

2007: TOWARD A COMMON STANDARD RUBRIC FOR EVALUATING CAPSTONE DESIGN PROJECTS

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Liz joined Penn State in 1999 after 11 years as a design engineer with a defense contractor (HRB Systems/Raytheon) and 5 years in a technology start-up (Paragon Teechnology). She has been an instructor in the electrical engineering capstone class (EE403W), and in conjunction with the E-SHIP Minor, has sponsored capstone projects for ME, EE and CSE students to do new product development projects. In Spring 2007, Liz taught the capstone class for the E-SHIP Minor with two projects which combined engineering design, commercialization feasibility analysis and customer needs surveys.

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Professor Ochs joined Lehigh in 1979 as an assistant professor of Mechanical Engineering, was promoted to associate professor in 1983, and to full professor in 1990. From 1996 to the present he has directed Lehigh's campus-wide Integrated Product Development (IPD) program. He is member of the ASME and past chair of the Entrepreneurship Division of the ASEE. In 2006 he received the Olympus Innovation Award for his leadership in entrepreneurship education.

Toward a Common Standard Rubric for Evaluating Capstone Design Projects

Abstract

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.

Introduction

The need for a quality capstone design experience is universally recognized by engineering educators, employers, ABET and the professional engineering societies. In addition, most students view the capstone design experience as their primary opportunity to engage in an open-ended team-based project and to utilize their theoretical knowledge toward solution of a real-world engineering problem. It is therefore surprising that a lack of consensus exists on how to actually define a quality capstone design experience. Furthermore, little consensus exists on the deliverables and documentation that should serve as evidence of a quality design experience.

As a counter example, consider the case of Thermodynamics, which is a course that you will find in some form within every accredited undergraduate mechanical engineering program in the United States. Because of its universal acceptance as a critical engineering science, a first

course in Thermodynamics will be virtually identical among every undergraduate mechanical engineering program. While there are a multiple popular textbooks available on the subject, a perusal of the tables of contents of these books reveals only slight differences. Moreover, as this course is typically presented in lecture format, it is understood that if a student gets good grades on several written tests, that he or she is considered to have mastered the subject. By their very nature, then, courses such as Thermodynamics (and Statics, Dynamics, Solid Mechanics, Electricity and Magnetism, etc.) have an inherent consistency that is governed by popular peer-reviewed textbooks, accepted practices of content delivery (lecture and problem sessions) and accepted practices of assessment (tests and homework).

Conversely, the standards for evaluating the quality of a capstone design project are typically developed in-house (e.g. at a department or college level) with little or no external quality control measures. Indeed, the standards by which capstone design experiences are evaluated 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 panel is to begin the steps necessary to develop a common standard rubric for assessing the quality of capstone design projects. Panelists were selected from a high-quality liberal arts institution, a comprehensive master's institution with an intense project-based learning component, a specialized integrated product development program within a research university and a large undergraduate engineering program at a research university. In this accompanying paper, each of the panelists describes the current status of the capstone experience at their institutions. Common elements of the capstone design experience are highlighted among these seemingly very different institutions, as well as the differences in terms of resources and scale of their capstone design process. The paper describes 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 performed 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. Streaming media platforms such as YouTube, with which most students are already conversant, are also presented as a convenient enabling technology for peer-to-peer assessment.

In the following sections, the capstone design experiences at the University of St. Thomas, Rowan University, Lehigh's Integrated Product Development Program and Penn State are summarized. These institutions represent a high quality liberal arts program; a comprehensive master's institution with an 8-semester design sequence; an integrated product development program that combines engineering, the design arts and business; and a large undergraduate engineering program at a well-regarded research institution.

Capstone Design at the University of St. Thomas

The UST School of Engineering provides mechanical and electrical engineering bachelor degrees. The combined enrollment in the two programs is approximately 275. Two-thirds of the students are in the mechanical engineering discipline and the remainder study electrical engineering.

The two programs are staffed by seven full-time faculty members, who work closely together to integrate courses within the curriculum. Among the integrated courses is the two-semester senior design capstone course. During the 2005-2006 academic year, approximately 45 students participated in the capstone course; these students were subdivided into ten teams. All

projects at UST are industrially sponsored and are assigned a faculty advisor and an industrial advisor from the company which sponsored the project. On many teams, both mechanical and electrical engineering students worked together on problems that spanned their individual disciplines.

UST is considered an undergraduate teaching institution and faculty expectations and workload are directed largely to the delivery of education to undergraduate students. A full-time teaching load is six courses. All faculty advise at least one capstone project. Advising a year-long project is equivalent to a single regular course.

Capstone Design at the Pennsylvania State University

The Penn State/University Park campus has approximately 5,600 undergraduate engineering students, and in the 2005-2006 academic year, graduated 1,313 students. Ten of the thirteen undergraduate engineering majors have senior capstone course requirements. In the list below, capstone courses for the majors in *italics* have a “W” suffix, meaning the course is writing-intensive, with at least 25% of the course grade is based on technical writing.

- Architectural
- *BioEngineering*
- *Civil*
- *Computer Eng.*
- *Computer Science*
- *Electrical*
- Engineering Science
- *Industrial*
- *Mechanical*
- *Nuclear*

The capstone (or senior) design projects in each department have the common features of providing students with a team-based design course which requires students to use skills and knowledge from previous courses, and specific “deliverables” across the semester. Most capstone faculty have worked in industry, and require students to provide weekly status reports, do multiple presentations (from rehearsed powerpoint to surprise verbal updates on project issues), and teach that hitting a deadline is part of meeting business expectations. Most faculty member play many roles in the capstone classes: lecturer, interface to industry, project advisor, teamwork coach, and performance evaluator.

In the list above, five majors provide students the option to work on an industry-sponsored project (*BioEngineering*, *Computer Engineering*, *Electrical*, *Industrial*, and *Mechanical*). All of the *Mechanical Engineering* projects are either industry sponsored, are projects to support product concepts from the *Engineering Entrepreneurship Minor*, or are *EPICS* (*Engineering Projects in Community Service*) projects.

Currently, the capstone courses are used by the different majors to meet specific ABET standards. However, the “map” of ABET criteria to the capstone courses varies between departments. This fact makes it difficult for a student to work on a project he/she is interested that is offered by another department. