 PM			
3:30 PM	Poster Session Engineering Lobby Tours of ITLL		
3:45 PM			
4:00 PM			
4:15 PM			
4:30 PM			
4:45 PM			
5:00 PM			
5:15 PM			
5:30 PM			
5:45 PM			
6:00 PM			
6:30 PM	Banquet Dinner - Folsom Stadium Club Keynote Speaker David Holger (Iowa State University) Capstone Design: ABET Expectations and Opportunities		
7:00 PM			
7:30 PM			
8:00 PM			
8:30 PM			

Friday, June 15, 2007

	Track A	Track B	Track C
	Event	Event	Event
Time	ECCR - 245	ECCR - 265	ITLL-1B50
8:30 AM	Keynote Speaker		
8:45 AM	Sheri Sheppard (Stanford University)		
9:00 AM	Future Directions for Capstone Design		
9:15 AM	MCDB A2B70		
9:30 AM			
9:45 AM			Session 6C
10:00 AM	Session 6A	Session 6B	Workshop 5
10:15 AM	Paper	Panel	Capstone Design
10:30 AM	Novel Approaches	Going Global	Assessment Instruments
10:45 AM			
11:00 AM			(30 participants max)
11:15 AM	Coffee Break - Engineering Lobby		
11:30 AM	Session 7A	Session 7B	Session 7C*
11:45 AM	Paper	Panel	Panel
12:00 PM	Advanced	BioMedical Projects	Highly Collaborative
12:15 PM	Pedagogy		Experiences
12:30 PM			
12:45 PM	Lunch		
1:00 PM	Engineering Lobby		
1:15 PM			

* Session 7C will be held in ECCR 200.

Wednesday, June 13, 2007

Conference Registration
Engineering Center Lobby
8:00-1:00

Keynote Presentation

<u>Where Are We Now? Statistics on Capstone Courses Nationwide [11005]</u>
Susannah Howe
Smith College
MCDB A2B70
1:00-2:00

Session 1
2:15-3:45

Session 1A
Support and Structure (papers)
Room: ECCR 245
Chair: Junichi Kanai

2:15 – 2:30 <u>Team Teaching Capstone Design</u> by Sigurd Lillevik [11786]

2:30 – 2:45 <u>Using Advisory Boards in the Capstone Design Process</u> by Lizette R. Chevalier, J. Kent Hsiao and William Eichfeld [11845]

2:45 – 3:00 <u>Evolution of a Capstone Design Program: Changes in Focus, Purpose and Mentorship</u> by Robert Mayer, Jennifer Waters and David Kriebel [11775]

3:00 – 3:15 <u>Redesign of the Senior Capstone Design Experience: A Flexible Model for Continuous Improvement</u> by James Widmann and Joseph Mello [12008]

3:15 – 3:30 <u>Product Design for Industry: The NUS Experience</u> by Jerry Y H Fuh, Seh Chun Lim, Li Lu and C. Quan [12001]

3:30 – 3:45 <u>Mandatory and Desirable Elements of a Capstone Design Course</u> by Roger Seals, Chester G. Wilmot and Miles B. Williams [12009]

Session 1B
Sharing Startup Experiences (panel)
Room: ECCR 265
Chair: Susannah Howe

2:15 – 3:45 Sharing Startup Experiences with panelists Joseph Emanuel, Linda Riley and Jack Zable [11000]

Session 1C
Obtaining Industry Sponsors (Workshop #1)
Room: ITLL 1B50
Facilitator: Paul Jones

2:15 – 3:45 Developing Long-Term External Sponsor Relationships by Paul Jones [11001]

Coffee Break
3:45-4:15
Engineering Lobby

Session 2
4:15-5:45

Session 2A
Managing Industry Sponsored Projects (papers)
Room: ECCR 245
Chair: Junichi Kanai

4:15 – 4:30 Starting an Industry-Based Capstone Design Course by Joseph Emanuel [11880]

4:30 – 4:45 Integrating External Client-Based Engineering Senior Design Projects into a Capstone Class by Linda Riley [11910]

4:45 – 5:00 Ensuring Success in Interdisciplinary Externally Sponsored Capstone Design Experiences by Jon Rust and Russell Gorga [11800]

5:00 – 5:15 Successful Capstone Course Model for Industry-Academic Partnerships by Jeffrey Ray [12002]

5:15 – 5:30 Starting a Multidisciplinary Senior Capstone Design Course by Gary Spivey and Robert Harder [11890]

5:30 – 5:45 The Move to Industry Sponsored Capstone Design Projects - Why and How by Jack Zable [11917]

Session 2B
Toward a Common Rubric (panel)
Room: ECCR 265
Chair: Anthony Marchese

4:15 – 5:45 Toward a Common Standard Rubric for Capstone Projects by Anthony Marchese, John Abraham, Christopher Greene, Elizabeth Kizenwether, John Ochs [11846]

Session 2C
Coaching Student Teams (Workshop #2)
Room: ITLL 1B50
Facilitator: Annie Virkus

4:15 – 5:45 Coaching Student Teams by Annie Virkus [11002]

Reception
6:00-7:00
Engineering Lobby

Thursday, June 14, 2007

Keynote Presentation

Industry Sponsor Expectations of Capstone Design Team Deliverables [11006]
Deborah Limb
Boeing Corporation
MCDB A2B70
8:30-9:30

Session 3
9:45-11:15

Session 3A
Project Evaluation (papers)
Room: ECCR 245
Chair: Liz Kisenwether

9:45 – 10:00 Continuous Improvement and Quality Assurance in the Capstone Project at the University of Pretoria by Nicolaas D. L. Burger [11774]

10:00 – 10:15 Assessment and Evaluation of Engineering Senior Design at Colorado School of Mines by Catherine Skokan, David Munoz, Douglas Sutton and Richard Burczyk [11822]

10:15 – 10:30 Evaluating the Capstone Experience from the Professional Practice Perspective by Debra Larson, Paul Gremillion, Paul Trotta and Tom Loomis [12187]

10:30 – 10:45 Achieving Uniform Content Deliverables and Assessment in a Capstone Design Course Having Many Diverse Projects, Advisors and Teams by Janis Terpenny, Richard Goff and Clinton Dancey [11821]

10:45 – 11:00 Development of a Supplemental Course Evaluation for Capstone Design by Kay C Dee, Glen Livesay and Renee Rogge [11823]

11:00 – 11:15 Discussion

Session 3B
Improving Technical Communications (panel)
Room: ECCR 265
Chair: Teadora Schuman

9:45 – 10:00 The Role of Capstone Design in Technical Communications Instruction by Len Trombetta, Chad Wilson, Diana de la Rosa-Pohl, Paul Ruchhoeft and Fritz Claydon [11865]

10:00 – 10:15 Improving Technical Writing in Senior Design through Input from External Constituents by Nirmala Gnanapragasam [11806]

10:15 – 10:30 The Continuing Evolution of Capstone Design in EECS by James Reising [11798]

10:30 – 11:15 Discussion

Session 3C
Effective Practices for Project Formation (Workshop #3, Part 1 of 2)
Room: ITLL 1B50
Facilitators: Ralph Ford and William Lasher

9:45 – 11:15 Effective Practices for Project Formation and Faculty Involvement by Ralph Ford and William Lasher [11898]

Coffee Break
11:15-11:30
Engineering Lobby

Session 4
11:30-12:30

Session 4A
Non Traditional Approaches (papers)
Room: ECCR 245
Chair: Scott Palo

11:30 – 11:40 Undergraduate Research Opportunities in Senior Design by Katherine Kuder and Nirmala Gnanapragasam [12179]

11:40 – 11:50 Interdisciplinary Capstone Design at the University of Houston by Richard Bannerot, Ross Kastor and Paul Ruchhoeft [12181]

11:50 – 12:00 A Comparison of Capstone Design Course Choices for Undergraduate Industrial Engineering Students: Requirements and Advantages of the Integrated Product and Process Design Program versus Senior Design Project by R. Keith Stanfill and Rudolph Santacroce [12189]

12:00 – 12:10 The Structure and Conduct of a Capstone Systems Engineering Design Course by Thomas R. Lalk, Aaron Cohen and William Schneider [11805]

12:10 – 12:30 Discussion

Session 4B
Service Learning (panel)
Room: ECCR 265
Chair: Jeff Gilles

11:30 – 11:40 Community Projects for Capstone Design: Case Study by Robert Grisso, Saied Mostaghimi and Mary Leigh Wolfe [11873]

11:40 – 11:50 Environmental Engineering Service Learning Projects for Developing Communities by Angela Bielefeldt [12183]

11:50 – 12:00 Capstone Design and Rehabilitation Engineering: A Great Team by Don Dekker, Stephen Sundarrao and Rajiv Dubey [12184]

12:00 – 12:30 Discussion

Session 4C
Effective Practices for Faculty Involvement (Workshop #3 Part 2 of 2)
Room: ITLL 1B50
Facilitators: Ralph Ford and William Lasher

11:30 – 12:30 Effective Practices for Project Formation and Faculty Involvement by Ralph Ford and William Lasher [11898]

Lunch
12:30-1:25
Engineering or DLC Lobby

Session 5
1:30-2:55

Session 5A
Sponsor Involvement (papers)
Room: ECCR 245
Chair: Mark Steiner

1:30 – 1:45 Challenges to the Development of a "Real-World" Experience for the Engineering Senior – A Conflict with the Consulting Engineering Community? by David Munoz, Doug Sutton, Cathy Skokan, Richard Burczyk, Melvin Capehart, John Gormley and Julie Van Laanen [12188]

1:45 – 2:00 Critical Issues Associated With an Industrially Supported Capstone Design Program by Thomas Barber [12023]

2:00 – 2:15 Involving Industrial Partners through the Capstone Design Course by Cesar Luongo and Chiang Shih [11792]

2:15 – 2:30 Institutionalizing a Capstone Program - The Devil's in the Details by Harry Wildblood [11913]

2:30 – 2:45 Improving the Results of a Capstone Design Program - A Continuous Process by Jack Zable [11918]

2:45 – 3:00 Discussion

Session 5B
Team Dynamics (panel) [11008]
Room: ECCR 265
Chair: Doug Wilde

1:30 – 1:45 Capstone Team Dynamics by Stephen Zahos and Alan Hansen [11903]

1:45 – 2:00 Multidisciplinary Teaming through Student Design Competitions by Dan Dolan, Mike Batchelder and Jim McReynolds [11876]

2:00 – 2:15 Challenges in Mentoring Individuals in Biomedical Engineering Team Design Projects by Jennifer A. McCann-Brown, Allison Sieving, Brett Bell, Seth Kreger, Nan Zhou, Andrew Brightman, Ann Rundell and Sherry Voytik-Harbin [11826]

2:15 – 3:00 Discussion

Session 5C
Teaching Students to Give Oral Presentations (Workshop #4)
Room: ITLL 1B50
Facilitator: Lee Potts

1:30 – 3:00 Coaching Your Students to Create and Deliver Effective Presentations by Lee Potts [11003]

Coffee Break
3:00-3:30
Engineering Lobby

Poster Session and Tour of ITLL
3:30-5:15
Engineering Lobby
Chair: Mark Lehto

Banquet Dinner
6:30 – 9:00
Folsom Stadium Club

Keynote Presentation

Capstone Design – ABET Expectations and Opportunities [11004]
David Holdger
Iowa State University

Friday, June 15, 2007

Keynote Presentation

Engineering Education in the United States: How Well Are We Preparing Our Students for Practice? [11007]

Sheri Sheppard
Stanford University
MCDB A2B70
8:30-9:30

Session 6
9:45-11:15

Session 6A
Novel Approaches (papers)
Room: ECCR 245
Chair: Scott Palo

9:45 – 10:00 Capstone Design Project - An Integrated Approach to Design by Mark Ackerman and Curt Stout [11547]

10:00 – 10:15 Melting-Pot Senior Design at Oakland University by Michael Latcha, Debatosh Debnath, Imad Elhajj, Edward Gu and Richard Haskell [11884]

10:15 – 10:30 Capstone Design at WPI - An Evolution of Projects Based Education by Fred Looft [11723]

10:30 – 10:45 Individual Driven Capstone Design Projects in the Multidisciplinary Fields of Microelectronic Engineering MEMs and Nanotechnology by Santosh Kurinec, Michael Jackson, Sean Rommel, Karl Hirschman and Lynn Fuller [12215]

10:45 – 11:15 Discussion

Session 6B
Going Global (panel)
Room: ECCR 265
Chair: John Lamancusa

9:45 – 10:00 Globalization: The New Frontier for Capstone Programs by Gregg Warnick, Spencer Magleby and Robert Todd [12191]

10:00 – 10:15 Our Second International Senior Design Projects by John Aidoo, James Hanson, Kevin Sutterer, Robert Houghtalen and Samuel Ahiamadi [11810]

10:15 – 10:30 Motivation, Inspiration and Economics of an International Service Project by Peter Johnson, Mark Budnik, Kathleen Sevener and Jeffrey Will [11893]

10:30 – 10:45 Development, Implementation and Outcomes of International Service Learning in Structural Engineering by David Dinehart and Shawn Gross [11819]

10:45 – 11:15 Discussion

Session 6C
Capstone Design Assessment Instruments (Workshop #5)
Room: ITLL 1B50
Facilitator: Steven Beyerlein

9:45 – 11:15 Capstone Design Assessment Instruments by Steven Beyerlein [11795]

Coffee Break
11:15-11:30
Engineering Lobby

Session 7
11:30-12:30

Session 7A
Advanced Pedagogy (papers)
Room: ECCR 245
Chair: Santosh Kurinec

11:30 – 11:45 Using Capstone Design Projects to Differentiate Engineering Programs by J. Ronald Bailey [11888]

11:45 – 12:00 Enhancing Capstone Design Courses Through Graduate Student Mentoring and Leadership Development by Edwin Odom [11901]

12:00 – 12:15 Improving a Capstone Design Course through Blended Learning by Marjan Eggermont and Robert Brennan [11843]

12:15 – 12:30 Discussion

Session 7B
Biomedical Projects (panel)
Room: ECCR 265
Chair: Gary Pawlas

11:30 – 11:40 Improvement of a Capstone Biomedical Engineering Design Course by Paul King [11605]

11:40 – 11:50 Biomedical Engineering Design and the Development of High-Value Relationships with Clinical Medicine by Robert Hitchcock and Kelly Broadhead [11827]

11:50 – 12:00 Evolution of Bioengineering Capstone Design at Arizona State University by Vincent Pizziconi, Jeffrey LaBelle and Eric Guilbeau [11908]

12:00 – 12:30 Discussion

Session 7C
Highly Collaborative Experiences (panel)
Room: ITLL 1B50
Chair: Spencer Magleby

11:30 – 11:40 IMPaCT - Innovation through Multidisciplinary Projects and Collaborative Teams by Kelly Crittenden [11784]

11:40 – 11:50 Multi-University and Industrial Collaboration for Research-Oriented Capstone Experience by Suzanne W. Smith, Keith E. Rouch, William T. Smith and Jamey Jacob [11815]

11:50 – 12:00 The Antarctic Undergraduate Telescope: An Invitation to a Multi-School Capstone Project by Patrick Little [11894]

12:00 – 12:30 Discussion

Lunch and Recap
12:30-1:30
Engineering or DLC Lobby

Poster Session: Titles and Authors

01. Capstone Design Program for Department of Electrical Engineering in Southern University by Jiecai Luo [11195]

02. Bridging the Gap between Academia and Industry through Capstone Design by Tongele Tongele [11348]

03. Designing/Building Innovative Conceptual Prototypes in Capstone Course by Eugene Rivin [11780]

04. Institutionalizing the Capstone Design Course in the I.E. Department at the University of Louisville by Suraj Alexander [11787]

05. Cooperative Engineering Center - An 18 Year Success Story by James Arthur [11788]

06. Multi-Dimensional Capstone - It Takes a Village by Gerald Crain [11789]

07. The Engineering Senior Design EXPO and Multidisciplinary Projects at UIC by David Schneeweis and Vladimir Goncharoff [11791]

08. Enhancing Students' Experience Using a Discussion Board System as a Collaboration Tool by Junichi Kanai [11793]

09. A Multidisciplinary Team Approach for Capstone Design Courses: Challenges and Lessons by Patricia Wojahn and Young Ho Park [11797]

10. Raising the Bar: Taking Senior Design from Student Projects to Academic Industrial and Entrepreneurial Contributions by Ronald Lasser [11804]

11. The Structure and Conduct of a Capstone Systems Engineering Design Course by Thomas R. Lalk, Aaron Cohen and William Schneider [11805]

12. Civil & Environmental Engineering Infrastructure Projects by Max Anderson, Mark Meyers and Philip Parker [11809]

13. Ten Years of Industrially Sponsored Capstone Design Projects by Alan Weimer [11812]

14. Life-Cycle Integrated Capstone Project Design by Ruinian Jiang [11816]

15. Capstone Design in a Large University Environment by Jay DeNatale and Gregg L. Fiegel [11820]

16. The Astronautics Capstone Program at the United States Air Force by Kenneth Siegenthaler [11842]

17. Capstone Design for Mechanical Engineering by Warren N. Waggenspack Jr. and Michael C. Murphy [11852]

18. Integrating Liberal Education and Professional Engineering Goals in Capstone Design Courses by Chiou Chen [11956]

19. A Capstone Software Engineering Project Class for the Modern Era: Emphasizing Requirements and Testing by John Bowles [11997]

20. Capstone Design Course-Quality Control by Jie Chen [11999]

21. Impact of Curricular Revision on Senior Design Projects and ABET Accreditation at a Hispanic Institution by Mark Lau and Sastry Kuruganty [12000]

22. Guiding Productive (and Happy) Student Groups by Wayne Chudyk [12004]

23. Benefits of Industry Involvement in Senior Capstone Design Courses by Jay Goldberg [12006]

24. Equipping Students with an Engineering Toolbox in a Capstone Design Course by Alan Hansen, Stephen Zahos and Douglas Bosworth [12007]

25. College-Wide Senior Design Competition: A Motivating Approach by Rama Venkat, Paolo Ginobbi, John Wang, Mohamed Trabia, Henry Selvaraj, Nader Ghafoori, Walter Vodrazka and Laxmi Gewali [12022]

26. Transitioning To a Two-Semester Capstone Design Sequence in Mechanical Engineering by Keith E. Rouch, William E. Murphy and Vincent R. Capece [12175]

27. Comparison of Two Project-Based Capstone Design Teaching Approaches by Scott Morton and David Walrath [12177]

28. Mobile Robot Control as a Multiple Disciplinary Project: A Capstone Experience by Jian Peng [12178]

29. Combined ME / MET Capstone Projects at Montana State University: Organization Issues, Case Studies and Lessons Learned by Robb Larson and Vic Cundy [12182]

30. A Management Structure for Multidisciplinary Capstone Design Projects by Roy McGrann, Colin Selleck and Matt Laferty [12186]

31. Capstone Design in Materials Engineering at Iowa State University by M. Hogan [12222]

32. University and County Working Together via a Capstone Project: Focusing on Recycling Facility and Green Community by Matthew Sanders, Kyle Scott, Julie Hinterman [12223]

Abstracts: Keynote Speakers

#11004: Capstone Design – ABET Expectations and Opportunities

David Holdger (Iowa State University)

ABET accredits programs in applied science, computing, engineering, and engineering technology. The ABET Accreditation Council, made up of the leadership of the four accreditation commissions and associated ABET staff, is charged with enhancing consistency of policies, procedures, processes, and criteria across the four commissions. This includes a major current effort to better align, where possible, the four sets of accreditation criteria. Important unifying elements of the accreditation criteria of the four commissions are the expectation of "outcomes-based approaches" that include systematic assessment and evidence for the achievement of specified program outcomes. The four sets of accreditation criteria specify from nine to eleven program outcomes, and nine of the outcomes are quite similar across commissions. Of the nine, eight are outcomes for which significant evidence of accomplishment can be documented in connection with capstone design projects. In addition, both engineering and engineering technology criteria include explicit expectations for culminating capstone experiences that build upon earlier elements of the curriculum. A holistic approach to engineering capstone design experiences can be leveraged by programs to demonstrate compliance with the explicit requirement for such experiences, while also providing excellent opportunities for the culminating assessment and documentation of the achievement of many of the specified program outcomes. For engineering programs the capstone design experience is clearly a major unifying element of the curriculum as well as a specific expectation for accreditation by ABET.

#11005: Keynote: Where Are We Now? Statistics on Capstone Courses Nationwide

Susannah Howe (Smith College)

Capstone design courses are an increasingly common component of engineering curricula nationwide, but how much do we really know about the current practices? How do capstone courses differ across departments and institutions? How have capstone courses changed in the past 10 years? This talk will highlight data from a survey of engineering capstone design courses conducted in 2005, based on responses from 444 programs at 232 institutions. Particular focus areas will include course logistics and management, faculty involvement, project coordination, funding details, and industry sponsorship. The 2005 data will also be compared with results from the comparable survey by Todd and Magleby et al. in 1994 (*Journal of Engineering Education*, April 1995), thus providing both a snapshot of current practices plus an indication of trends over the past decade.

#11006: Keynote: Industry Sponsor Expectations of Capstone Design Team Deliverables

Deborah Limb (Boeing Corporation)

Boeing is a leader in developing and using new technologies. The new 787 is an especially ambitious project using new composite materials and manufacturing techniques. Deborah Limb is currently the Director of Payloads and Structures for Boeing Commercial Airplanes. Deborah led the international team responsible for the design, build and support of the new composite Fuselage and Interior for the 787 airplane. Deborah is a Seattle University graduate and participated on a project as a senior in mechanical engineering.

Boeing has been working with SU for over 50 years and with the SU project center since its inception in 1987. Over 1200 SU grads work at Boeing and Boeing employees sit on many different SU boards. Mrs. Limb's group has sponsored several SU capstone projects over the last few years in ME, EE, and CS.

Mrs. Limb will provide a brief overview of the new 787 composite airplane. In addition, she will discuss the benefits of university and corporate project center partnerships. She will talk about the impacts she expects the capstone project to have both on the students and her own engineers. She will also examine the benefits both to Boeing and the broader community.

#11007: Engineering Education in the United States: How Well Are We Preparing Our Students for Practice?

Sherri Sheppard (Stanford University)

The Carnegie Foundation for the Advancement of Teaching has produced many studies of professional education, beginning with the influential Flexner report on medical education in 1910. Building on that tradition, the foundation initiated the Preparation for the Professions Program (PPP) in 1999 to address the perception that professional education has been plagued by a long-standing failure to connect theory and practice in systematic, productive ways. In law schools, for instance, theoretical academic learning is the coin of the realm; little attention is paid to the "lawyering" skills and values that are essential in the world of practice. In addition, professional preparation tends to be insular, with no mechanism for learning from other fields to develop strategies for tackling common challenges of professional preparation. The goal of PPP is to raise issues and broaden the frame of reference for leaders and practitioners in all fields of professional education. Phase I of the program is focused on preparation for three professions—law, the clergy, and engineering. Phase II, simultaneous studies of medical and nursing education, was just recently launched.

An important goal of the PPP's engineering study has been to develop a clear picture of how administrators, faculty, and students understand the nature of engineering practice and to identify a set of core ideas that are consistent across these groups and in line with published analyses of the essential features of the profession. The resulting picture of engineering practice will be presented. In addition, findings will be described that illustrate how currently employed teaching methods and curricular structures (particularly as related to design and laboratory instruction) support (or do not support) developing engineering practitioners.

ABSTRACTS: PAPERS AND PANELS

#11000: Sharing Startup Experiences

Moderator: Susannah Howe (Smith College)

Are you in the start-up phase of a capstone design course? Would you like to build on the successes of others who have been there but avoid their mistakes? Do you have questions you would like to get answered? If so, this is the panel for you!

This panel will address lessons learned (both good and bad!) while starting capstone design courses. The three panelists – Joseph Emanuel (Bradley University), Linda Riley (Roger Williams University), and Jack Zable (the University of Colorado at Boulder) – will start with very short remarks about their own experiences and then open the floor to questions from the audience. The moderator will also supply general questions as needed. The goal of this session is to stimulate an informal dialogue to answer questions about starting capstone courses, share ideas and best practices, and identify pitfalls. Experienced capstone educators are also welcome to attend and contribute their experiences.

#11008: Team Dynamics

Moderator: Doug Wilde (Stanford University)

A computer with PowerPoint 2003 will be available. Each panelist will have 8 minutes to provide a presentation and/or opening comments. After the panelists conclude their remarks, the moderator should direct the audience to interact with the panel. The moderator may wish to prepare some leading questions for the panel—perhaps even posing these questions in his opening remarks. The moderator has the additional responsibilities of collecting the audience presentation ratings form, recommending a panelist paper for possible publication in an ASEE online journal, and providing summative comments on the session to Keith Stanfill, the "Institutionalizing" track chair (a few bullets capturing current best practices discussed and opportunities for further research).

Panelists

Steve Zahos, Capstone Coordinator, Agricultural and Biological Engineering Department at the University of Illinois at Urbana-Champaign is a 34 year education advancement and business professional. Bachelor and Masters Degrees in Mechanical Engineering from the University of Illinois, numerous opportunities in engineered product development, sales and marketing have lead to the interesting, important work of preparing engineering graduates for the real world. Steve proposed this panel session

Mike Batchelder, South Dakota School of Mines and Technology, co-author of "Multidisciplinary Teaming through Student Design Competitions" with Dan Dolan and
Jim McReynolds

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.

Jennifer A. McCann-Brown, Purdue University, co-author of “Challenges in Mentoring Individuals in Biomedical Engineering Team Design Projects” with Allison Sieving, Brett Bell, et al.
Jennifer A. McCann-Brown, Ph.D. is a post-doctoral research associate in the Weldon School of Biomedical Engineering. She coordinates and helps teach the capstone design course and the biotransport laboratory course and serves as the assessment coordinator for the undergraduate program.

John Twomey is a University of Colorado mechanical engineering spring graduate and recent capstone participant. John is just entering the workforce.

Mr Glenn Pope from John Deere's Worldwide Combine Development Center in Moline has agreed to come and be an industry rep. on the panel. He and his company are long time supporters of the UIUC capstone program. Glenn is a project Engineer and is a direct contact for the teams his organization sponsos. Despite having attended Colorado State, he immediately agreed to come to Boulder and contribute his insight.

#11547: Capstone Design Project - An Integrated Approach to Design

Mark Ackerman and Curt Stout (University of Alberta)

There are many approaches to teaching design to Engineering students. Mechanical Engineering has chosen to integrate a methodology throughout the undergraduate program in hopes that a consistent approach will make the material more easily understood by the students and easier to deliver by the academics involved. The approach presents a three stage design methodology: Specification Development, Conceptual Design and Detail Design. While this approach has been well accepted by the students it is very intensive from an academic perspective, especially at the senior level. Individual work loads approach 200 hours per term per academic involved (assuming 80 students per class) so that a strong departmental governance commitment is necessary. Industrial projects, while not absolutely necessary, allow the students to work on, and solve, real problems. Response from both the students and industry to this approach has been overwhelmingly positive. There are pitfalls as well as real costs associated with taking this approach but the effort is well rewarded in the development of more well rounded and well prepared young engineers.

#11605: Improvement of a Capstone Biomedical Engineering Design Course

Paul King (Vanderbilt University)

The capstone design course in Biomedical Engineering (BME) at Vanderbilt University has been taught since 1991. It had been relatively stable in structure and content (full year course beginning in 1997 (roughly half project based), and textbook based (rather than notes based) from 1999 on. The funding of an NSF ERC in Bioengineering Education in 1999 and the appointment of the author as the “design thrust” director, and several related grant and other initiatives, enabled the author to make a significant number of changes to this design sequence.

These changes include (in brief) the following items. Industrial input to the course was significantly increased, with industry sponsored projects changing from 0 to 7% of all projects to an average of 30% over the past seven years. Collaboration with the industry based author of the textbook used resulted in the generation of a jointly authored biomedical engineering specific design textbook with this author; this text is in current use in a number of US programs. Collaboration with learning scientists via the ERC led to the introduction of the use of concept maps in design instruction and evaluation of student's understanding of design concepts. An affiliation with industry led to the introduction of a design tool into the course sequence (Innovation Workbench), the use of concept mapping techniques was adapted to assist in the use of this software. An NCIIA course improvement grant was obtained to support design projects in this course via equipment purchases (prototyping materials primarily). A design workshop was held by the author and others in 2002, (Whitaker and NSF support) to exchange ideas between design instructors. This workshop has been held yearly since (spearheaded by Stanford University, with NSF, Whitaker, and NCIIA support), one of the primary outcomes has been a national BME design contest. Several consensus design grading sheets have also been an outcome of these efforts. An engineering school wide design seminar was noted by the author at another university, this effort was duplicated at Vanderbilt in 2003, leading to a common design seminar attended by all seniors in BME, ME, EE, Computer Engineering, and Civil Engineering at Vanderbilt. This has led to the development of interdisciplinary design teams, with BME previously having ~ 0% outside students on BME design teams, to an approximate 20% non-BME composition of BME design teams for the past three years. Design team size rose from an average of 1.5 students to 3.5 per team during the same interval.

The above topics and their relationship to ABET outcomes will be elaborated upon in the following presentation of this material.

#11723: Capstone Design at WPI - An Evolution of Projects Based Education

Fred Looft (Worcester Polytechnic Institute)

Since 1971, all students at WPI have had to complete two major projects as part of their graduation requirements. The first, known as the Interactive Qualifying Project, is a project that "relates technology and science to society or human needs. This project ... challenges students to relate social needs or concerns to specific issues raised by technological developments" (http://www.wpi.edu/Academics/Projects/intro.html). Currently, more than half of all WPI undergraduates complete this project as part of a "project center", the vast majority of which are in international locations. The second project - the subject of this paper - "is a project in the major field of study ... called the Major Qualifying Project, or MQP. This project should focus on the synthesis of all previous study to solve problems or perform tasks in the major field with confidence, and communicate the results effectively" (ibid). The MQP satisfies the ABET capstone design requirement and is fundamentally different than a course based capstone experience. Specifically, a project team is typically composed of 2-4 students and is closely advised and mentored by one or two faculty members for the duration of the project. As might be expected, our concept and implementation of the WPI vision for projects based education, and in particular our fourth-year capstone project (the MQP) has changed in several fundamental ways since its inception. Traditionally, the MQP has been completed on-campus and not in collaboration with industry. Over the past 10-15 years we have changed, in some ways dramatically, our approach to supporting, managing and advising this project. Among these changes have been the development of numerous industry based and located "project centers", the development of global project opportunities, on and off-campus opportunities to complete the project as part of interdisciplinary teams focusing on specific technologies or issues, and on-campus interdisciplinary project opportunities that have a specific national program focus (e.g. development of a nanosat, designing a renewable energy and fully instrumented demonstration house, or taking part in a national robot design competition). In this paper we present an overview of our approach to the capstone experience, and provide detailed information on how our projects program in general, and our capstone project have adapted to changing educational needs, globalization and student interests. Finally, we will also describe how we advise, assess and continuously improve our projects and the WPI projects program.

#11774: Continues Improvement and Quality Assurance in the Capstone Project at the University of Pretoria

Nicolaas D L Burger (University of Pretoria)

The Faculty of Engineering, Built Environment and Information Technology (EBIT) at the University of Pretoria is a leading and dynamic faculty that is one of the foremost providers of high-level intellectual capital and research in the country. The Faculty is renowned for its unique approach to innovation, its international status and links with industry.

The Department of Mechanical and Aeronautical Engineering is one of 14 departments in the Faculty of Engineering, Built Environment and Information Technology, and is the largest Department of Mechanical Engineering in South Africa. Its graduate and postgraduate students are trained to become top quality engineers, owing to the Department's internationally accepted programmes.

The mission of the Department of Mechanical and Aeronautical Engineering is to prepare engineers for success and leadership that is recognised internationally for its quality in the conception, design, implementation, and operation of mechanical and aeronautical related engineering systems.

The Department of Mechanical and Aeronautical Engineering is facing a major challenge in view of the diversity of intake of students and the constant pressure on delivering more engineers to industry in an attempt to feed the growth of the economy. In this strive to increase the number of engineers delivered to industry, quality cannot be compromised and therefore quality control systems must be put and kept in place that will ensure that the University of Pretoria will not only be under the top 500 universities in the world but will improve its position on these lists
One of the major challenges as described in this paper is to ensure the quality of work and also as important the quality of assessment of the final year capstone project.

#11775: Evolution of a Capstone Design Program: Changes in Focus Purpose and Mentorship

Robert Mayer, Jennifer Waters and David Kriebel (U.S. Naval Academy)

This paper traces the transition of the capstone design experience in the ocean engineering program at the U.S. Naval Academy from one based on student ingenuity to one that focuses on real-world problems of client sponsors with opportunity for design testing and even product development. The pros and cons of each capstone approach are identified, along with lessons learned and experience gained. Examples and highlights of the capstone design projects in each phase of transition are also reviewed to show how student teams have advanced from use of designer handbooks and the drafting board to dealing with the natural effects of the ocean realm and its surroundings.

#11784: IMPaCT-Innovation through Multidisciplinary Projects and Collaborative Teams

Kelly Crittenden (Louisiana Tech University)

IMPaCT (Innovation through Multidisciplinary Projects and Collaborative Teams) is a collaborative effort between faculty, students and industry representing engineering, business and other colleges at Louisiana Tech University. The goal of IMPaCT is to support multidisciplinary design experiences for engineering, business and others such as graphic design, nursing, and education students. As a result, IMPaCT promotes a culture of entrepreneurship and innovation throughout the university and region. IMPaCT's year-long multidisciplinary design projects provide opportunities for students to experience the entire research, development and marketing process. IMPaCT courses provide vertical integration by including freshman through senior students in the product design process as well as horizontal integration across various disciplines and majors. IMPaCT students can earn technical elective credit as well as capstone design credit. To date, IMPaCT teams have included a variety of junior and senior engineers (mechanical, biomedical, electrical) along with finance, marketing, MBA, and aviation students; one team is even working with a team of manufacturing engineering students in Taiwan.

IMPaCT students learn and practice a variety of team-work and team-leading skills. Students learn effective brainstorming methods based on the IDEO philosophy. Also, the students hone their prototyping skills through simple sketching and foam-core mock-ups all the way to state-of-the-art computer aided design and rapid prototyping. The business side of product development is explored as the students learn about intellectual property, market sizes, and value propositions. This business knowledge is demonstrated when the teams prepare business plans to support their newly developed product. The students learn to become effective communicators by delivering several small presentations each quarter and two large presentations (one for a business plan competition and the other for a capstone senior design conference) at the end of the project. IMPaCT students will have an excellent product development experience to draw from whether they intend to enter traditional industry or start their own.

This paper will present the overall results of the first two years of IMPaCT (one pilot year and one year of NSF funded activity) and the future direction of the program. These results describe projects that were derived from faculty research, intellectual property, student ideas, and industry sponsorship. As one of the objectives of IMPaCT is to stimulate a culture of entrepreneurship, this paper will include examples of IMPaCT projects that have the potential for becoming startup companies. Also, the interdisciplinary structure and rationale behind IMPaCT courses will be presented along with an overview of the course content and custom modules.

#11786: Team Teaching Capstone Design

Sigurd Lillevik (University of Portland)

This paper describes a team taught capstone design course and outlines some of the logistical issues for the student (grades), faculty advisor (time), industry representative (standards), and coordinator (consistency). It describes a set of best practices that include consensus on course objectives, integration of an industry representative, checks and balances, clear expectations and roles, published grading rubric, assignment of advisor and industry representative by their choice, and strong communications. Since no two institutions are the same, these recommendations will require adaptation for successful implementation.

#11792: Involving Industrial Partners through the Capstone Design Course

Cesar Luongo and Chiang Shih (Florida State University and FAMU-FSU)

The Mechanical Engineering curriculum at the FAMU-FSU College of Engineering features a capstone one-year senior design course in which students work in teams tackling engineering problems provided and sponsored by industrial partners. This paper describes the evolution of the capstone course over the last eight years. As the course matured, the department has been able to attract more and more industrial sponsors; today almost all the senior projects are sponsored by industry. This high level of industrial participation allows us to draw some important conclusions on what constitute "best practices" for capstone design courses.

#11798: The Continuing Evolution of Capstone Design in EECS

James Reising (University of Evansville)

In the past decade, a number of changes in the EECS capstone design sequence at the University of Evansville have occurred. Still other modifications will be implemented in 2007. Some of these changes are in response to continuing departmental assessment activities, while others are due to the recent adoption of a new university writing program requiring writing across the curriculum.

A previous paper described the capstone senior design project course sequence at the University of Evansville as it existed in 1997. Although the basic structure of the three-course sequence was left intact, several changes, described in a later (2004) paper, were made to broaden the coverage of the engineering discipline and facilitate assessment of the outcomes of ABET Criterion 3. The present paper provides an update of the capstone experience's ongoing evolution, including a detailed summary of recent revisions.

A brief summary of the course sequence is as follows:

1. EE 494 Senior Project Seminar (0 credits)
2. EE 495 Senior Project Phase I (3 credits)
3. EE 497 Senior Project Phase II (3 credits)

The first course, typically taken in the spring term of the junior year, primarily serves to present possible design project ideas to the students, who choose their design projects by the end of the semester. The second course devotes a few weeks to discussion of professional ethics, with the remainder of the semester used to develop both written and oral presentations of the students" engineering design proposals. This second course also serves as part of the university writing program for electrical and computer engineering majors. The third course in the sequence requires students to validate their designs either by producing a prototype, or in a few cases, by completing a detailed simulation of the proposed system.

Although this description and organization remains unchanged, a completely new EE 497 will be offered for the first time starting in January, 2007, in an attempt to resolve problems noted in departmental review of the senior project experience. Additionally, future assessment of EE 495 will include the writing component as part of the university-wide writing program, requiring new guidelines for the faculty involved in the process.

Other modifications made since the 2004 paper include the use of a new text for EE 495 that includes chapters specifically devoted to the social and global issues in engineering, and a new procedure for assigning course grades in EE 497.

These and the other changes to our capstone design sequence described in this paper represent further steps in our attempt to enhance students' writing skills, grade their design projects consistently, and further refine the assessment of the methodology to discover yet other ways to improve their experience.

#11800: Ensuring Success in Interdisciplinary Externally Sponsored Capstone Design Experiences

Jon Rust and Russell Gorga (North Carolina State University)

The Textile Engineering (TE) Program at North Carolina State University has long been utilizing external sponsors for senior design projects. Today, senior design projects in our department focus on diverse fields such as material science, information systems and electro-mechanical design. In this paper, we will focus on methods to encourage external sponsors (within the university community as well as without) and initiate discussions of capstone design opportunities. In addition, we will discuss strategies to evaluate a project description in order to facilitate success whether the sponsor is a manufacturing company, a faculty member or a student. We have found that a successful project requires more than finding a sponsor with a project description. Therefore, we will also focus on the elements that ensure the success of the project and the students involved (such as sponsor involvement, student support, setting/achieving milestones, and providing peripheral instruction). Furthermore, we will present methodologies to incorporate external sponsors into new or existing programs. Specifically, we will discuss advantages for using external sponsors within the university community to not only build the Capstone program but provide an opportunity for faculty (especially junior faculty) to gain experience and confidence in guiding a team to successful completion of a short-term project. Paradigms for several groups working on a single project versus unique projects for each group are explored. Finally, we will highlight recent projects including a bioreactor intended to show proof of concept of an apparatus allowing the harvest of fetal liver cells, a test method and apparatus to test the castability of fishing line, and the design of a robust database to assist all facets of information management for a burgeoning seminary.

#11805: The Structure and Conduct of a Capstone Systems Engineering Design Course

Thomas R. Lalk, Aaron Cohen and William Schneider (Texas A&M University)

The capstone design courses in mechanical engineering at Texas A&M University have undergone tremendous change in the past 10-15 years in both emphasis and methodology of presentation. Previously, emphasis was on the design of mechanical elements such as gears, cams, linkages, springs, bearings, clutches, shafts, etc., that is, traditional machine design. The method of presentation was to first cover basic concepts and design calculations such as stress, deflection, stiffness, and toughness followed by application of these to the design calculations needed to size specific mechanical elements and finally synthesis of elements into the design of some mechanical device. This method of teaching mechanical engineering design is exemplified by popular textbooks such as *Mechanical Engineering Design* by Shigley and Mischke and *Machine Design* by R.L. Norton. This teaching emphasis and methodology of presentation was referred to in a 1991 report from the National Research Council, Improving Engineering Design – Designing for Competitive Advantage. It was noted that: “Engineering curricula focus on a few conventional design procedures rather than on the entire product delivery process." This report also lamented the "lack of truly interdisciplinary teams in design courses."

Recently there has been a change in both emphasis and methodology of presentation of the mechanical engineering capstone design course at Texas A&M University. The emphasis has shifted from merely teaching design calculations and synthesis of mechanical elements to the teaching and application of a systematic and structured process that can be applied to the design of any device or system, as well as to problem solving in general. The capstone design experience is presented in a two-course sequence with instruction in application of the design process to conceptual and preliminary design the focus of the first semester, and detailed design emphasized during the second. Students are required to apply the process to open ended design problems about which they have little or no previous knowledge. This necessitates that they integrate their science, engineering science and mathematical background with their creativity to identify a well specified need that they develop from a general customer problem statement and constraints, and devise a solution that meets this need.

The capstone systems engineering design, two course sequence is described including the philosophy, objectives, content, organization and conduct of the courses. The three general topics addressed in these courses are: the general systematic top-down design process, analysis for design, and system engineering project management. Specific topics covered are: establishment and analysis of the top level need with attention to customer desires, functional decomposition, development of a hierarchical function structure, determination of functional and performance requirements, identification of interfaces and design parameters, development of conceptual designs using brain storming and parameter analysis, selection of criteria for the evaluation of designs, trade studies and down-selection of best concept, parametric analysis, preliminary design and detailed design. Application of engineering analysis including the depth and detail required at various phases during the design process is discussed and illustrated. Systems engineering management procedures such as failure modes and effects analysis (FMEA), interface control documents, work breakdown structures, scheduling safety and risk analysis, cost analysis and total quality management are discussed and illustrated with reference to student projects. The advantages of conducting large complicated design projects, rather than smaller more easily completed ones, is explained in the context of examples of students' projects. Opportunities for and experience with collaborative and multidisciplinary projects is discussed in terms of previously completed and future design projects.

#11806: Improving Technical Writing in Senior Design through Input from External Constituents

Nirmala Gnanapragasam (Seattle University)

Seattle University has an industrially sponsored, yearlong, senior design program that has been in existence for the past 20 years. Students work in teams of three or four under the supervision of a liaison from the sponsoring agency and a faculty advisor. The fall quarter is spent on preparing a proposal detailing the work to the client (the sponsoring agency, in this case). At the end of spring quarter, the team prepares a final report to the client describing the design approach, solution, conclusions, and recommendations. The capstone experience provides the students with an opportunity to integrate their knowledge of science, engineering, ethics, and humanities, to work effectively in a team setting, to improve communication skills, to understand and respond to client needs, and to develop project management and human relations' skills.

Technical writing is an important component of the senior design program. The Civil

Engineering Department at Seattle University has taken several steps to improve technical writing within the senior design program. A decade ago, it worked with the Seattle University English department to develop a manual that provides guidelines to write professional proposals and final reports. Students from the English department who planned to enter the field of technical writing in the future served as ‘writing consultants’ to engineering students. The writing consultants reviewed and critiqued the project documents prepared by the student teams.

Five years ago, the Civil Engineering Department brought in a technical writer from the industry to review and provide feedback to student teams a couple of times during the year. Though effective, the department felt that the students would benefit more if there were more interaction between the technical writer and the student teams. For the past two years, it has hired a part time technical writer to review and provide feedback to the teams several times during the fall quarter during which time students prepare the project proposals. For the past six years, the Civil Engineering Department has also been using a panel of practitioners from the local civil engineering community to review the project documents before they are finalized and submitted to the client.

The aim of this paper is to discuss the evolution of the writing component of the senior design program within the Civil Engineering Department at Seattle University over the past decade. It shares the experience and the lessons learned at each stage of improvement. The paper further discusses the assessment process in place to evaluate writing. This experience will be helpful for other senior design programs that are working on improving the written communication skills of their students.

#11810: Our Second International Senior Design Projects

John Aidoo, James Hanson, Kevin Sutterer, Robert Houghtalen and Samuel Ahiamadi
(Rose-Hulman Institute of Technology)

In 2005, the Department of Civil Engineering at Rose-Hulman Institute of Technology decided to incorporate an international component into its 18 year old capstone senior design program. The advantages of international experiences for engineering students are well documented:

- Students have the opportunity to partner with local or international organizations
- Students get exposed to international design codes and standards
- Students get to experience the global working environment

These are just a few of the benefits associated with international projects. However getting involved in foreign projects is not without its problems:

- Students face challenges associated with distance
- Students have to deal with the different cultural and educational environments
- Access to pertinent codes and engineering data is often difficult

In the department’s first international project, some of these major problems were encountered and the lessons learned were documented. Using these lessons learned, we decided to undertake a second international senior design project. This paper discusses how recommendations and experiences gained from our first international project were used to our advantage. Specifically, the paper addresses the following issues:

- Partnership with the Rose-Hulman Engineers Without Borders (EWB-RHIT)
- Collaboration with overseas academic institution
- Support provided by an engineer in the problem-source country

Additionally, the paper presents a survey of the student team experiences as well as the client's comments. These comments are compared with similar surveys from our first experience to ascertain if there has been any improvement in the areas of obtaining relevant engineering data, client communication, etc. The paper finally highlights the advantages of this project, the pros and cons of working with the EWB chapter and our experience gained in working with an overseas academic institution.

#11815: Multi-University and Industrial Collaboration for Research-Oriented Capstone Experience

Suzanne W. Smith, Keith E. Rouch, William T. Smith and and Jamey Jacob
(University of Kentucky, Oklahoma State University)

NASA is addressing the anticipated shortage of aerospace engineers in part through workforce development projects of the National Space Grant College and Fellowship Program. BIG BLUE is a workforce development project currently in its fifth year at the University of Kentucky (UK). UK does not have an aerospace engineering major, and this year, for the first time, the BIG BLUE project is a joint effort of students in Mechanical Engineering at the University of Kentucky and students in Aerospace Engineering at Oklahoma State University. To date, over 250 students have participated in the BIG BLUE project.

This unique multi-university, multidisciplinary project is providing students with opportunities to learn about and to prepare for aerospace engineering careers. BIG BLUE is a comprehensive aerospace project experience to design, build and conduct a complex, high altitude experiment to verify the feasibility of inflatable-wing technology for Mars exploration. To date, three successful experiments have been completed, along with participation in a student unmanned aerial vehicle competition. From the workforce development perspective, students involved in BIG BLUE join the aerospace workforce while participating in the challenging research-oriented project, which influences their decision to choose and pursue an aerospace career.

Collaboration with industry is also an important aspect of the BIG BLUE project. Technologies are developed and tested in consultation and partnership with high-tech industries, including conducting a detailed design review with industry representatives. Partnering with another university for this process presents communication and other challenges for students, in addition to the technical challenges. However, this is a more realistic representation of the current working environment for research and development of high-tech systems.

In this paper, the educational aspects of the BIG BLUE project are detailed, including multidisciplinary and multi-university teams. In addition to capstone design courses, students involved with BIG BLUE attend short course and workshops presenting critical information and skills as needed to supplement undergraduate and capstone courses. Annual support and expenditures, student and faculty involvement in project management and aerospace workforce development results are included. A five-year review of BIG BLUE reveals the effort, cost and results of experiential aerospace workforce development via multi-disciplinary, multi-university capstone design.

#11819: Development Implementation; and Outcomes of International Service Learning in Structural Engineering

David Dinehart and Shawn Gross (Villanova University)

The primary role of a civil engineer is to serve the community; thus, it is essential that students understand the impact of engineering projects on, and the context of engineering projects within, society. One objective of an engineering capstone design course should be to mesh the technical knowledge of the discipline with an encompassing engineering problem that incorporates "real world" issues and challenges. With all of the aforementioned criteria in mind, the objective of Villanova University's structural capstone course described herein is to tie together technical and non-technical issues through a challenging real world project. This paper presents the development, implementation, and outcomes of a unique structural engineering capstone course.

#11821: Achieving Uniform Content Deliverables and Assessment in a Capstone Design Course Having Many Diverse Projects, Advisors and Teams

Janis Terpenny, Richard Goff and Clinton Dancey (Virginia Tech)

The capstone senior design course in Mechanical Engineering at UniversityX is a two semester sequence with an enrollment of over 280 seniors, nearly 30 different projects advised by 20 different faculty project advisors. The course sequence offers students several different project options: those closely connected to funded research, those proposed and sponsored by private industry, and others that involve national and international competitions. Such diversity is one of the course strengths, giving students a choice in their design experience. Yet, with the diversity among design projects, it is important for all students to achieve, in the course of their senior design experience, a consistent set of course learning objectives, regardless of the project selected. To achieve this degree of consistency, while embracing the diversity of the projects, a significant effort has been invested over the last two years in the redesign of this course sequence, including common major measurable learning objectives, course format and procedures, course deliverables, and grading policy.

#11822: Assessment and Evaluation of Engineering Senior Design at Colorado School of Mines

Catherine Skokan, David Munoz, Douglas Sutton and Richard Burczyk (Colorado School of Mines)

The Multidisciplinary Senior Design Program in the Engineering Division at the Colorado School of Mines encompasses a two-semester course sequence, with an average enrollment of 225 students/year working on 45-50 externally-sponsored projects/year, has a faculty team of 8 members, and has five stated program objectives. These objectives are:

- To practice opened-ended problem solving skills through a hands-on, technical project
- To improve oral and written communications skills
- To participate in a multidisciplinary team
- To interface with the "real world", and
- To develop a professional work ethic.

The major goal of the first semester is the preparation of a formal design proposal. There are weekly lectures in the first semester that provide systematic design tools and aid in the process of engineering design, project management, workplace issues, and communications. During the second semester, students implement the proposed project that was designed during the first semester. On-going assessment of the students, teams, instruction and class structure has taken place for over twenty years. Students are assessed through individual assignment grades, self-evaluations, peer evaluations, and individual interviews with a team faculty advisor. Team performance is evaluated through team assignment grades, external client feedback, trade fair judging and faculty advisor ranking. The class grade from each semester is based on both team and individual measurements. Instructional assessments include a school-wide faculty evaluation "bubble form", as well as student comments on a course survey. Finally course evaluations come from a variety of sources: students, clients, alumni, Trade Fair Judges, Corporate Advisory Board, and design faculty. These data have helped in continual improvement of the Senior Design Program. Examples of changes made as a result of this assessment and evaluation are included. These data have provided a solid portfolio for ABET evaluation of both the program and the department. More importantly, analysis of these data has helped in making positive changes to the program.

#11823: Development of a Supplemental Course Evaluation for Capstone Design

Kay C Dee, Glen Livesay and Renee Rogge (Rose-Hulman Institute of Technology)

Capstone design is, in many respects, different from other courses in that students undertake a large, often multi-term project, and must apply knowledge gained from previous courses to solve a problem. Design courses are challenging for many students because the problems are open-ended and the projects are student-driven. These aspects make design courses very different from traditional engineering courses, in which instructors often craft problems specifically to reinforce particular content/skills to be learned, and the instructor largely sets the pace and direction of student learning and activities. Compared to the learning that occurs in traditional engineering courses, the learning that occurs in design courses is more dependent on the student and less dependent on the instructor.

Student evaluations of teaching are the most common method of obtaining feedback on perceived course quality and instructor performance. Traditional evaluation forms, however, tend to be instructor-centered, and do not provide information about the students' contributions to their own learning. We are therefore developing a supplemental design evaluation, to be used as a tool for assessing some of the student actions and attitudes important to a quality design experience. We are avoiding rating scales that ask students to rate items as either good or bad. Instead we seek to provide information to the instructor about the prevalence of specific student practices and attitudes.

In this paper we report results from an initial investigation of the first version of our supplemental evaluation, which was administered at the end of the Fall and the Winter terms to biomedical engineering (*n* = 30 Fall, *n* = 27 Winter) and civil engineering (*n* = 30 Fall, *n* = 46 Winter) seniors in their respective capstone design courses. Using the supplemental evaluation, we were able to detect statistically-significant shifts from the Fall student responses to the Winter responses on a few evaluation items. These shifts were logical given the pedagogical goals and practices of the instructors of the design courses. Factor analysis showed that the evaluation instrument contained questions that could be grouped into eight underlying factors or components, with most of the evaluation items assessing the concepts of students' ability to function independently (in uncertain situations), students' self-perception of their maturation and achievement, and students' acceptance of responsibility and the source of their motivation for the work.

We are currently working on revising the supplemental design evaluation presented in this paper by: revising items that appear to be interpreted in multiple ways by students; eliminating items that appear to obtain redundant information; and adding items related to an underlying factor of student self-assessment of the technical quality of their design product. Our ultimate goal is to develop and disseminate a robust instrument that could be used to obtain feedback beyond that available from traditional instructor-centered course evaluations, with particular relevance to design courses.

#11826: Challenges in Mentoring Individuals in Biomedical Engineering Team Design Projects

Jennifer A. McCann-Brown, Allison Sieving, Brett Bell, Seth Kreger, Nan Zhou, Andrew Brightman, Ann Rundell and Sherry Voytik-Harbin (Purdue University)

The undergraduate curriculum in biomedical engineering at Purdue University allows students to practice design and teamwork skills each semester, culminating in the capstone design experience in the senior year. The capstone course is a unique opportunity for students to experience real-world projects and for instructors to carry out assessment and mentoring practices that prepare students for professional practice. Our approach is unique, in that assessment and mentoring are directly related to one another. Assessment is built into the course through measurement of student performance using detailed rubrics. Mentoring occurs in many formats: detailed critiques of student work, formal team or one-on-one conversations, informal conversations at workstations, etc. We have found these practices essential to the transformation of students to practicing engineers; without them, many students would not have made the transformation. Ultimately, the course is time intensive for both students and instructors, but the processes we employ provide experience in a real-world industrial design process as a means to complete the students' professional training and allows for mentoring which impacts and assesses students in a way that no other courses currently include. The details presented in this paper might easily be incorporated into other design courses as a means to enhance learning and the design experience.

#11827: Biomedical Engineering Design and the Development of High-Value Relationships with Clinical Medicine

Robert Hitchcock and Kelly Broadhead (University of Utah)

The Department of Bioengineering at the University of Utah embraces its interaction with both the University Hospital and the local medical device industry as one of its core values. Central to this interaction with both industry and clinical medicine is student training in Biomedical Engineering Design. In order to foster a richer environment for innovation and to better instruct students in the art of gathering user requirements, we have recently redeveloped our two-semester undergraduate Biomedical Engineering Design course by partnering student teams with design ideas that have been conceptualized by physician partners (clinical champions). The clinical champions are typically physicians who have conceptualized an idea for consideration by the faculty and student design teams. Another key feature of the capstone projects is the use of standard operating procedures (SOPs) that were developed for the relevant areas of the design process. By establishing our own internal procedures for this course, we mirror the approach that is taken by industry, thereby exposing our students to current best practices. In addition, the SOPs provide all student design teams with a common interpretation of design control as contained in the Code of Federal Regulations. This paper will describe the Bioengineering Design Collaboration Program as a model partnership between those in clinical medicine who have the expertise to identify problems and students who possess the initiative, technical skills and resources to convert the ideas into their physical form while adhering to Design Control mandates. The paper will also present the key features of the class structure that provide a common framework for the collaborative design as well as downstream receptors for the ideas including senior design projects, business plan and innovation competitions and technology commercialization.

#11843: Improving a Capstone Design Course through Blended Learning

Marjan Eggermont and Robert Brennan (University of Calgary)

The CEAB (Canadian equivalent of ABET) requirements for a Capstone design course are as follows:

> "Engineering design integrates mathematics, basic sciences, engineering sciences and complementary studies in developing elements, systems and processes to meet specific needs. It is a creative, iterative and often open-ended process subject to constraints that may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may relate to economic, health, safety, environmental, social or other pertinent multidisciplinary factors.
>
> The engineering curriculum must culminate in a significant design experience which is based on the knowledge and skills acquired in earlier course work and which preferably gives students an exposure to the concepts of team work and project management."
>
> Canadian Engineering Accreditation Board
> Accreditation Criteria and Procedures

Our full-year capstone design course, "Mechanical and Manufacturing Engineering Design Methodology and Application" focuses on both design methodology and design application. The largest aspect of the course is design application, where the design methodology is applied to a team-based, open-ended project. However, our experience has been that students often become so deeply involved in their projects that they fail to see "the forest for the trees". More specifically, they often fail to see how the design process applies to their project and potentially miss the methodology message of the course.

A key redesign issue was to determine how to more effectively prepare students for the "application" aspect of the course. In particular, it was important that students were provided with a more meaningful presentation of the design process before they embarked on their major project than could be obtained from lectures and tutorials alone.

The approach was essentially a short inquiry-based learning exercise that was augmented by web-based teaching modules. The idea was to provide student teams with a very compressed version of their course project at the beginning of the term, before they had any pre-conceived notions about the design process. This blended learning approach gave the students an immediate sense of team dynamics and project management skills necessary to complete this short exercise (and their year-long project). This open-ended design problem combined with new software, in-class peer critiques, on-line submissions, and discussions, forced students to be innovative and to work together to get the project done in the two weeks allotted.

This paper discusses the design of this short inquiry-based blended learning design project. It discusses results of a pilot project, which ran in our first year design course, and the results of the first capstone iteration of this project. Finally there will be a discussion of an e-learning engineering design portal, which houses many projects such as the one described above.

#11845: Using Advisory Boards in the Capstone Design Process

Lizette R. Chevalier, J.Kent Hsiao and William Eichfeld
(Southern Illinois University Carbondale)

The Capstone Design Course has been developed in recent years through the active participation of the Department's Professional Advisory Board. This paper presents how the course evolved, the assessment tools for continued improvement, the relationship of the course to ABET's "a-k" and program criteria, and plans for future work. Included are the results of surveys as well as a description of the senior design projects.

At one time, the Department's capstone design course assigned civil and environmental engineering students to projects involving students from other engineering departments. The assessment data showed that this was not helping students prepare very well for careers in their profession. The course was modified to involve small groups of only civil and environmental engineering students working together on different small projects. The assessment of this method showed improvement but room for much more improvement. The Advisory Board suggested that larger groups of students work together in teams on larger projects and that all teams work on the same project to create a situation similar to several firms responding to a proposal.

In addition to providing understanding of the basic concepts of planning and design of engineering projects to the students, the main objective of a capstone design project is to encourage students to develop their coordination and collaboration skills working in teams and in various engineering disciplines.

#11846: Toward a Common Standard Rubric for Evaluating Capstone Design Projects

Anthony Marchese, John Abraham, Christopher Greene, Elizabeth Kizenwether, John Ochs (Rowan University, University of St. Thomas, Penn State, Lehigh University)

Although the need for a quality capstone design experience is universally recognized by engineering educators, ABET, industry and the professional societies, there is a surprising lack of consensus on what actually constitutes a quality capstone design experience as well as the deliverables and documentation that should serve as evidence of a quality design experience. Indeed, the standards for evaluating the quality of a capstone design project are typically developed in-house (e.g. at a department or college level) and, as a consequence, are most likely governed more by the institutional realities of faculty expertise, available resources, funding and the total number of students simultaneously engaged than by any national norm or rubric. The goal of this workshop is to begin the steps necessary to develop a common standard rubric for evaluating capstone design projects. A panel of faculty members from a broad cross section of institutions (Doctoral, Comprehensive Masters and Liberal Arts) presents the current status of capstone design at their universities. Their brief presentations highlight the common elements among these seemingly very different institutions, as well as the differences in terms of resources and scale of their capstone design process. Next, the panelists describe an effort underway between their schools to begin to move toward a standard common rubric. Specifically, a new approach has been applied to obtain external, peer assessment of student work carried out in a senior-level engineering capstone course. This approach involves the review of student work by participating faculty at a variety of universities and evaluation of the work by means of a survey. In 2006, the University of St. Thomas, in cooperation with Rowan University and the Milwaukee School of Engineering (MSOE) completed a first phase of peer-to-peer assessment of final reports prepared by students during a capstone course that is taken by both mechanical and electrical engineering students. The preliminary feedback has already provided valuable information for modifying and substantially improving the course. In addition, the feedback clearly indicates a need for improving the peer-to-peer assessment process to account for differences in curriculum and resources between the participating universities. Streaming media platforms such as YouTube, with which most students are already conversant, provide a convenient enabling technology for peer-to-peer assessment.

#11865: The Role of Capstone Design in Technical Communications Instruction

Len Trombetta, Chad Wilson, Diana de la Rosa-Pohl, Paul Ruchhoeft and Fritz Claydon
(University of Houston)

The purpose of this report is to describe how the Department of Electrical and Computer Engineering (ECE) in the Cullen College of Engineering at the University of Houston uses their capstone design course, ECE 4334, to “cap” not only technical design skills, but also technical communications skills. We describe how technical communications skills are taught in capstone design as well as the approach to technical communications throughout the ECE curriculum in order to show how ECE 4334 acts as the culmination of students’ communications abilities. We then describe an assessment conducted in ECE 4334 to determine how students’ abilities change over the course of the semester as well as how their attitudes toward technical communications changes in the context of a project management course. The results indicate that students’ writing abilities and attitudes toward writing do improve over the course of the semester.

#11873: Community Projects for Capstone Design: Case Study

Robert Grisso, Saied Mostaghimi and Mary Leigh Wolfe (Virginia Tech)

Finding appropriate and challenging projects for Senior Capstone Design can be difficult. Our experience shows that student teams benefit greatly from working with “real world” projects. Projects that have open-ended design problems, coupled with the real constraints faced by the private sector create an ideal environment for completing the student’s undergraduate education. Often industrial projects have limited timeframes and the partnership is faced with proprietary information issues. Therefore, we have identified several community interest projects. Most of these projects focus on environmental issues, with particular emphasis on environmental issues and stormwater management.

Projects are solicited from faculty and other professionals who are actively engaged with community activities. Projects are matched with student teams of appropriate background and interests. Each design team has an academic advisor from the Biological Systems Engineering department and a second advisor from the community involved with the problem. These individuals provide advice and coaching to the team, but they are not expected to be the only technical authority or provide design concepts.

The objective of this paper is to show several cases from community projects that have been completed successfully for the capstone experience. These projects include designs to improve water quality and stormwater management in a residential community; design of a raingarden for homeowners; design of stormwater systems for municipal facilities; design of a waste system to decrease the nutrients in an existing international waste treatment facility; waste management from a public fishery and development of an environmental friendly biomass-to-ethanol plant. Student teams collected information on the design requirements including local/state regulations, economic constraints, as well as other site-specific constraints. The project solutions and recommendations were presented to the community and alternative implementation plans were described.

This paper will discuss the design process and the response of the community to the proposed designs. The advantages and disadvantages of these community projects will be compared and contrasted. The benefits from student learning and community education will be discussed.

#11876: Multidisciplinary Teaming through Student Design Competitions

Dan Dolan, Mike Batchelder and Jim McReynolds
(SD School of Mines and Technology)

> "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. Students are generally well prepared technically. Projects 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 a another project
- 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 seminary open to all team members provide topics on project management, scheduling, documentation, teamwork, conflict resolution, and setting priorities
- 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), 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.

#11880: Starting an Industry-Based Capstone Design Course

Joseph T Emanuel (Bradley University)

For a department to starting an industry-based capstone design course requires a significant commitment of resources. This paper presents answers to many questions that need to be answered before making such a commitment. The guidelines presented, based on 40 years of industry-based capstone experience can help departments avoid some of the problems.

#11884: Melting-Pot Senior Design at Oakland University

Michael Latcha, Debatosh Debnath, Imad Elhajj, Edward Gu and Richard Haskell
(Oakland University, American University of Beirut)

Over the past 3 years the School of Engineering and Computer Science (SECS) at Oakland University (OU) has developed a philosophical strategy with which to deliver a meaningful, truly multidisciplinary and comprehensive capstone design experience. This strategy, dubbed the "Melting-Pot" approach, brings together all senior students majoring in electrical, computer, systems and mechanical engineering as well as computer science and, after assignment into multidisciplinary design groups, charges them with either a common task or with the challenge to develop a meaningful project that might be successful in the global marketplace.

The essential features of the Melting-Pot approach to senior design are:

- Senior design teams are supervised by at least three professors from the Computer Science and Engineering, Electrical and Computer Engineering, Industrial and Systems Engineering, and Mechanical Engineering departments.
- Design teams are assigned considering only the engineering fields, experiences and special skills of the students.

- The design projects assigned have not been solved, or even explored in depth, by the instructors.
- Questions from students are seldom answered; they are always treated as opportunities for research.
- The design experience always ends with a public display and competition
- The experience includes a significant communication component (reports, presentations, posters).

The success of this approach to senior design has been well received by students, sponsors, industry partners and accreditation evaluators alike. As a result of the high quality of the projects developed in this experience, Oakland University has begun to fund the prototype development of the projects as part of OU's undergraduate research initiative. We have begun to partner with colleagues in the School of Business Administration to further develop the marketing aspects of the design projects and have recently been approached by outside companies to work on industrial projects.

In order to incorporate the feedback data obtained in our assessment process, the SECS core curriculum was recently revamped. One of the goals in changing the core curriculum was to correct deficiencies observed in student background and understanding in the senior design experience. As a result, a sophomore level design course has recently been instituted, incorporating many of the Melting-Pot principles. We anticipate that introducing students to meaningful and multidisciplinary research design experiences earlier in the curriculum will better prepare them for both the senior-level experience and professional practice, as well as positively contributing to retention.

This paper tracks the progress of the development of the Melting-Pot approach, documenting both mistakes and successes from its initial offering to the present. Specific assessment data will be shown along with the actions taken to incorporate the feedback and measure the improvements. Special attention is given to the development, assessment and improvement of the sophomore design experience.

#11888: Using Capstone Design Projects to Differentiate Engineering Programs

J. Ronald Bailey (University of Tennessee at Chattanooga)

Capstone design projects are used in many engineering education programs to give students near real world experience in design activities that culminate in production of a working prototype. These projects give students the opportunity to work in teams, develop project management skills, and handle time and budget constraints. As a minimum, capstone design projects give students an opportunity to practice what they have learned in theory. Capstone design projects can also be an effective way to demonstrate many of the educational outcomes necessary for continued accreditation. Beyond achieving minimum educational objectives, capstone design projects can be used to generate stronger corporate support and alumni relationships. Perhaps overlooked among the benefits of effective capstone design projects is the powerful impact that well executed and publicized capstone design projects can have on recruiting K-12 student to study engineering, and perhaps more importantly, to choose your school because of the differentiation that can be seen between your programs that emphasis capstone design versus those all of the other programs that can only offer the minimum classroom and laboratory experience required in order to award a degree from an accredited engineering program. This paper will share experiences gained from enhancing capstone design experiences at three universities, each with a different starting point. Results include discussion of a very successful Capstone Showcase that was organized along the lines of a trade show with more than 80 capstone design teams bringing their projects to an afternoon exhibit for corporate sponsors and supporters, followed by an open house the next morning attended by more than 700 high school students and their parents. Many of the graduating students made contact with potential employers during the corporate afternoon, and approximately 80% of the high school students attending the Capstone Showcase with their parents subsequently in the university, indicating the powerful recruiting influence that successful capstone projects can have when presented in a "marketing" format by the graduating students who are proud of their accomplishments and appreciative of the opportunity and support provided by the university. Furthermore, by placing links to the capstone design projects on the university website, high school students not able to attend the open house could view projects that back up the assertion that they will not only be able to study engineering but they also will be able to practice engineering if they choose to come to a university with a successful capstone design program.

#11890: Starting a Multidisciplinary Senior Capstone Design Course

Gary Spivey and Robert Harder (George Fox University)

In 2000, George Fox University expanded its engineering program from a 3/2 program to a complete four year engineering program providing a Bachelor of Science in Engineering with concentrations in both electrical and mechanical engineering. 2004 saw the first graduates from the program which became ABET accredited the following year.

Very early in the program development, it was decided that the senior capstone experience would be a multidisciplinary experience. The small class sizes (9-10 seniors in the first three years) also enabled the program to focus on a single project in the initial years and expanded to two projects to accommodate the 17 seniors in the 2006/2007 academic year.

While many senior capstone experiences are constructed to focus on the design experience, we decided to expand this focus. By their senior year, George Fox University engineering students have already experienced a number of significant design experiences. This wealth of prior design practice enables the program to use the capstone experience to help students transition from the mindset of a "student" to that of an engineer. This desire to imitate "real-life" engineering project experience drives the structure and pace of the capstone experience. Students tend to be surprised at all the "non-technical" issues that must be confronted and addressed.

The project progress is assessed throughout the two semesters and input is frequently provided by the faculty members and the representative from the industry sponsor. Both the complete team and individual students are assessed. This course serves as an excellent place to measure the overall learning and progress of the students as well as the success of the engineering program. Final oral presentations and demonstration of successful prototype functionality are given at the annual Design Project Day and at the client's industrial site.

In this paper we describe the methods used by the George Fox University engineering program to acquire and work with industry sponsors and define the scope of these projects. Additionally, we will describe the specifics of the student group formations and how students have, either effectively or ineffectively, participated in the multidisciplinary experience. We will use the specific examples from the delivered prototypes, using these elements to emphasize those efforts that have worked well and to indicate those areas that have been less successful.

#11893: Motivation, Inspiration and Economics of an International Service Project

Peter Johnson, Mark Budnik, Kathleen Sevener and Jeffrey Will (Valparaiso University)

In the Fall of 2005, a team of five engineering seniors selected a multidisciplinary senior project in which they were to design and build a power generation system for a small village on Ometepe Island in Lake Nicaragua, Nicaragua. The power generated was to be used for lights in a small clinic and a classroom, a refrigerator for vaccines, and an emergency radio for this remote village. The team successfully designed a working wind generation system, and they raised enough funding for four team members and their faculty advisor to travel to Nicaragua for installation.

Building on the lessons learned from this experience, course instructors offered a similar project the following year. In the Fall of 2006, senior design students were offered a follow-on, Nicaragua-based service project as an option. Six engineering seniors volunteered to take on this design problem. Their task was to design a sustainable power generation system for an orphanage that is located on the same island. The major difference with this second project is that the orphanage is located in an area on the island that is connected to a power grid supplied by power from four diesel generators. The power is intermittent (blackouts occur five to ten times a week, with each lasting from five minutes up to multiple hours) and expensive. As with the previous year, students were given the option of traveling to the island to implement their design; however, travel costs would once again need to be raised by the students themselves.

This paper discusses some of the pitfalls encountered by this second team of students. These include changing the direction of the project from the initial design based on wave energy, and the impact on student motivation when the benefits and costs of the project were analyzed from a purely economical standpoint. Our focus here is how the faculty guided the students through these problems. The paper will also address how projects can be affected by design choices from prior project groups. In this course, teams are required to create their own design solution. For this project, team members were encouraged to consult with the students from the prior project to avoid repeating mistakes made the previous year and to speed up the design due to time constraints. The results of this decision have implications for the types of projects offered in the future and serve as an example of how the flexible course structure can allow the faculty involved to adapt to unique project constraints without negatively impacting educational outcomes.

#11894: The Antarctic Undergraduate Telescope: An Invitation to a Multi-School Capstone Project

Patrick Little (Harvey Mudd College)

Engineering programs at many colleges and universities currently offer capstone experiences or courses. These cover a wide spectrum ranging from teacher designed and driven activities to externally generated and funded projects. The typical purpose of these courses is to give students the opportunity to learn and apply design skills, to exercise analytical techniques, and to develop project management and communication skills. The course often represents the students’ primary introduction into professional practice. Increasingly, the experience of engineering students upon graduation requires the ability to work in teams that are geographically disparate and culturally diverse. Even the most fully established and well run capstone programs find this a difficult challenge to address, since it requires larger projects and more partners than are typically available to them. To address this, we propose a partnership with a variety of schools to design, build, and participate in the operation of a 2-meter class astronomical telescope on the Antarctic Plateau. Prior projects in this area by Harvey Mudd College Clinic teams suggest that it is possible to build such a telescope, and have demonstrated that a significant share of the engineering design work could, under proper supervision, be completed by undergraduates.

The basic concept calls for a group of colleges and universities to allow one or more student teams in their capstone course to work on design or testing elements for the Antarctic Undergraduate Telescope (AUT). A central design clearinghouse will be needed to organize the particular projects, and each participating school will be responsible for providing appropriate faculty supervision of the students, in concert with experts from the astronomical and engineering communities. Each school will be reimbursed in accordance with their current capstone course policies, along with funds to cover AUT-specific overheads, such as travel to design meetings. As such, no school can expect a “windfall” from their participation, but their costs will be covered as for other projects.

A first step is to undertake a discussion with engineering faculty interested in exploring the concept, leading to a proposal to a funding source. This paper sets forth background information and proposes a basic structure for the AUT project, with the intention of providing a target for the participants in such a discussion.

#11901: Enhancing Capstone Design Courses Through Graduate Student Mentoring and Leadership Development

Edwin Odom (University of Idaho)

Graduate education is highly focused on the development of technical and analytical skills, but typically provides minimal experience in team formation and interpersonal growth. To assure a more balanced graduate school experience, Idaho Engineering Works (IEW) at the University of Idaho is formed of a diverse group of graduate students whose purpose is to develop an environment that fosters professional as well as technical excellence. This paper analyzes IEW actions taken each year to form a well-trained, collaborative, and highly-reflective cohort of graduate students that support design education. This team is developed through directed study courses, team projects, personal reflections and monumental technical and interpersonal challenges. Over the course of the last ten years, the IEW has been successful in delivering hardware that exceeds expectations of industry customers, shortening time frames required for large-scale design projects, enriching senior design mentoring, and expanding the number of members. Each academic year produces a unique engineering leadership experience that has lifetime impact for its members and a legacy of improved infrastructure for design education. In this paper, the teamwork model of Larson and LaFasto is used to reflect on the people, strategy, and operations that form the IEW. This analysis is useful in revealing why IEW has been successful and how it might evolve to become an even more formidable force for design education at the University of Idaho.

#11903: Capstone Team Dynamics

Stephen Zahos and Alan Hansen (University of Illinois at Urbana-Champaign)

I wish to propose the outline for topics of discussion during a panel and audience participation session related to Team Dynamics in capstone design courses. I am the Senior Capstone Design Instructor and Coordinator in the Agricultural and Biological Engineering Department at the

University of Illinois and have many years of industrial product design and business experience for entrepreneurial and traditional manufacturing and consulting companies, as well. I am offering to be the session moderator and panel member or panel member only if so desired by the organizing committee.

It is our experience that the understanding of the reasons behind and the utilization of team dynamics information is very important and that the capstone experience for the students and the results obtained for the project sponsors is maximized when the following elements of human teamwork are acknowledged and guided, rather than left to chance. It will be very instructional for attendees to be exposed to the treatment of the topics by panel members and to freely offer their comments, suggestions and ideas to the panel and other attendees. The discussion should be revealing and refreshing to all participants and lead to better preparation of the students as they enter their chosen fields. The discussion should also lead to providing practical ways for attendees to adopt techniques appropriate to their philosophy and academic mission.

Some topics for discussion include:

- Student preparation for the capstone experience:
    - Teamwork in other courses and professional workplace experiences
    - Curriculum prerequisite courses and class level standing
    - Breadth of curricula represented on teams
- Personality profiling
    - What is done, when and what is used
    - Prediction of team member / whole team moods and attitudes
- Team building exercises
    - What is used, and why
- Team formation
    - What techniques are used to decide team makeup
    - How is team leadership determined
    - How is project division of labor determined
- Measures of performance
    - Peer evaluation techniques
    - Sponsoring organization evaluation techniques
    - Faculty and observers evaluation techniques
    - Expected outcomes, their forms and how evaluated
- Team guidance
    - The role of the instructor in the course and the relationship to the teams
    - The qualifications and traits of the instructor
    - Frequency of meetings between team members and between teams/instructor
- The meeting experience and format
    - Styles of meeting /class settings
    - Styles of how meetings are conducted: as a classroom, a professional workplace or other variations.

I envision the format being a fairly traditional one of having a maximum of 5 panel members representing a mix of organization type and size, giving brief opening remarks about any or all of the above topics, utilizing visual media such as PowerPoint presentations as desired. The floor would then be opened for questions and additional comments and experiences from any participants in attendance. Participation on some level by some students who have gone through capstone programs would be beneficial.

#11908: Evolution of Bioengineering Capstone Design at Arizona State University

Vincent Pizziconi, Jeffrey LaBelle and Eric Guilbeau (Arizona State University)

Biomedical engineering capstone design at ASU was created at the inception of our undergraduate bioengineering program over two decades ago. Since then, biomedical engineering capstone design has evolved over the last 25 years to meet our changing constituent needs, i.e., ABET and the bioindustry. Currently, we offer a year long, two-semester BME 417 / BME 490 capstone design sequence which is specifically tailored to the design and development of medical devices. The two-semester capstone design sequence offers BME seniors in good standing the opportunity to carry out a full-fledged medical device product design and development effort using best industry practices intended to meet, if not exceed, ABET 2000 capstone design guidelines. The expansion of capstone design into a year long, two-sequence, major design experience has markedly improved the student's design education but, due to burgeoning enrollments in our undergraduate program over the last decade, it continues to severely tax both the department, college and university resources available for this use.

In order to meet the demands for a high quality design experience for our undergraduate bioengineering program, we have recently opened the first phase of a fully dedicated bioengineering design education facility at ASU. The second phase of this unique design studio facility is scheduled to open in the Fall, 2007. The design studio is configured to house the necessary infrastructure and personnel to allow our capstone design students (individually or in teams, and as a class) to simultaneously carry out the full spectrum of real world medical device product development activities. This includes all design process activities starting with the initial product planning and concept stages to the fully working, prototypical medical device product verification and validation stage. We believe that by providing an environment where all of the necessary product development process steps can be virtually accomplished under 'one roof', i.e., all within the design studio complex and without having to rely on shared resources where access and logistics are oftentimes problematic, the quality of design instruction will be significantly increased as will the likelihood of success by our BME graduates in the bioindustry workforce and other career options. We believe that, once fully implemented and after anticipated refinements, it will serve as a capstone design model for programs nationally.

#11910: Integrating External, Client-Based Engineering Senior Design Projects into a Capstone Class

Linda Riley (Roger Williams University)

One of the most challenging aspects of coordinating an engineering capstone class is assuring that course learning objectives are met. Regardless of the type of senior design project undertaken in the class, whether competition, service, or client-based, each choice presents certain challenges. However, the most difficult scenario occurs when truly open-ended, client-supported projects are integrated into the curriculum. Having taught the engineering senior design class in a multidisciplinary context for the past ten years using several different project approaches, I find the one consistent unknown from semester to semester remains the quality of the client student interaction in externally-based, client-supported design experiences.

Therefore, this article discusses the value associated with, as well as the challenges in integrating external client projects into the engineering senior design curriculum. Several methods for 1) identifying external projects, 2) qualifying projects, 3) defining client roles and responsibilities, 4) assessing the experience from both the client and student perspective, and 5) communicating successful results will be presented. In addition, several strategies for maximizing the students' experiences in these partnerships are included in the article.

#11913: Institutionalizing a Capstone Program - The Devil's in the Details

Harry Wildblood (University of Illinois, Urbana-Champaign)

The successful institutionalization of the capstone engineering design course in the Department of Industrial and Enterprise Systems Engineering (IESE) (formerly known as the Department of General Engineering) at the University of Illinois, Urbana-Champaign has been a process of analyzing all aspects of the program such that it can run efficiently and almost autonomously within the Department. This requires that all Department resources are used effectively and impact on other Department functions is minimal.

This capstone program has evolved over a forty year period into course which annually does forty or more industrially sponsored semester-projects, each of which has a three-student team and is advised by a faculty advisor. The course goal is to prepare students to work successfully in a commercial engineering environment. Projects are therefore scoped to be identical to those encountered by an entry level engineer in industry. Each project has a specific scope of work to be accomplished and a set of deliverables which include the problem solution, specific recommendations, and a supporting economic analysis, typically showing a two-year payback or better. The student teams make several trips to the industry sponsor, meet semiweekly with their faculty advisor, and maintain weekly communication with their sponsor contacts. Many presentations and reports are given throughout the semester, including the final presentation to the sponsors and the final report. Because of the extensive nature of the program, involving all faculty, dozens of sponsoring companies, all senior undergraduates, several lab facilities, equipment purchases, travel, etc., the potential for chaos is great. Also, because projects vary greatly from semester to semester with respect to equipment needs, software requirements, lab space, safety, intellectual property, etc., the management and operation of the program must be highly responsive to issues that will arise. This responsiveness is based on (1) analysis and review of all known aspects of the course, (2) establishing procedures and policies for these areas, (3) effectively interfacing with company sponsors, faculty, other departments and university administration, and (4) a program administrator who can communicate externally with sponsoring companies, as well as internally with faculty, staff, students, and university administration. Specific areas addressed are program marketing and solicitation of projects, self-funding of the program, creating a sustained marketing effort, scoping of reasonable projects, interfacing with industry sponsors, data management, program staffing requirements, working with faculty, establishing project standards, selection and management of equipment, labs and software, reasonable and effective prototyping procedures, safety guidelines, dealing with intellectual property and non-disclosure issues, requirements for economic analysis, presentation standards, report formats and standards, managing sponsor expectations, meeting ABET requirements, and capstone program recognition. All of the above items, when managed appropriately, serve to create a effective, self-funded, and highly accepted capstone program which is seen as a benefit to the engineering department and curriculum.

#11917: The Move to Industry Sponsored Capstone Design Projects - Why and How

Jack Zable (University of Colorado)

The Mechanical Engineering Department at the University of Colorado at Boulder (CU) decided to change its two course capstone design sequence in such a manner that the design projects were almost entirely comprised of industry sponsored projects. This was initiated after the completion of a small study comparing three projects from industry with three student selected projects. Some of the results of these comparisons are given in this paper. The implementation of a new industry sponsored capstone design program is also highlighted, along with the myriad of barriers that had to be overcome. At the time of the comparison, 1999, student teams in the capstone or senior design course were formed, more or less, on a friendship basis, with each team working on a project of their choice. Many of the projects selected by the student teams dealt with sports equipment, and other devices with which the students had some familiarity and interest. It was felt that these projects had limited value with respect to what students might ultimately undertake in most industry environments. One goal for a capstone design course is to better prepare students to enable them to succeed in their future careers. Thus, an industry based experience seemed to be more appropriate. Additionally, the primary driver for the student teams to excel in a self-selected projects environment was their grade for the course. For the most part, there was no receiver for their completed design and hardware, and as such the results of their efforts were eventually discarded. Coincidently, at this point in time ABET requirements were being modified to put a much greater emphasis on the educational role of the capstone design course sequence.

#11918: Improving the Results of a Capstone Design Program - A Continuous Process

Jack Zable (University of Colorado)

In the Fall of 2000, the Department of Mechanical Engineering at the University of Colorado (CU) initiated a change to their capstone design program whereby the great majority of the projects would be sponsored by industry and government labs. A center was formed, called the Industry/University Cooperative Projects Center (I/UCPC), to obtain, oversee, and administer these projects. As mentioned in a sister paper entitled ‘The Move to Industry Sponsored Capstone Design Projects – Why and How’, a fair amount of success was obtained after the first year, Fall 2000- Spring 2001, of the program. However, there were areas of deficiency that needed to be improved upon. These problems occurred as a direct result of switching to capstone design projects that were predominantly industry sponsored. Some of these problem areas included; underestimating the teaching workload for the capstone design faculty in this new environment of industry sponsored projects, team sizes being too small, a small but vocal minority of students strongly desiring to design and develop their own products, having very limited interdisciplinary participation, and receiving pressure from industry to further improve the intellectual property agreements. Continuous improvements to these particular deficiencies as well as other new problems that have occurred over the past six years are described in this paper.

#12001: Product Design for Industry: The NUS Experience

Jerry Y H Fuh, Seh Chun Lim, Li Lu and C. Quan (National University of Singapore)

The Department of Mechanical Engineering (ME) at the National University of Singapore (NUS) has evolved a curriculum where design is integrated vertically in its undergraduate program. The goals and objectives of the design-centric curriculum are to expose students to the total design process early in their programs of study, and reinforce design problem solving skills at every stage. In this paper, the rationale for moving into a design-centric curriculum for the NUS’s ME Program will first be presented. Details of the Industry-sponsored Design Project Program will then be described, including the methodology of project solicitation, how to resolve related Intellectual Property issues with industry sponsors, the allocation of projects to students and the method of assessment adopted. The desired educational outcome for this Program will be presented. Some thoughts and experience on how this Program could be improved for subsequent batches of NUS ME students will also be shared.

#12002: Successful Capstone Course Model for Industry-Academic Partnerships

Jeffrey Ray (Grand Valley State University)

Engineering education has evolved over the past years, due in large part to the ABET EC2000 criteria, to include a culminating experience for students. The number of engineering programs utilizing industry funded projects for capstone courses has been on the increase over the past ten years. Integrating industry partners into the capstone experience has proven to have many benefits for all constituents involved. The downside observed is the significant time commitment to establish and maintain industry partnerships for successful projects. However, the development of industry partners is one of the most critical phases in securing appropriate projects. Communicating the expectations of the program is essential to having dedicated industry partners and successful projects. Working together with industry partners allows several iterations in the project definition to occur prior to students being assigned to student teams. The capstone model implemented has resulted in over 80 projects being successfully completed for regional industries over the past ten years. The equipment and materials costs for these projects have exceeded $1 million dollars in the same time.

This paper presents the model used to develop and maintain industry partnerships, securing appropriate industry projects, process of assigning projects to student teams, involvement of engineering faculty and industry mentors, and final deliverables. Also, a discussion of the benefits of the model implemented and feedback from industry partners and students over the past 10 years is included.

#12008: Redesign of the Senior Capstone Design Experience: A Flexible Model for Continuous Improvement

James Widmann and Joseph Mello (California Polytechnic State University,
San Luis Obispo)

In the 2005-2006 academic year, the Mechanical Engineering Department at California Polytechnic State University, San Luis Obispo initiated a redesigned capstone experience to serve an average of 180+ graduates each year who solve 70+ different “externally” supplied problems with functioning hardware. Prior to that time, the department required two separate senior design experiences. The first was an industry sponsored design class that lasted one quarter and resulted in a “paper” design solution to the given problem. The second experience involved an individual student initiated project that required a design, build and test regimen that nominally lasted two quarters. In an effort to improve graduation rates and student learning, to address ABET review concerns and to reduce faculty workload, these experiences were combined into a single project-based, team learning experience. Results from the first year indicate an approximate doubling of project completion rates and a significant decrease in faculty workload with no sacrifice of student learning or project quality. A major requirement of the course redesign was to incorporate sufficient flexibility for modification and continuous improvement. This paper describes the course structure, the student learning objectives, the attainment and organization of the externally sponsored projects, the organization of the involved instructors and the assessment of student learning and performance. Also described is how the flexible course structure allows the incorporation of multidisciplinary, service, sustainable, entrepreneurial, global and undergraduate research based design projects. Recommendations and requirements for implementing this type of program as well as plans for future improvement and expansion to include the entire college of engineering are given.

#12009: Mandatory and Desirable Elements of a Capstone Design Course

Roger Seals, Chester G. Wilmot and Miles B. Williams (Louisiana State University, Sigma Consulting Group)

The Civil Engineering program at Louisiana State University (LSU) allows students to select one of several capstone design courses to satisfy the requirement of a Project Elective in the curriculum. However, since the courses are taught by different faculty members, they can result in an uneven and inconsistent design experience. Finding it difficult to agree upon a reasonably consistent format and set of course elements, the Department of Civil and Environmental Engineering at LSU turned to its Civil Engineering Professional Advisory Committee (CEPAC) for help. Beginning with a set of suggested desirable course elements generated by a departmental faculty member and reviewed by the members of the committee, CEPAC was asked to rank the relative desirability of the listed elements on a five-point scale of desirability. The survey was subsequently extended to the Civil Engineering faculty at LSU; faculty at other universities in Louisiana and Southeastern Conference (SEC) institutions; practicing engineers in the public and private sectors; and students enrolled in the capstone design course at LSU. The results of the survey indicated that there was general agreement about the most important features. Specifically that the design experience be based on realistic conditions; that the students schedule the design activities; and that the products of the design include drawn plans, a written report, and an oral presentation. The least important factors were team size, the necessity to log activities, and the peer evaluation of performance. However, differences were evident among groups based on their individual perspectives.

#12023: Critical Issues Associated With an Industrially Supported Capstone Design Program

Thomas Barber (University of Connecticut)

Senior level capstone design courses are run in many different ways in the academic community. A growing number of institutions strive to promote immersion into the real world of engineering through industrially sponsored projects. While this approach offers many immediate benefits to near-graduating seniors, it introduces many unique problems to the academic community. Developing and sustaining an industrially-sponsored capstone design program requires an understanding of the synergies and differences between academia and industry. Key issues that are addressed in this paper are why a company would sponsor such a program, how does industry allocate funds to sponsor such a program and what level of involvement is required to make a successful project and what are the legal implications of sponsoring a meaningful project.

#12179: Undergraduate Research Opportunities in Senior Design

Katherine Kuder and Nirmala Gnanapragasam (Seattle University)

Senior design projects are typically consultant-based programs in which students interact with members of industry to complete a design project. Students benefit from a hands-on learning experience with a technical project, including analytical work, project management, and technical communication. However, another possibility is to have experimental, research-based projects sponsored by industry that expose students to academic research. These projects include analytical work, project management and technical communication, but also incorporate problem-based learning in which the students design and conduct experiments and analyze research data. At Seattle University, we have found that experimental, research-based design projects can be successfully incorporated into the civil and environmental engineering senior design capstone experience and that the students, faculty, and industry sponsors benefit from this approach. In this paper, we will present three experimental, research-based senior design projects that were coordinated and advised at Seattle University. Details will be provided about how the projects were attained, the scope of the work, the final outcomes, and the overall response of students, faculty, and industry sponsors.

#12181: Interdisciplinary Capstone Design at the University of Houston

Richard Bannerot, Ross Kastor and Paul Ruchhoeft (University of Houston)

In this paper we identify some of the issues and problems that we confronted while developing a new, one-semester, interdepartmental, multidisciplinary capstone design course. We implemented the following changes to the pre-existing capstone design course:

- utilized a website to enhance information transfer
- modularized the course and replaced lecturing with facilitating,
- introduced a studio/critique teaching format,
- integrated communications professionals into the teaching of the course, and
- allowed the students to be involved in establishing the final expectations for their project.

The details of the implementation process, the effects of the changes, and the students' responses are discussed.

#12183: Environmental Engineering Service Learning Projects for Developing Communities

Angela Bielefeldt (University of Colorado)

The senior-level Environmental Engineering Design course has evolved since 1998 to include service learning projects. These projects have been conducted for the University, in association with a local non-profit group (iCAST), in association with Engineers Without Borders (EWB), and through other contacts. Students enrolled in the course are earning a Bachelor's degree in Environmental or Civil Engineering, or a Master's degree in the environmental emphasis of Civil Engineering. An evaluation survey was first developed in 2002 and has since evolved. It currently includes 27 questions that students respond to on a Likert scale from 1 to 5, mostly focused on the abilities that the course imparts relative to the ABET A to K criteria and the four additional learning outcomes from the American Society of Civil Engineers' Body of Knowledge. There are also questions related to the students' perceived differences in various project types. In Fall 2006 this survey was administered for the first time in the Civil Engineering capstone projects course, where students worked on a single non-service learning project. In Fall 2006, the students in the Environmental Design course with service learning projects reported significantly greater improvements in abilities to design based on economic, environmental, social, sustainability, and health and safety constraints; oral communication skills; and the awareness of engineering impacts in a global and societal context, compared to the Civil Engineering course. All respondents in the Environmental design course agreed that "service learning projects are appropriate to include" in the design course; by comparison, only half the students in the Civil engineering design course agreed. The broader benefits of service learning projects are also evidenced in student essays on their design experience. Thus it is concluded that service learning projects provide more emphasis on non-technical aspects of importance in engineering design and a richer learning experience than projects based on real world needs that are executed solely for the educational benefit of the students.

#12184: Capstone Design and Rehabilitation Engineering: A Great Team

Don Dekker, Stephen Sundarrao and Rajiv Dubey (University of South Florida)

The Capstone Design course at the University of South Florida (USF) has evolved over the past several years into nearly an ideal course arrangement that increases students' practical design experiences, cultivates teamwork skills, and benefits the community. Students design and build a prototype that will in some way help individuals with disabilities. The course, based on a 15-week semester, gives the students opportunities to work on 'real-world' problems in a structured amount of time. The time constraints imposed on the students mimic the deadlines that many industries must meet.

Project ideas for the Capstone Design Course come from many sources. The ASME Design Challenge, NASA, local start-up companies, industries, and students who identify specific needs of disabled family members or friends are some of the sources for projects. The majority of the projects for this course are provided by the Rehabilitation Engineering and Technology Program, which is based at USF. This Program, the only one of its kind in the United States, is funded by the state of Florida. It is unique in that it integrates potential services for disabled individuals with education, research and development. Seven field engineers and six technicians travel throughout Florida to identify barriers of accessibility for individuals with disabilities. The barriers that do not have commercial solutions in existence are then referred to the Capstone Design course as projects for the students to select. These projects, which range from devices for personal hygiene, wheelchair mobility, driving adaptations, recreation, or sports, provide mechanical engineering students with a variety of problem-solving situations, and potential solutions for helping disabled individuals improve the quality of their lives.

The student design teams 1) select a project, 2) clarify goals, 3) develop different conceptual designs, 4) formulate the embodiment design, and 5) finalize the detail design. These are the essential steps in the design process as described by Hales and Gooch in their book "Managing Engineering Design." During each of these steps, the teams meet with the instructors, and both the results and the team processes are discussed.

The detail designs are drawn on Pro-Engineer or a similar CAD program, and then are given to USF's engineering shop for the necessary parts to be made. Both the faculty and shop personnel collaborate on the manufacturability of the detail designs with the design teams. Once the shop produces the parts, the student teams assemble them into prototypes. The Rehabilitation Engineering and Technology Program provides the funding to order the parts and materials necessary to construct the prototypes.

During this course, the student design teams must work effectively to achieve their goals. To this end, two personality tests, the Myers-Briggs Type Indicator and the Herrmann Brain Dominance Instrument, are given to the students. The results of these tests help the students understand their team's personality characteristics, creative abilities, management strengths and weaknesses, and their ability to work as team members. In addition, they are introduced to engineering ethics, the patenting process, and small business education.

The USF Capstone Design course and The Rehabilitation Engineering and Technology Program combine to make it possible for USF students to experience a complete design process that culminates with a professional presentation, a final written report, and, most importantly, a working prototype. The students derive a great deal of satisfaction working on these rehabilitation projects and the recipients of the prototypes are excited and grateful. There is a synergy between the rehabilitation projects and the students that exceeds normal expectations.

#12187: Evaluating the Capstone Experience from the Professional Practice Perspective

Debra Larson, Paul Gremillion, Paul Trotta and Tom Loomis (Northern Arizona University, Maricopa County Flood Control District)

In the Department of Civil and Environmental Engineering at Northern Arizona University, we work closely with our Departmental Advisory Committee (DAC) to assure our curriculum is relevant to current engineering practice. The DAC consists of professional engineers primarily from the Arizona engineering community. In January 2005, the DAC set out to develop a capstone evaluation tool for their use in evaluating the final presentations of the year-long capstone design projects of our senior engineering students as a measure of learning outcomes. The tool, however, goes far beyond evaluating outcomes. It also serves to inform the faculty and students about what skills and attributes are important to our constituency as represented by the DAC, to enhance the overall performance of our seniors with their design project, and to further engage our DAC with the Department.

#12188: Challenges to the Development of a "Real-World" Experience for the Engineering Senior – A Conflict with the Consulting Engineering Community?

David Munoz, Doug Sutton, Cathy Skokan, Richard Burczyk, Melvin Capehart, John Gormley and Julie Van Laanen (Colorado School of Mines)

The Interdisciplinary Capstone Design Program in the Engineering Division at Colorado School of Mines encompasses a two-semester course sequence; with an annual average enrollment of 225 students working on 45-50 externally sponsored projects per year guided by a faculty team of eight members.

The major objective of the first semester is the preparation of a formal design proposal. During the second semester, students generally implement their design through the construction of a working prototype or prepare a design/build level bid package for the project that was designed during the first semester.

Project clients range from individuals to large corporations. Most of the corporate clients are interested in hiring our graduates. Many of these are companies that bring significant industrial problems with financial returns, or very difficult or complex problems that they have considered for several years without finding a cost effective solution. Most of these projects also come with expenses for travel and consumables for prototype or model development. Students can also work on inter-collegiate design competitions such as the Hybrid Electric Vehicle Challenge, Mini-Baja, Formula SAE or Clean Snowmobile Challenge, sponsored by the Society of Automotive Engineers, or the Steel Bridge and Concrete Canoe competitions, sponsored by the American Society of Civil Engineers, to meet the senior design requirements.

The funding sources used to cover the costs of these Senior Design project expenses include discretionary and directed gifts from corporations that hire our graduates, endowment funds from alumni, research contract support, and more recently a pre-determined and agreed upon project specific fee for a specific client-based project, payable even if the project is not completed.

Some of these project design activities have been criticized in the past by local consulting engineers as providing unfair competition in their realm of business. The area of major concern appears to be the perceptions that work done by students for no or reduced fee will take business away that could otherwise be done by professional consultants. Some cite an ethical canon, such as the second fundamental canon of the American Society of Mechanical Engineers Code of Ethics, "Engineers shall perform services only in the areas of their competence; they shall build their professional reputation on the merit of their services and *shall not compete unfairly with others.*" Closely associated with this issue is a concern of student project oversight by supervisors with professional engineer's licenses.

This paper will focus on the verbal response of engineers within the professional community to document these and perhaps other concerns. Through this paper, we hope to identify the breadth of these concerns and find a reasonable balance for these varied requirements, in addition to investigating potential ramifications for the faculty serving as advisers to student teams.

#12189: A Comparison of Capstone Design Course Choices for Undergraduate Industrial Engineering Students: Requirements and Advantages of the Integrated Product and Process Design Program Versus Senior Design Project

R. Keith Stanfill and Rudolph Santacroce (University of Florida)

Currently all national ABET accredited colleges and universities require their undergraduate students to pass a capstone design course prior to graduation. These courses are as different as the universities that offer them but all focus on some common goals: to provide engineering undergraduate students with real-world project experience while honing their communication, teamworking, leadership, and management skills.

Students enrolled in some colleges may be faced with an intriguing decision: enroll in a one-semester, single-discipline course, or opt for a one to two semester multidisciplinary capstone course. To evaluate this decision, the following approaches to fulfilling the capstone requirement for industrial engineering students are examined: a two-semester Integrated Product and Process Design program (IPPD) using a multidisciplinary-engineering team and a one-semester single discipline Senior Design Project. Common elements shared by these courses include teamwork, time management, innovative design, and project reporting. These two courses offer a number of individual advantages that students and faculty should consider. This paper may be used to inform students of each courses' aspects and advantages in order to make an informed decision on which would best benefit the student's academic and future career-related needs.

#12191: Globalization: The New Frontier for Capstone Programs

Gregg Warnick, Spencer Magleby and Robert Todd (Brigham Young University)

The world we live in is constantly changing. Engineers must not only understand the fundamentals of math, science and engineering, but must also be prepared to work within a global environment. Engineers within industry commonly work in multi-national corporations or are involved in work that requires communication and collaboration across international boundaries. A former president of the American Society for Engineering Education (ASEE) indicated that there needs to be a "major revolution in engineering education. We must internationalize our curriculum; to include ….intercultural interaction….We must mold our students to be entrepreneurs, and spirited international adventures as well" (Abata, 2004).

Over the last twenty years, capstone programs have become widespread as major contributors to better prepare engineering students for their leadership roles in industry (Todd et al, 1994). We need to ask ourselves, how can capstone programs contribute to the new frontier of globalization needed in engineering education? What can we learn from other globalization efforts for engineering students that will help us modify capstone courses to better prepare students for leadership roles in a globalized product and process development world? .

This paper will explore: (1) several learning activities currently pursued by engineering programs throughout the country aimed at preparing students for globalization, (2) a sampling of globalization activities currently occurring in some capstone programs in the United States, (3) a summary of the experiences that Brigham Young University is pursuing to provide international opportunities for engineering and technology students, and (4) potential models for globalizing capstone programs including strengths and weaknesses of each model along with a description of some of the challenges and resource requirements involved

The authors anticipate that the ideas and models presented in this paper will generate additional ideas and thoughts that will foster collaboration for finding ways to enhance the contribution of capstone courses in preparing students to be leaders in globalization and not victims of it.

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#12215: Individual Capstone Design Projects in the Multidisciplinary Fields of Microelectronic Engineering MEMs and Nanotechnology

Santosh Kurinec, Michael Jackson, Sean Rommel, Karl Hirschman and Lynn Fuller
(Rochester Institute of Technology)

The capstone senior design projects in the BS curriculum in Microelectronic Engineering at Rochester Institute of Technology consist of individual projects since the inception of the program twenty five years ago in 1982. This model has served the students and the program extremely well as the senior projects have resulted in continuous laboratory development while proving a powerful tool for program outcome assessment. Each year the projects become more advanced and challenging. During the early years the capstone project course was a one four credit course. As the semiconductor process technology became more advanced, the capstone experience was spread over two academic quarters consisting of two courses - Senior Design Project I and II. During the Senior Design Project I, each student develops and defends a proposal describing project goals, a detailed research plan with experimental design, a time table, and resources needed, and anticipated results. The students are also required to address ethical and societal impact of their project work. Typically the topics have included integrated circuit devices and components, process developments for advanced structures, MEMs, sensors, micro/nanolithography, plasma deposition and etching, and PVD or CVD processes. In addition, projects include simulations, modeling, test and characterizations. Even though projects are individual, students work with *self assembled* teams of faculty, engineers, technicians, graduate and undergraduate students and sometimes industry personnel.

ABSTRACTS: WORKSHOPS

WORKSHOP #1

#11001: Developing Long-Term External Sponsor Relationships

Paul Jones (Corporate and University Relations Group)

This workshop is intended to assist administrators and faculty members from schools who are seeking to establish sustainable industrially-sponsored capstone programs or who wish to increase the institutional strength of existing programs. The primary focus will be how to identify and attract appropriate sponsors, how to increase the breadth of sponsored programs across departments and programs, and how to extend the relationships beyond "single-champion" activities. Particular attention will be given to how to establish a pilot program which does not initially conflict with the existing educational programs. Based on experiences with a variety of schools and sponsors, the workshop presenters will cover the following topics:

- Identifying key assets needed for external programs
  - Faculty
  - Administrators
  - Development and support staff
  - Career center/placement staff
  - Potential sponsors
  - Alumni
- Financial resources for a successful program
  - Understanding long term financial relationships
  - Linkages sought by sponsors (research, education, hiring, diversity)
- Establishing a pilot program
  - Setting goals and intentions of the program
  - Staging the pilot program
  - Relationship with current activities
  - Evolving and expanding programs
- Moving from donor relationships to partner relationships with sponsors
  - Understanding sponsor intentions
  - Balancing sponsor needs with educational needs
  - Expanding the relationship beyond individual projects

The intended audience for this workshop is conference attendees from schools in the early stages of developing relationships with external sponsors (including those who have little of no previous experience), and those who are actively considering how to move programs based in a single department or with an individual "champion" onto surer institutional footing.

WORKSHOP #2

#11002: Coaching Student Teams

Annie Virkus (Rensselaer Polytechnic Institute)

How can you make a good team great? What tools can assist a dysfunctional team? We all are aware that team dynamics can make or break a capstone project. Based on successful models of team development and interpersonal communication, participants will receive practical strategies and techniques for effective coaching and team success.

Through application of Dr. Bruce Tuckman's Stages for Team Development (1965) and Glenn M. Parker's Characteristics of an Effective Team (1990), participants will be able to assess trouble spots with previous capstone project teams and discover preventative measures for future success, as well as tools to help dysfunctional teams recover. Participants will experience an interactive program and discover first hand the importance of effective teaming and the impact of successful coaching on establishing a high-performing team.

WORKSHOP #3

#11898: Effective Practices for Project Formation and Faculty Involvement

Ralph Ford and William Lasher (Penn State Behrend)

This workshop will focus on two critical and inter-related issues in capstone design projects - project formation and faculty involvement. Project formation is a notoriously difficult process in any environment, whether it be academia or industry. Teams must be formed, project concepts identified, a project selected, specifications and goals must be clearly identified, and implementation plans developed. Each of the preceding elements is critical to achieving success and requires a good level of understanding by both the students and faculty involved. Students often have little experience in this process and are challenged by its ambiguity and fluidity. Furthermore, faculty are not typically prepared by their academic training to understand or supervise capstone projects, and likewise find it challenging. This presents many barriers to effective and consistent project advising. When multiple faculty members advise projects there need to be consistent expectations and assessment methods. The inclusion of industrial sponsors and advisors adds another level of complexity, as their expectations are often different from those of the institution.

This interactive workshop will focus on helping educators involved in capstone projects develop effective approaches for dealing with these issues. In particular, workshop will address the following topics:

1. Team formation
    - Models for forming student teams
    - Development and assessment of teaming skills
    - Selecting faculty advisors and defining their role
    - The roles of faculty and industrial advisors
2. Project selection models & scope assessment
    - Project selection models
    - Identifying industrial projects
    - Developing guidelines for students
    - Ensuring that projects are appropriate and addressing adequate technical content (i.e. inclusion of standards and realistic constraints and ABET Criterion 4)
3. Working with industrial sponsors
    - Developing guidelines for sponsors
    - Obtaining donations
    - Effective engagement of industry sponsors
    - Handling intellectual property issues and non-disclosure agreements
    - The role of industry sponsors in projects

4. Problem definition and development of specifications
    - Identification of projects needs
    - Writing problem statements
    - Development of verifiable and realistic project specifications
    - Development of realistic project plans
5. Faculty advisor development
    - Defining common learning objectives
    - Ensuring technical competence and uniformity of expectations
    - Development of assessment rubrics
    - Evaluation of projects by faculty committees
    - Rewarding faculty involvement
    - Continuous process improvement

Participants in the workshop should expect to participate in an active-learning environment and bring their experiences and challenges to the workshop. Participants will learn about processes applied at other institutions, including those of at the workshop facilitators. Most importantly, participants will develop exercises and activities that they can apply in their own environment.

The workshop schedule has been revised to accommodate the available blocks of time (1 ½ hrs and 1 hr, with a 15 minute break). The sessions will be structured to stand alone, so that participants can attend either one independently. Results of activities will be collected and disseminated to participants following the workshop.

First session – 90 minutes – Project Formation

Time, mins	Description of activity
10	Introduction – the need for processes; overview of session
25	Team formation and development – presentation on models for forming student teams; ACTIVITY – team process guidelines
20	Project identification – presentation and discussion on different models; guidelines for students; assessing project scope and appropriateness
15	Working with Industrial sponsors – presentation and discussion
20	Problem definition – overview of processes and instructions; ACTIVITY – assessment of specifications

Second session – 60 minutes – Faculty Involvement

Time, mins	Description of activity
5	Introduction/overview of session
10	Faculty involvement – presentation of Behrend model and discussion of issues
20	Faculty advisor development – ACTIVITY – have each working group discuss ways of doing ONE of the following: getting faculty to participate in development of learning objectives; ensuring technical competence and uniformity of expectations; evaluation of projects by faculty committees; rewarding faculty involvement
15	Project evaluation – discussion of rubrics; presentation of Behrend rubrics
10	Continuous improvement in capstone design – presentation and discussion

About the Facilitators

Bill Lasher and Ralph Ford are experienced educators who teach the capstone design courses in their respective programs. They have facilitated active learning and have been using active learning in their courses for a number of years. They have published numerous articles on pedagogical innovations in engineering and engineering design, and both have been nominated for The Behrend College Council of Fellows Excellence in Teaching Award. They have been instrumental in program and curriculum development and led their respective programs through initial accreditation in 1996 and re-accreditation under EC 2000 in 2002.

The School of Engineering at Penn State Behrend has strong design-oriented undergraduate programs. All of the academic programs have year-long capstone projects and all faculty members in the School are actively engaged in senior projects – through both advising and serving on project committees. There is also a great variety in the number of projects – each project team works on a different problem – and there are nearly 100 different capstone design projects in the School each year. Over 1/3 of projects are sponsored by industry. The School hosts the annual Richard J. Fasenmyer Engineering Design Conference, in which all project teams present the results of their capstone project to the industrial and regional community.

Bill Lasher is Program Chair of Mechanical Engineering. In addition to the capstone course, he has been the lead faculty for the introductory first-year design course at Behrend. He is an ASME fellow and has been active regionally and nationally on educational issues in mechanical engineering.

Ralph Ford is Director of the School of Engineering and a faculty member in Electrical, Computer and Software Engineering. He is co-author of Design for Electrical and Computer Engineers, published by McGraw-Hill, a textbook devoted to capstone design for electrical engineers. He is also an ABET program evaluator.

WORKSHOP #4

#11003: Coaching Your Students to Create and Deliver Effective Presentations

Lee Potts (University of Colorado)

Although professional life requires us all to give presentations, few receive adequate training in doing it well. In this symposium we will investigate:

1. how to create engaging, content-rich, well-organized talks supported by strong visual materials
2. how to deliver them with dynamism, authenticity, and authority

The workshop will include both lecture-demonstration and participation. Experiential components are designed to maximize skill acquisition; participants will have the opportunity to practice vocal and nonverbal communication techniques and learn strategies for coaching students. A training model will be offered and numerous handouts will be provided.

WORKSHOP #5

#11795: Capstone Design Assessment Instruments

Steven Beyerlein (University of Idaho)

The purpose of this workshop is to introduce participants to classroom assessments developed for capstone engineering design courses. Participants will engage actively with assessments.

They will be introduced to the research foundation for capstone engineering design assessments, explore specific assessment instruments, and review student work and scoring from selected assessments. Over the last five years, the Transferable Integrated Design Engineering Education (TIDEE) consortium has developed and tested tools for measuring personal/professional growth, team dynamics and productivity, and skills for identifying stakeholder needs and specifying solution requirements.

Participants will benefit from:

- Grasping a research foundation for design education that develops learners and solutions
- Obtaining performance criteria for four areas of performance for engineering design
- Receiving assessment instruments and scoring rubrics for three areas of design
- Gaining experience in scoring student work related to selected assessment instruments

Classroom assessment is vital to engineering education to support both program accreditation and student learning. Yet, assessment of learning and project achievement is identified by capstone design course instructors as a serious challenge for which they need help [1]. A cornerstone of classroom assessment is a robust model for learning within a specific subject area or performance context [2, 3].

The client-focused, team-based, project-oriented features of design prompt educators to define design learning outcomes broadly. Many outcomes will apply across engineering disciplines [4] and be related to the profile of engineering professionals [5]. Design learning outcomes may appear as competencies, professional growth, experiences, accomplishments, or integrated performances [6]. Targeted achievement must fit varied types of capstone courses found in engineering while also capturing key elements that distinguish novice from expert designers. Four key areas of performance have been defined: solution requirements, solution assets, personal capacity, and team processes. Two focus on development of design solutions, while two others address development of professional practitioners as individuals and teams.

Performance factors for design learning are suggested by attributes of engineering practitioners [5], while performance factors for project achievement are suggested by qualities of valuable design products [7]. From these performance factors we have crafted performance criteria and performance tasks to explore design expertise. Rubrics that span novice to expert performance have been developed to score student work. These assessment instruments and scoring rubrics are applicable to all engineering students, regardless of their developmental level or discipline.

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ABSTRACTS: POSTERS

#11195: Capstone Design Program for Department of Electrical Engineering in Southern University

Jiecai Luo (Southern University and A & M College)

The Capstone Design Program at Southern University is an innovative two-semester design course titled as EE SENIOR DESIGN PROJECT I & II. This design course is taught in a way that makes the experience simulate a model of what happens in the real word. One of the great strengths of SU's EE curriculum is the emphasis on fundamentals and how they apply to real-world problems. The ultimate goal of this design course is to bring together seniors in electrical engineering, mechanical engineering, manufacturing engineering, and industrial design. The Capstone Design Program combines educational elements to produce a unique class environment. These elements include the use of industrially sponsored design and build projects, a structured design approach, the integration of product and manufacturing process design, multi-disciplinary student design teams, and emphasis on engineering and people skills. Student's assignments are 'deliverables,' much the same as would be found in industry. They include: a project schedule, functional specification, concept generation and evaluation, layout design, experimental plan and report, part and process definition, working prototype, production sample, and final documentation. Project deliverables are presented orally to industry representative, faculty members, and senior students. In this paper, the Capstone Senior Design Program teaching procedures will be provided, and some design projects results also will be provided.

#11348: Bridging the Gap between Academia and Industry through Capstone Design

Tongele Tongele (Southern Illinois University Edwardsville)

The need for graduating engineers to be well prepared in technical knowledge, skills, and possess the ability to communicate and collaborate effectively in the work place can never be overemphasized. It is therefore important that theoretical concepts and principles learned by engineering students through various courses provide them with the skills and the self confidence of being prepared, ready to enter the work force and become productive. Capstone Design Course (CDC) can serve not only as a bridge for the crossover from academia to industry, but also as a stimulus and an indicator of confidence level. As a bridge, CDC course provides students with opportunities to tackle real world projects that require, beside engineering knowledge and skills, qualities for team work, ability to understand the economical, societal and environmental impact of engineering decisions as well as professional responsibilities of an engineer. As a stimulus, CDC fosters creativity and self reliance through which students gain control over their educational experience, thus inducing in them (students) the surge in a forward momentum to complete the crossover. Last but not least, CDC allows students to show the products of their creativity and work. Both the products and the process of showing them indicate how confident the students are, and how well they apply theoretical engineering concepts and principles to design, document, build, test, and demonstrate or simulate a working prototype. This paper outlines efforts by the Mechanical Engineering Department at the Southern Illinois University Edwardsville to use CDC to bridge the gap between the academia and industry.

#11780: Designing/Building Innovative Conceptual Prototypes in Capstone Course

Eugene Rivin (Wayne State University)

“Creative Thinking”, especially in design, is one of the most important issues to be addressed in engineering education. However, emphasis of many engineering curricula is moving steadily towards increasing role of computers. While computers and such computer-based techniques as CAD, CAD/CAM, FEA are very powerful tools significantly improving productivity of practicing engineers, they do not help much in developing novel concepts while engineers are solving design and manufacturing problems. It is well known that our overseas competition, both across Atlantic and across Pacific, frequently have much less (or less powerful) computers but develop better designed and more competitive products in a shorter time.

There is a definite need to give students some guidelines for creative thinking and some experience for formulation and conceptual solving of design and manufacturing problems with innovative solutions. If this effort were successful, then effectiveness of computer applications would be also enhanced. The paper will describe how these goals are addressed in the Capstone Design course in mechanical engineering at Wayne State University.

There are two required capstone design classes for mechanical engineering students, both one semester long. One course is addressing computer simulated design of thermal/fluid systems (no hardware is built). Another course addresses mechanical design. This course will be described in the paper. The number of students fluctuates in 10-20 students range. Previously, one or two projects had been assigned to teams, each about ten students. Such large teams do not develop and/or teach good team work, it is difficult to identify and correct “freeloading”, the designed and built devices were bulky, heavy contraptions, consumed inordinate amounts of machine shop time, etc. However, the most important shortcoming of this model was a difficulty, if not impossibility, of building really innovative designs.

In the last several years the above model of running the capstone course on mechanical design was radically changed. The team size was reduced to 3-4 students, 5 students in exceptional cases. Most of the projects require designing, building, and testing of conceptual prototypes proving an innovative concept to perform a certain function, rather than “final products”. There were some exceptions when a project assignment required building an enabling device for special education schools (for handicapped children).

There is only one lecture, at the first class meeting, wherein after brief description of the design process and factors to be considered in the process, such as ethics, manufacturing, costs, etc. (which are to be emphasized later, in working with each team), an overview of TRIZ is provided.

The Theory of Inventive Problem Solving (TRIZ in its Russian abbreviation), was developed in the former Soviet Union by G. Altshuller. This is a methodology allowing to alleviate psychological inertia in problem solving. It also provides engineers with powerful algorithmic approaches to formulate, analyze, and solve complex engineering problems, as well as to use objective Laws of Evolution of Technological Systems for directed development of new generations of innovative products. TRIZ emphasizes importance of considering of physical, chemical, and geometric effects and new materials in developing innovative designs.

The TRIZ lecture, while being too short for teaching TRIZ methodology, gives students many examples of its applications and familiarizes them with TRIZ lingo, which was found to be very useful in the process of designing innovative mechanical systems.

The paper will give examples of the innovative projects developed/built in the Wayne State capstone design class.

#11787: Institutionalizing the Capstone Design Course in the I.E. Department at the University of Lousiville

Suraj Alexander (University of Louisville)

The Accreditation Board of Engineering and Technology (ABET) requires accredited programs to provide a meaningful major design experience at some point when the student's academic development is nearly complete. This paper describes the Capstone Design course in the Industrial Engineering program at the University of Louisville, which is designed to provide this major design experience.

In this course industry is used as a source for "real world", open-ended design problems, for which teams of IE students develop creative solutions. The industrial engineering faculty assigned the Capstone Design course as a required course for the spring semester of the senior year. Students would have completed most of their undergraduate course work by this time and it was a critical time to instill in students the need to pursue their M.Eng. degree. A number of students who continue on to the graduate program use ideas from their Capstone experience as seed ideas for their research projects. Also, some students have received national recognition through awards received from Institute of Industrial Engineers, for papers derived from their Capstone projects.

Although the course is coordinated by one faculty member, all faculty are involved in mentoring student teams, and evaluating midterm and final project presentations. For instance in spring semester 2006, twenty two students participated in five projects in three industries, with different faculty mentors and industry representatives. Potential project descriptions are defined by the industry sponsors around three weeks before the start of spring semester. Students are assigned to teams and projects based on their background, work experience and interests. There are discussions in class on team dynamics and the importance of commitment, trust, communication and attitude. At the start of the semester faculty mentors take the student teams on company tours, after which, they sit down with management and clarify their project goals. The teams then develop project plans and schedules to meet project objectives and goals. Team members evaluate themselves and each other four times during the semester; these evaluations are used as a means of monitoring the functioning of the student teams and their progress. There are mid-term presentations, final presentation dry runs, and final presentations, where students get to polish their presentation skills, and also get feedback from faculty mentors and industry sponsors. The student teams also write project reports and obtain feedback on the reports from faculty mentors; with this feedback they complete their final reports. One copy of the report is given to the industry sponsors, and one copy is kept in the department.

The program's execution and evaluation receives considerable scrutiny by the faculty. The outcomes measures from the course are used as a measures for several ABET criteria. Industry representatives also evaluate the course.

Student teams have worked with a variety of industries including, UPS, UPS-SCS, Ford, Smurfit-Stone Container, Lantech Corp, Colgate, Dow-Corning, Stride-Rite, Worthington Steel, Porter Paints, Shelby Industries and others. The projects provide a "win-win" opportunity for the both the participating companies and the students. The companies benefit from fresh new ideas from eager students. In addition, they are able to observe first hand the collaborative skills of the students, their expertise in developing engineering design solutions, and their presentation skills. A number of students have been hired by the companies in which they completed their Capstone projects. The engineering students benefit, since they get great satisfaction in applying the knowledge gained in the classroom. They also learn to function within teams. In addition, they realize the importance of defining goals and project management, since they have to define solutions to open ended problems in approximately thirteen weeks.

#11788: Cooperative Engineering Center - An 18 Year Success Story

James Arthur (Virginia Military Institute)

A senior-industrial design relationship called the Cooperative Engineering Center (CEC) was developed by the Mechanical Engineering Department of the Virginia Military Institute in 1989. The primary purpose of the CEC is to serve as a challenging Capstone Design Course and to provide all of our senior mechanical engineering students a realistic excursion into the exciting, real world of engineering. The program is centered around the final mechanical engineering design course - ME 444W which is three credit hours and is offered in the spring term of each year. The essence of the program is to provide a comprehensive experience between classroom instruction and industrial projects. The design experience is a decision-making process that builds on the strength of courses in mathematics, the basic sciences, the engineering sciences, and the humanities and social sciences. It is believed that this experience will better prepare the mechanical engineering student for his or her profession after graduation.

Consulting design teams of two or three cadets are formed to investigate and to propose a solution to an engineering design problem submitted by a local industrial client These design teams interact directly with the industrial clients" representative. An alternative to an industry sponsored project is for the student design team to participate in one of the National Student Engineering Design Contests. Students who choose this path must meet the requirements of the contest: design and build the machine (vehicle or device), and compete in the contest.

The Cooperative Engineering Center has a faculty member appointed as the Director who will solicit projects from a variety of industries (clients) located in an approximate ninety-mile radius of the school. The function of the Director is to direct the Center and to secure a wide variety of engineering projects well before November of each year to ensure a copious selection of engineering topics. The CEC Director also teaches pertinent design topics, and meets weekly with all engineering design teams. Once final topics are selected, for a good educational balance, the students select topics of interest and one faculty design team adviser is assigned each team. The faculty design team adviser has the responsibility of ensuring that his team follows acceptable standards of performance and quality. Emphasis is on conducting a professional-level design study and the preparation and presentation of an oral and written report to industry. All mechanical engineering faculty serve as design team advisers.

Design teams will vary from two to three cadets who select one member as their team leader. The team leader is responsible for organizing work, meeting deadlines, writing letters, ensuring that the team works smoothly together, and that all members share in the consulting work and in completing the final report. After arriving at a solution for the design project and writing a formal report, the team makes an oral presentation before a departmental faculty review panel. After a faculty design team advisor accepts the written report, the team visits the client and orally presents the project solution and submits a copy of the written report to the client representative.

The client representative completes a grade and comment form and returns it to the CEC Director for 40% of the team's final grade.

#11789: Multi-Dimensional Capstone - It Takes a Village

Gerald Crain (University of Oklahoma)

The Electrical and Computer Engineering Capstone experience at the University of Oklahoma relies heavily on a set of multi-dimensional, external contributors. Their disciplines match those required to fully execute an engineering design. These areas include Technical Writing, Team Building, Communications, Engineering Economics, and Professional Engineering. Assigned projects address stated needs of external sponsors who provide funds for execution and guidance from practicing engineers. Competitive student teams are challenged to research, design, develop, document and demonstrate a design to meet the needs of the sponsor in a single semester experience.

External people who provide lectures and/or who make contributions to the assessment of student accomplishments are critical to the success of this Capstone concept. Outside speakers are brought in nearly every week to introduce project-development concepts and skill development materials. Extra-departmental experts are engaged in the assessment of oral and written communications assignments made to the students. Sponsors are charged with continuous monitoring of team progress and with facilitating sophisticated designs through funding hardware developments and providing test environments.

Establishment of a complex reward system has been principally responsible for enabling this process to continue and thrive for 24 semester offerings since its inception in spring of 1995. Among the contributors and benefactors to this program are counted: Students, Sponsors (including project mentors), Graduates and Visiting Advisors to the School of ECE, Representatives from local industries/agencies contribute to the instruction on quality, ethics, and building small businesses and Experts from across campus whose disciplines include the skills which can define the success of an engineering career.

The process of this class does have shortcomings from an institutional perspective. Direct faculty contributions are limited. A source of funds must be established to provide for expert support to the program. There is a requirement to continuously replenish the list of speakers and support personnel each semester that sometimes requires agility in finding alternatives. These problems and ways to solve them will be discussed in the paper.

#11791: The Engineering Senior Design EXPO and Multidisciplinary Projects at UIC

David Schneeweis and Vladimir Goncharoff (University of Illinois at Chicago)

Every Spring Semester the College of Engineering at UIC sponsors an exhibition of senior design projects from eight of its ten undergraduate degree programs of study. Not only is this an opportunity for student design teams to show off their final products and compete for prizes, but it is also a time when projects from different departments with different senior design course requirements are on display at the same event. This poster will overview the Spring 2007 Senior Design EXPO, explain its organizational goals/methods/difficulties, and describe our attempts at creating multidisciplinary design teams. In particular, the results of collaborative efforts between ECE and BioE Departments will be presented.

#11793: Enhancing Students Experience using a Discussion Board System as a Collaboration Tool

Junichi Kanai (Rensselaer Polytechnic Institute)

In capstone design courses at Rensselaer Polytechnic Institute, a team of students works on a problem specified by an industrial partner. The course goals are to develop a solution and to demonstrate its feasibility in a 15 week semester. A faculty adviser and a sponsor mentor assigned to the team serve as coaches and consultants.

RPI’s computing network and students’ notebook PCs, which are mandatory, help the students to work on the project both inside and outside of the scheduled class time. To let students be better organized, a discussion board system was introduced to the courses as a web-based collaboration tool for managing project related information in the spring 2005.

Some issues in selecting a collaboration tool included the campus network policies, technical supports available, and budget. The features considered when choosing a tool included managing users’ rights, creating sub-boards, notifying members of new message, attaching files to a message, and searching messages. Many students had not had any experience in using a collaboration tool and/or discussion board before attending the course. Hence, it was important to provide a tutorial and to encourage students to start using the system.

High performance teams naturally utilized the tool for their advantage. For example, the students kept track of their progress by posting the minutes of meetings and/or progress reports, including To Do lists, regularly. Some students also conducted informal design reviews by posting comments on teammates’ design documents without waiting for a next scheduled class time. The tool also improved the effectiveness of faculty advisers and sponsor mentors. It allowed the faculty adviser and sponsor mentor to assess the teams’ progress and problems from anywhere and at any time. Hence, they were able to provide helpful information to the team quickly by posting it to the system. This quick turn over of information had significant impact.

Furthermore, the system allowed sponsor mentors to share information about the project with a broader audience within their organization. It enabled them to provide better and timelier feedback to students and faculty about the problem, thus permitting more realistic solutions. Broader dissemination of successful project results also led to easier justification of future project sponsorship. Meetings with a team and reviewing their reports might not tell the whole story of a single student’s contribution to a project. Therefore, fair assessment of individual contributions to a team-based design project is a rather difficult task. The messages posted to the system were time stamped and provided the history of a project, including the origin and evolution of ideas and designs. A combination of the number and quality of the messages posted was a good indicator for measuring how the students participated in the project. Similarly, a lack of access to the system by a student suggested that the student was not engaging in the project.

A web-based collaboration tool provides much benefit to students, faculty advisers, and sponsor mentors in team-based design projects.

#11797: A Multidisciplinary Team Approach for Capstone Design Courses: Challenges and Lessons

Patricia Wojahn and Young Ho Park (New Mexico State University)

For the seventh consecutive year, faculty from three disciplines—industrial engineering, mechanical engineering, and technical communication—have joined forces to offer a unique capstone design course. The multidisciplinary capstone experience brings together students from these disciplines to design products or systems for various clients who sponsor the projects. In addition to providing opportunities to apply the analytical tools of their fields (as do most capstone courses), this capstone experience also offers students practice in gaining from the analytical systems of other disciplines while seeing in new ways potentials of their own. After all, multidisciplinarity can allow the integration of various "disciplinary perspectives into a larger, more holistic perspective" (Newell, 1992). Yet realizing this goal is neither straightforward nor easy. As Schiappa (1995) explains, "What one group might consider a dead issue, another might find a fascinating question. What counts as evidence or appropriate methodology varies from one [specialization] to another." Overall, we see such characteristics as potential assets for making informed decisions or creating exceptional products. Yet these same characteristics create challenges for students educated in one specialized area to be open to unfamiliar if not contradictory notions and practices of other specializations. These challenges can, in turn, prompt students to articulate for themselves and for others what they know and what their disciplines can offer.

In this paper, we report on experiences we as faculty have encountered in annually assessing aspects of the multidisciplinary capstone design course. For instance, we have seen multidisciplinary students foster longstanding professional relationships; we have also seen students from one discipline failing to inform counterparts from other disciplines about where they were meeting or what decisions were being made. We have seen departments view the capstone effort as a priority to be supported annually; we have also seen the capstone effort treated as an option not regularly supported. We have seen our work recognized and making measurable contributions to student learning; we have also seen our interests waver in the face of evolving pedagogical, logistical, or ideological circumstances.

Our story of this ongoing endeavor begins with background to and rationale for the multidisciplinary aspect of the capstone design course. The story moves to assess solutions for addressing challenges and concludes with suggestions for promoting practices that have consistently seemed to foster learning if not success among multidisciplinary student teams. But, mainly, our story revolves around a paradox. On the one hand, we know that expertise is characterized by specialized knowledge and specific methods of investigation; in the United States, a university therefore tends to consist of scholars characterized by these differences (Russell, 1997; Schiappa, 1995; Mahala & Swilky, 1993). On the other hand, we know that complex problems require expertise from multiple disciplines. Yet learning to value contributions from one's own discipline at the same time as encountering challenges to it can be highly disconcerting. As Geisler, Rogers, and Haller (1998) argue, "for multidisciplinary design to work, practitioners must be taught to seek out and respect the opinions of other affiliated professions, to know that other issues exist and are valid, and to know that others have the expertise to address them."

Toward that end, our aim in this paper is to acknowledge similarities to other capstone design courses while sharing the unique experiences that our multidisciplinary work offers ourselves and our students. As Schiappa (1995) states, "interdisciplinary projects can allow people to see, sometimes for the first time, the assumptions and underpinnings of their own beliefs, values, and attitudes." As this paper attests, our story—our own and that of our students—has not been an exception.

#11804: Raising the Bar: Taking Senior Design from Student Projects to Academic Industrial; and Entrepreneurial Contributions

Ronald Lasser and Dr. Joseph Noonan (Tufts University)

This paper discusses the metamorphosis of an engineering department-centric capstone design program for senior electrical and computer engineering students to a multi-disciplinary, individual and team projects, and variable sponsorship environment. Establishing and communicating the vision, developing the curriculum, and teaching the skills to students is presented in an historical context as the course was expanded from a single semester to a full academic year and beyond.

The senior design course in the Electrical and Computer Engineering Department at Tufts University started as a one semester course presenting the rudimentary skills in design such as electrical schematics, computer algorithms, and test and verification methods combined with simplified examples to show classroom topics in an industrial setting. Students were asked to read articles and papers, build and test a simplified circuit or computer program, then present their work to the class. As an alternative, a student could work with a professor in the department and present the research performed during the semester.

In the spring and summer of 2002, the department introduced a new vision for the design curriculum. The five year goal was to develop a two semester program that would provide the students with skills and experience in engineering design to achieve recognized contributions in academic research or on industrial projects. Further, the objectives were set on nurturing the latent passions of the students to harness their specific engineering talents on projects they desired to pursue, rather than upon the traditional areas of faculty research or scholarship. Success is measured in the ability of the student to make a contribution in their area of interest and in an increase in their confidence level, decision-making maturity, and ownership of responsibility of their work product. Ultimately, we desire to have graduating senior engineers realize that they possess the skills and abilities to confidently meet the expectations of the next steps on the path toward their chosen career direction at the conclusion of their undergraduate education.

This paper will discuss the three stages in establishing the pedagogy—vision, transition, and foundation—for a student-centric engineering design program. The creation of the vision statement, determining the various customers and their needs, setting the objectives and requirements for the course, building consensus of faculty and students, transitioning from the initial situation to the desired foundation is discussed, and examples of coursework, projects, and student work products are presented.

The most significant issue was the cultural change within the department as the students became responsible for creating their own senior design projects. The challenge is to generate multiple projects while keeping the multi-project scopes and students on a forward converging path towards graduation. The lessons learned and the real-time adjustments made during the semester and from year-to-year to reach a foundation level to balance out-of-the box ideas with results in an academic year are shared. The strategy developed to eliminate the obstacles preventing success in such areas as moving beyond the electrical and computer engineering discipline, defining classroom work and lectures, setting student project scope, teaching design and career skills, attracting industrial support and real-time failure student driven design are explained, Finally, with the success of the program and ABET accreditation and acknowledgement, the vision to build on the foundation and our next steps to expand it is defined.

#11805: The Structure and Conduct of a Capstone Systems Engineering Design Course by

Thomas R. Lalk, Aaron Cohen and William Schneider (Texas A&M University)

A capstone systems engineering design two course sequence is described by presenting the philosophy, objectives, content, organization and conduct of the courses. The three general topics addressed in this course sequence are described. They are the general systematic top-down design process, analysis for design, and system engineering project management. Specific topics presented are: establishment and analysis of the top level need with attention to customer desires, functional decomposition, development of a hierarchical arranged function structure, determination of functional and performance requirements, identification of interfaces and design parameters, development of conceptual designs using brain storming and parameter analysis, selection of criteria for the evaluation of designs, trade studies and down-selection of best concept, parametric analysis, preliminary design and detailed design. Application of engineering analysis including the depth and detail required at various phases during the design process is discussed and illustrated. Systems engineering management procedures such as failure modes and effects analysis (FMEA), interface control documents, work breakdown structures, safety and risk analysis, cost analysis and total quality management are discussed and illustrated with reference to student projects. The use of large complicated design projects rather than smaller more easily completed ones is explained in the context of examples of students' projects.

#11809: Civil & Environmental Engineering Infrastructure Projects

Max Anderson, Mark Meyers and Philip Parker (University of Wisconsin-Platteville)

The Capstone Senior Design Project at the University of Wisconsin-Platteville has evolved over the past twenty-five years from a summer three-week class in which all students worked in teams on the same civil engineering project to the present multi-disciplinary format. In the present format, students enroll in the capstone class in their final semester to work in teams on civil and environmental engineering infrastructure projects. The projects are chosen from those submitted by or solicited from municipalities, county, state, federal agencies, private individuals, and non-profit groups. Although new projects are chosen each semester some may be a continuation of one completed in a previous semester. The projects are all real world ones that typically have not been constructed but are still in the planning stage. The projects are chosen based upon their inclusion of content that addresses Program Objectives as well as expected ABET Outcomes for civil and environmental engineering graduates.

There are a number of requirements and assignments for each project to ensure that all of the ABET Outcomes and Program Objectives are met and to assess the quality of student work. Projects are selected based upon their ability to involve multiple disciplines and interests to students. Students are assigned to teams based upon their selection of first or second choice of project and the need for students from multiple disciplines on each project. Once the projects are selected and teams are chosen, a meeting is scheduled between each student team and the project client. The purpose of the first meeting is to discuss project needs and scope with the client and to set a timetable for future meetings.

The class is coordinated by one faculty member and each faculty member in the department serves as a "consultant" on one or more projects each semester. This consultant assignment is counted as part of each faculty member's teaching load. The class meets for two hours of lecture each week and a three hour "lab" is scheduled for team work on the project. The coordinating faculty member selects students for each team, schedules the initial client meetings, schedules guest speakers for the lectures, and assembles all of the grades from assignments to compute the final grade. The consultant faculty member's role is to help with technical questions, to keep the project on track with biweekly progress meetings, and to grade the final report and presentation.

The paper will provide more details of how communication skills are stressed, how projects are managed, how grading rubrics are used, how projects are assessed, and how the desired quality of the final product is achieved.

#11812: Ten Years of Industrially Sponsored Capstone Design Projects

Alan Weimer (University of Colorado)

Capstone design projects sponsored by industry have been used in The Chemical and Biological Engineering Department at the University of Colorado for the past ten years. In 2006 alone, 16 different projects were supplied by companies and supported by industrial liaisons. Although most of these projects are process oriented, an increasing fraction has been product design oriented. Feedback from both the students and the liaisons has been positive. Design projects span a range of interests including biotechnology, pharmaceutical processing, oil and natural gas processing, renewable energy, food manufacturing, nanomaterials, polymer processing, and environmental remediation among others. Student teams select their projects during the first two weeks of class. They are then required to carry out a literature review, to determine battery limits, and to provide a preliminary process/product design approach as part of a written and oral project proposal. The industry liaison provides feedback regarding the direction of the project. The oral proposal presentation is evaluated by both the students in the class and a panel of industrial liaisons. The oral presentations are recorded using a digital video recorder and feedback is provided to the students, including a DVD copy of their presentation. The students are required to prepare a written critique of their presentations based on the feedback from their peers and industry liaisons and their own viewing of their presentation. Near the completion of the project, student teams make a second presentation which is also recorded and evaluated. They present a poster at a college-wide Engineering Design Day and must submit a final bound report to both the instructor and the industrial liaison. The liaison provides feedback on the report. A confidential peer evaluation among team members is also part of individual final grades.

#11816: Life-Cycle Integrated Capstone Project Design

Ruinian Jiang (New Mexico State University)

Capstone design course provides students an opportunity to review and apply knowledge they learned during college studies. The review is not simply revisiting what has learned; the best way is to apply the knowledge learned through a well designed capstone project. It is generally difficult for the faculty to develop such a project by themselves since the project should reflect multi-disciplinary aspects of up-to-date practice including design codes, specifications, field operation skills, and new technology. Designing a capstone project from scratch is time consuming. A good way to develop a capstone design project is to find industry sponsors and obtain necessary information from them. The project is better being under construction or recently completed, and the project location is nearby so students can conveniently visit the project site.

One important issue in capstone project design is how to address the life-cycle and system-wise optimization. For most traditional design classes, the typical practice is to learn how to apply codes and specifications to solve certain class-type engineering problems. The design is targeted at isolated independent pieces and seldom reflects the characteristics of the whole system from which they are extracted. In this situation, students tend to seek sub-optimal solutions and have little chance to see the whole picture of the entire system and how their design contributes to its performance. The life-cycle and system-wise optimization is especially critical for large construction projects such as transportation infrastructures. To make a change over the traditional design system, designers of the new generation should be encouraged to have an open and active mind and a willingness to adopt others' inputs into their design. At the same time, it is also important to introduce a design process that can attract voices from various interests starting from the very early stage of a project, and keep having them all through the project development and design process. This is the primary intention of life-cycle integrated design.

New Mexico State University (NMSU) has been cooperated with New Mexico Department of Transportation (NMDOT) since 2003 in its highway engineering capstone design course. A process of life-cycle integrated design was applied in the class project. The main purpose of the integrated design was to establish a formal design procedure in which the elements of users, infrastructure and vehicles are considered all through the design process, and the effect of design on social system and natural environment is carefully addressed and measured. A local small size highway project was selected for the capstone design. Students were requested to address problems from the early stage through the completion of the project. Students were also asked to apply context-sensitive design concepts in the environmental impact evaluation and to design portions of the project based on the information provided by NMDOT and the project documents. Engineers from NMDOT were invited to the class to address important issues and field trips were arranged time to time to visit NMDOT and the project field. Student were trained through actual projects in order to establish a broad vision while developing their skills in specific technical fields such as geometric, drainage, and traffic design.

#11820: Capstone Design in a Large University Environment

Jay S. DeNatale and Gregg L. Fiegel (California Polytechnic State University)

In 2006, the Civil Engineering capstone design sequence at California Polytechnic State University, San Luis Obispo morphed from an individual study course into a regular directed study offering. This change was motivated by a number of concerns shared by the Department, the University, and the Accreditation Board for Engineering and Technology (ABET), including (1) the need for a truly multidisciplinary capstone design experience, (2) uniformity with respect to both the scope of that experience and the assessment of student performance, (3) the absence of required instruction in a variety of important non-technical professional practice type issues, and (4) a less than stellar history of timely project completion under the old individual study format.

The new capstone design sequence has two very unique features. First, the instructional team consists of five tenured/tenure-track faculty and over twenty senior-level practitioners. Second, the organizational structure of the course permits it to be effectively used with a graduating senior class of as many as 144 (or more) students. The course is also a critical component of the

Civil Engineering Department's internal assessment process, since the various in-class activities, outside-of-class projects, and oral presentations permit direct measurement of several different performance metrics and program outcomes.

This paper reviews the objectives, content, and organizational structure of the new capstone design sequence. It also describes our experiences to date, and provides a preliminary assessment of the degree to which the course has improved the undergraduate design experience at Cal Poly.

#11842: The Astronautics Capstone Program at the United States Air Force

Kenneth Siegenthaler (United States Air Force Academy)

The Space Systems Research Center at the United States Air Force Academy is building a cadre of satellite space professionals “one cadet at a time.” Its motto and aim is for cadets to “Learn Space by Doing Space.” All the cadets majoring in astronautical engineering perform a one year long capstone program of the design, fabrication, testing, and launching of a rocket (FalconLAUNCH) or a satellite in space (FalconSAT). This program works just like any Air Force program, with the cadets being the contractor, and the faculty and Air Force funding agencies being the Air Force Manager. The program has approximately 45 students, with eight to ten faculty mentors. The program is fairly stabilized with a rocket launch every year and a satellite launch every two to three years. FalconLAUNCH and FalconSAT are multi-disciplinary programs. In addition to the cadets majoring in astronautical engineering, selected cadets majoring in, physics, electrical engineering, mechanical engineering, computer science, and management are also on the team. All of the normal milestones, reviews, presentations, and reports required in an Air Force Program are required of the cadets in these programs. The cadets do all of the briefing. The cadets also do all of the hands-on work including clean room manufacturing and assembly, and bake out and vibration testing. They are true cadet run programs with faculty mentors to keep things on track. Outside reviewing agencies include NASA, Air Force Laboratories, Aerospace Corp, Air Force Space Command, and representatives from the civilian space community. The current goal of FalconLAUNCH is to launch a 5-kg payload on a rocket to 100,000 meters and every FalconSAT satellite has DoD Space Experiment Review Board (SERB) approved experimental payloads (FalconSAT-3 has three). After presenting the development, challenges, and advantages of conducting an undergraduate space program performing world class research, this paper details the cadet construction, testing, preparations, and results of the January 2007 launch and operation of FalconSAT-3 on an Atlas V launch from Cape Canaveral and the April 2007 launch of FalconLAUNCH-5 from the NASA Goddard Space Flight Center Wallops Island launch facility.

#11852: Capstone Design for Mechanical Engineering

Warren N. Waggenspack Jr. and Michael C. Murphy (Louisiana State University)

This manuscript describes a model of and the challenges faced in supporting an effective two semester capstone design course sequence in a Mechanical Engineering curriculum at a midsized state university. One where teams of students devise solutions to real world engineering problems submitted by clients from industry, academia and the community at large. Alternative designs, considering all aspects of engineering, are investigated during the first term, and a working document detailing the requirements for manufacture of a prototype must be completed by semesters’ end. The follow-on semester encompasses fabrication, testing and whatever redesign is necessary to produce a functional prototype and validate the proposed design.

As with many capstone courses, several ABET outcomes are reflected in the primary course objectives which include the following:

1. To provide a comprehensive design experience culminating in a paper design (1st term) and subsequent product realization (prototype for 2nd term);
2. To demonstrate the application/use of fundamental engineering principles, accepted design methodologies, and appropriate engineering materials to actual design projects;
3. To develop the ability to refine ill posed design challenges into more detail engineering specifications and, throughout the term, be able to effectively communicate and defend the project status and technical material in both oral and written form;
4. To demonstrate an ability to contribute as a member of a larger team of students addressing a technical challenge.

As in any professional engineering environment, regular written and oral reports are required documenting the progression of each team's project. General requirements and guidelines are provided as each semester proceeds. Written documentation includes concise bi-weekly progress reports incorporated into each individual's chronological design notebook (project journal), a midterm feasibility draft, constructive/structured team assessments and lastly, a formal, comprehensive final report detailing the prototype design with ample, supporting analyses, testing and a complete set of fabrication ready engineering drawings. Two in-class oral presentations are used to report the groups' progress during each semester. During the last week of class each term, student teams formally defend their design before a Design Review Panel composed of practicing engineers as well as an audience of engineering faculty, students, guests and industry sponsors.

Also to be discussed are several challenges related to successfully supporting a capstone course: 1) accumulating and maintaining an adequate number of viable, funded/sponsored projects; 2) assignment of associated intellectual property; 3) effective team formation and management of group dynamics including group interactions with faculty advisors to projects; 4) properly assessing group versus individual contributions to projects; and 5) meeting the necessary space, equipment and staffing requirements.

#11956: Integrating Liberal Education and Professional Engineering Goals in Capstone Design Courses

Chiou Chen (Miami University)

This paper examines the integration of liberal education and professional engineering goals in capstone design courses at Miami University. First, the Miami Plan for Liberal Education to complement the specialized studies in student's major is illustrated. The course objectives, the course structure of engineering capstone design course and its methods of evaluation are then examined. The mapping of liberal education goals and capstone course objectives serves as the metric of assessment. Finally, student survey results are given to show the attainment of the liberal education and professional engineering goals.

#11997: A Capstone Software Engineering Project Class for the Modern Era: Emphasizing Requirements and Testing

John Bowles (University of South Carolina)

Capstone courses usually ask students to develop something and demonstrate that it works. Such projects complement engineering curricula which are strong on design and analysis but they may not prepare students for the economic realities in which businesses now operate or for modern professional practice in which the development of the project requirements, implementation, and testing may be spread across several teams or even companies. Over the last several years we have developed a capstone software engineering project course in which students work in teams of four or five students and each project is done by a pair of teams. One team (called the customer) develops the requirements for a product, a second team (called the developer) builds the product to meet those requirements; then the customer team tests the completed product against the original specifications. We believe this approach to a capstone project class results in better, more complete requirements, more thorough testing, and an overall higher quality product.

#11999: Capstone Design Course-Quality Control

Jie Chen (Indiana University Purdue University Indianapolis)

The goal of our capstone design course is to bridge the gap between classroom teachings and real world engineering. The design process serves as the guide, which link the two. Completion of the project is imperative for both student learning and industry. Thus, it is critical to develop a mechanism that guides the seniors through the entire design process within the class time frame. The process includes interaction with customers, development of specifications, development of concepts, identification of the best concept, completion of the design, and validation of the design. However, with other course commitment, the students are likely to be distracted and may fail to finish the assignments. To ensure success, project management and quality control become critical. We have developed a mechanism to deal with this issue. As a result, 95% of the design projects were completed.

#12000: Impact of Curricular Revision on Senior Design Projects and ABET Accreditation at a Hispanic Institution

Mark Lau and Sastry Kuruganty (Universidad del Turabo)

Seeking and maintaining accreditation by ABET (Accreditation Board for Engineering and Technology) is perhaps the most important commitment of most undergraduate engineering programs in the nation. Engineering departments utilize a variety of instruments to demonstrate the compliance of their engineering programs with the ABET requirements. Among these instruments, senior or capstone design projects are in many respects the most critical components. The complex and multidisciplinary nature of such projects makes them the most ideal evidence to showcase the quality of students' work and the fulfillment of program objectives and learning outcomes.

In this paper, we present the circumstances that led the electrical engineering faculty of the School of Engineering at Turabo University to undertake an ambitious curricular revision of the program. Turabo University is a Hispanic minority serving institution of higher education, and as such, it faces many of the challenges and predicaments of similar institutions in the country; but at the same time, Turabo offers many opportunities through its bilingual, i.e., English and Spanish, engineering programs to diversify the engineering workforce of the nation. The university's student population is classified as 100% Hispanic and comes mostly from low-income families in the surrounding communities, and over 84% of the students rely on Pell Grants and other federal aids to pay for tuition.

The José Domingo Pérez School of Engineering was established at Turabo University with an entering freshmen class of 75 students in the 1990 fall semester. The principal mission of the school is to produce truly bilingual engineers to serve the regional, national, and global needs in the engineering profession. The engineering program began with baccalaureate offerings in mechanical engineering and presently offers baccalaureate programs in mechanical, electrical, and industrial and management engineering with a combined enrollment of 705 undergraduate students. Nearly 20% of the students are women. The school has graduated more than 200 mechanical engineers and electrical engineers, who are employed as members of technical staff in local industries. About 25% of these graduates are currently working in the U.S. or pursuing advanced degrees in reputed American universities. The mechanical engineering program was ABET accredited in 2005. The School of Engineering is committed to seeking ABET for the electrical engineering program in fall 2010.

The curricular revision process started in the spring of 2005 and culminated with the approval of a new electrical engineering curriculum, which became effective since the fall semester of 2006. We explain the weaknesses encountered in the old curriculum and the impact these weaknesses had on our major design experience course. We also explain the rationale for the changes proposed for the new curriculum and the expectations of the faculty on future senior design projects and our ABET accreditation prospects. Finally, we comment on the assessment plan for evaluating the quality of students' projects.

#12004: Guiding Productive (and Happy) Student Groups

Wayne Chudyk (Tufts University)

The Capstone course is a required course for accredited degree recipients, so that many students are less than enthusiastic about taking this course. Offering a productive and enjoyable experience requires preparation, guidance, and feedback.

Students' choosing their projects allows them to express their interests and expertise. It also limits the sense that they are being forced to work on a project that they dislike.

Students select from project proposals comprised of a faculty advisor's ten-minute overview and a one-page summary that lists the client(s), areas of student expertise needed, resources available, and expected aims of the project. Once all project proposals have been presented to the class, students complete and submit ballot forms. Ballot forms include the student's name and spaces for ranking their first, second, and third choices for projects as well as the rationales for being selected for each project.

Criteria for placing a given student into a group include class rank, project proposal requirements, and the student's ballot explanation of why the student wants that project. Efforts are made to spread class rank within a project, so that students from the top, middle, and bottom of the class are part of the team. No project is allowed to be composed of mainly top members of the class or mainly bottom members of the class. Different projects may need different areas of expertise. The group selected for a project includes students self-identifying as the appropriate experts needed. Information from the ballots such as courses taken and relevant summer or internship work is valuable in matching student abilities and interests with project needs.

In order to maintain a constant effort load, and to avoid the phenomenon of only working at the time of project deadline, written and oral presentations are spread throughout the semester. The rule that “everyone talks, everyone listens” is enforced by having each group member participate in their oral reports, and each class member is required to submit critical summaries all of the other groups’ presentations. Within two weeks of project selection, each student team makes a first presentation outlining their expected scope of work. The second presentation and written report occurs soon after spring break, and represents a fifty percent progress report with projections of work to be completed. The final written report and formal oral presentation is at the end of the semester. Faculty are encouraged to attend and submit comments to the course coordinator.

Each group has a faculty advisor for their project that meets with them as a group once per week during the semester in a guiding role. The project’s faculty advisor also grades each of the presentations during the semester. The course coordinator meets with the entire class once per week, and also grades each of the presentations. The course coordinator helps serve as a leveler to maintain grading fairness between groups. By providing feedback to the students during the semester, students are kept aware of how well they and their projects are progressing.

#12006: Benefits of Industry Involvement in Senior Capstone Design Courses

Jay Goldberg (Marquette University)

There are many benefits to involving industry in senior design courses. Experienced engineers (working or retired) can be guest speakers, curriculum advisors, or project consultants. Industry sponsors of design projects can provide project teams with the resources needed to construct and test prototypes. Students benefit from the opportunity to work on real-world problems of importance to industry, gain experience with project management and the product development process, and become familiar with the requirements and constraints (economic, legal, and regulatory) affecting product design. This type of industry/academia collaboration benefits the university, students, and sponsoring companies.

#12007: Equipping Students with an Engineering Toolbox in a Capstone Design Course

Alan Hansen, Stephen Zahos and Douglas Bosworth (University of Illinois)

Industries seeking engineers have increasing expectations as to how well prepared students should be when embarking on engineering practice. Any prior experience such as through internships is highly valued as it implies that the student has potentially been exposed to some real life engineering. New engineers entering the workforce may be expected to tackle many facets of engineering and to begin making a meaningful contribution as soon as possible in the execution of projects. In capstone engineering design projects we attempt to incorporate as many aspects concerning engineering practice as we believe are necessary or that we can fit into a relatively crammed course schedule. In the Industry Linked Design Project course taught in the dept of Agricultural and Biological Engineering at the University of Illinois, the concept of an “engineering toolbox” is used in equipping students with a carefully selected knowledge set that covers most of the topics and issues which an engineer may be expected to face when practicing engineering. Topics range from ethical issues and product liability to project scheduling and designing for worldwide markets. In addition, topics that could have an impact on the success of a student and his future are included, such as personal financial management and career planning. Collectively these “tools” provide students with thinking skills and knowledge that help them quickly become effective and competent engineers. These topics for the engineering toolbox are covered during a semester while simultaneously the students undertake a “real life” industry project in which they are able to apply much of what they learn.

The selection of topics for the engineering toolbox has evolved over more than ten years in accordance with industry feedback and rapid technological changes. The strong connection with industry that is required for the course has helped to ensure that it remains relevant, effective and modern.

#12022: College-Wide Senior Design Competition: A Motivating Approach

Rama Venkat, Paolo Ginobbi, John Wang, Mohamed Trabia, Henry Selvaraj, Nader Ghafoori, Walter Vodrazka and Laxmi Gewali (University of Nevada Las Vegas)

Up until five years ago, capstone senior design project in the Howard R. Hughes College of Engineering, University of Nevada, Las Vegas, was mostly an individual student effort. Students were not necessarily expected to produce a working prototype by the end of one year capstone course. With a view to encourage commercially viable interdisciplinary and motivate the students to bring out their creative spirit without fear of lack of resources, our college began a college-wide senior design competition at the end of every semester. The competition is sponsored by Harriet and Fred Cox, a local philanthropist. The departments of Civil and Environmental Engineering, Electrical and Computer Engineering, and Mechanical Engineering offer two-course sequence senior design courses. By the end of the first semester, students should finalize their design and present a budget for creating a prototype in the second semester. Typically, a project is funded up to 85% of its total cost. At the end of the second semester, students have to participate in the competition by presenting their project along with a poster summarizing the highlights of their design. The projects and the posters are evaluated by three or four engineers from the local industry. The criteria for evaluation are: (i) innovation, (ii) potential for commercialization/ implementation, (iii) technical merit, (iv) clarity and soundness of the project, (v) oral presentation and (vi) poster presentation. Interdisciplinary projects are given a separate award. Additionally, the judges are given the opportunity to provide us their thoughts individually and collectively as a group. The evaluation data and comments are passed back to the students as a constructive feedback. Prize monies raging from $2500 to $500 along with medallions are awarded to the winners in an industrially sponsored “Senior Design Dinner” event in May, every year. This event is usually attended by about 300 local entrepreneurs and engineers and features an entrepreneur as a keynote speaker. The data is also used as one of the tools of external evaluation of our undergraduate degree programs for ABET purposes. Based on our past experiences, we are in the process of developing a Technology Commercialization Minor. We will also encourage students to participate in a state-wide Business Plan competition.

#12175: Transitioning To a Two-Semester Capstone Design Sequence in Mechanical Engineering

Keith E. Rouch, William E. Murphy and Vincent R. Capece (University of Kentucky)

Prior to 2005, the Mechanical Engineering capstone design experience at the University of Kentucky consisted of a one-semester course, with one hour of lecture per week, During this semester, students were expected to complete a sequence of formation of a team, selection of a project, preparation of a project plan, generation and selection of concepts, final design, and preparation of a final report. In some cases, a prototype at some level was developed. Two separate courses included the ethics and safety components of design.

After extensive review of approaches at benchmarks, we transitioned to a two-semester sequence beginning in Fall 2005. This paper will review the process of planning and evaluation, and identify the most significant issues that arose during the transition.. The curricular development was accomplished in conjunction with faculty at an extended campus, to meet needs of students at that location as well as at the main campus, and this process will also be described.

#12177: Comparison of Two Project-Based Capstone Design Teaching Approaches

Scott Morton and David Walrath (University of Wyoming)

There are a variety of models for capstone design courses, and prior to the spring 2004 semester the model used by the Department of Mechanical Engineering (ME) at the University of Wyoming was one or two person teams with projects that were self or department funded. The students were required to fabricate and test their designs. Starting with the spring 2004 semester the model changed to 100% externally sponsored projects. Sponsored projects were drawn from five sources; corporate sponsors, the University of Wyoming Research Products Center, a NSF assistive technology grant, individuals who wanted a concept developed, and to a limited extent faculty research projects. The students are still required to fabricate and test their designs.

Advantages in using sponsored projects include significantly increasing per student project funding, providing "real world" project experience, increasing interdisciplinary participation, increasing average team size, and providing client interaction. The gains move the ME capstone design experience closer to the Accreditation Board for Engineering and Technology, Engineering Accreditation Commission (ABET/EAC) guidelines, which state: "Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political." Disadvantages of this change include reduced student project choices, increased consequences for "failed" projects, increased difficulties with team dynamics, and increased faculty work to secure and manage sponsored projects.

Through experience with the two capstone design course models, better project selection and management criteria are being developed. Three general project selection criteria are now being applied to projects. These are the character and temperament of the sponsor or the sponsor's representative, the estimated project material costs per student, and the estimated difficulty of arriving at and fabricating a reasonable solution to the design project. The best sponsors are reasonable, amiable persons that have a good grasp of the concepts involved with their projects. Ideally, they must be willing to let students explore the problems on their own, yet be able to supply some firm guidance. The cost per student generally must fall within a certain range to have projects that are neither too easy nor too difficult. The judgment of experienced faculty on the feasibility of the various projects has become an increasingly important factor in weeding out undesirable projects.

Various project management arrangements have been tried with mixed levels of success. Two that were most successful involved assigned project managers. One manager was a volunteer from the Laramie community, who spent considerable time in working with the students. The second manager was a student team member who assumed project management responsibilities as part of a UW Business College management class in which he was enrolled.

#12178: Mobile Robot Control as a Multiple Disciplinary Project: A Capstone Experience

Jian Peng (Southeast Missouri State University)

This paper detailed the experience of a capstone design project: controlling a mobile robot to perform a search-and-retrieve task. Four students worked on different aspects of the project including mechanical, electrical, and software design and implementation. During the course the design was modified several times, yet we managed to achieve the design goal with good team and time management and, most importantly, hard work.

#12182: Combined ME / MET Capstone Projects at Montana State University: Organization Issues, Case studies and Lessons Learned

Robb Larson and Vic Cundy (Montana State University)

The Mechanical and Industrial Engineering (M&IE) Department at Montana State University is among the largest departments on the 12,000+ student campus. The 600+ student M&IE Department houses three ABET-accredited four-year undergraduate degree programs: Mechanical Engineering (ME), Mechanical Engineering Technology (MET), and Industrial Engineering (IE.) Each independent program has dedicated faculty with shared administration and office staff. Course sequencing is organized per individual program goals and accreditation requirements, with some cross-disciplinary offerings available as elective or required courses.

The ME and MET capstone courses are each organized conventionally into a two-semester sequence. Each course is staffed by an instructor responsible for lectures and course organization. Each course requires student teams to apply a formal design process to solve industry-sponsored engineering problems. Faculty advisors are assigned from a pool of faculty members representing the appropriate program. The first semester subject matter emphasizes design process application, alternative creation and evaluation, analysis, and documentation culminating in a formal oral presentation. The second semester features prototyping and testing, culminating in a “Design Fair” exhibition of results.

Over the past two years, capstone course instructors from the two programs have collaborated to assign multi-disciplinary student teams to several appropriate projects. The benefits expected from merging these two disciplines was very appealing: Combination of the more extensive analytical training of ME student participants with the applications and manufacturing focus of MET students seemed to increase the likelihood of project success, and in any case would more closely resemble the teaming approach favored by industry. The program coursework featured and the aptitudes of students drawn to each program results in notably different student skill-sets, so the project teams theoretically would be equipped to draw upon the strengths of both groups.

This relationship has usually resulted in projects beneficial to students, faculty and sponsors. However, many challenges are present. Some are primarily logistic in nature - e.g. difficulties in scheduling class meetings and in finding fabrication space for the relatively high-resolution prototypes. These have historically not “stopped the show” but sometimes require creative handling. Other issues include:

- Making accommodations for different levels of formal design process training between ME and MET students.
- Variations in evaluation and grading within a project team, based on the faculty advisor’s and course instructor’s discipline-specific student expectations.
- Different levels of faculty familiarity with elements of the two programs, varying levels of faculty acceptance, and buy-in to the notion of combined project work.
- Analytical training differs between the programs, so ME students often dominate design and analysis tasks during the first semester. The MET program includes welding and

machining training, so MET students often assume a greater fabrication role during the second semester. This workload and skills imbalance renders grading difficult and generates frustration among student team members.

- Prototype fabrication questions involving the desired resolution of the resulting parts (rudimentary vs. complex) and the ability of all students to participate in fabrication effort.
- Sponsor proprietary rights, nondisclosure agreements, patent issues, sponsor expectations, funding, budgeting, sponsor involvement, and other issues common to any sponsored project.

Case studies examined include projects which generally fulfilled expectations for combined ME/MET groups, projects that fell short of expectations, and failed projects that were abandoned mid-stream. Lessons learned from two years of experimentation yielded guidelines on project and faculty supervisor selection, highlighted the need for advance sponsor agreements, and clarified details of the extensive coordination required by instructors. Finally, the benefits and pitfalls of this unique approach to engineering capstone instruction in the ME and MET programs are discussed.

#12186: A Management Structure for Multidisciplinary Capstone Design Projects

Roy McGrann, Colin Selleck and Matt Laferty (Binghamton University (SUNY)

Although students have a wide range of technical skills when they enter a capstone design course, they are often unable to successfully employ the basic teamwork and negotiation skills required to work within a multidisciplinary team. The management structure of a capstone design course is one of the factors contributing to student learning of teamwork and negotiation skills.

Approximately one hundred and forty students from three disciplines (Computer Engineering, Electrical Engineering, and Mechanical Engineering) participate in the two-semester capstone design sequence at Binghamton University. The projects are a design-and-build sequence. Students are assigned to projects based on their technical skills and the skills required for the project. The types of projects include those sponsored by industry, service organizations, and faculty, as well as IEEE, ASME, and SAE national student competitions. Occasionally, there are projects sponsored by students themselves. Around thirty-five projects are approved each year.

The course is structured with two primary course instructors (usually one from the mechanical engineering department and one from electrical/computer engineering department). Each of the project teams is also assigned a faculty advisor. Industrially sponsored projects usually have an industry representative who acts as point of contact.

Students arrive in these multidisciplinary projects with different technical and professional skills, both as individual students and as students from different disciplines based on the particular engineering curriculums. This course is designed to help students negotiate cultural and disciplinary differences, solve disputes, make group decisions, and manage a project.

This paper describes the management structure and procedures of the courses. The process of project solicitation, selection and approval is presented. In addition, the procedure for assigning students to teams is discussed. The integration of a teaming-skills module, based on experiences in other courses, is proposed.

#12222: Capstone Design in Materials Engineering at Iowa State University

M. Hogan and E. Martin (Iowa State University)

This poster will present an overview of the sequence of Materials Design courses required of the Senior undergraduates (approximately 30 per year) in our program. The past, existing and near-future structure of the courses, their objectives, and their efficacies will be presented.

The required course sequence is currently two sequential terms of semester-long industry-sponsored, faculty-mentored, small-group projects concurrent with various seminars. The industry projects this year included topics such as the restoration/conservation of zinc printing plates (Iowa State Historical Society), the evaluation of laminate composite adhesives for their ultrasonic inspectability (Bell Helicopter), and studies of the fracture toughness of a giant magnetostrictive alloy for use in sonar applications (Etrema Inc.). The in-class seminars were on topics such as theory and practice of design, ethics and professional practice.

In the 2007-2008 academic year the sequence will become two more specialized courses. The first course focusing on classroom-based study of the fundamentals of the design process including intellectual tools and information sources, with “canned” small projects and assignments for class subgroups. [The textbook “Engineering Design: A Materials and Processing Approach” by G.E. Dieter was adopted this year[1].] The second in the sequence will focus primarily on matching small groups of students (3-4) with existing materials-based problems. The group project topics focus on technical problems being experienced by our industry contacts, affiliates, and on-campus research laboratories.

Case studies of past industry-sponsored projects and recurring challenges associated with the same will be discussed.

#12223: University and County Working Together via a Capstone Project: Focusing on Recycling Facility and Green Community

Matthew Sanders (Kettering University)

The Department of Industrial and Manufacturing Engineering (IME) at Kettering University requires a Capstone course for all of its graduating engineering students. Because of unique Cooperate Education (Co-Op) Program at Kettering University, these graduating students have a minimum of two and a half years of work experience and senior standing prior their enrolment in the IME Capstone Course. This Capstone Course entails a project which provides an opportunity for the students to use their classroom knowledge and their Co-Op work experiences to solve a real world open-ended problem. Open-ended problems are very challenging to accomplish in a traditional classroom setting, but allows the students to work in a team environment to solve a problem that has many solutions.

In the Fall Term of 2006, Kettering University's Industrial and Manufacturing Engineering department teamed up with Genesee County, in the State of Michigan, for their capstone project. Genesee County was interested in knowing if it would be feasible to built and operate a Material Recycling Facility (MRF) within the county. The county also wanted to know what type of corporate structure the MRF should be (private, public, non-profit, or joint venture), how should it be funded, and who would buy the recycled material. These are just a few examples of the types of questions the county needed answered. The results of the students' investigation were presented to the County Solid Waste Implementation Committee members along with their recommendations. Furthermore, the students were required to submit their final written report to the University and the Commission.

This paper will outline the initial steps that the Capstone Professor took in order to establish the project to the County and initial problem statement that was given to the students by the customer, the Professor, and the Commission. The paper will also explain the steps that the students took to tackle problem statement to explore possible solutions for the county. The discussion will show how the students applied their findings to produce several recommendations for Genesee County.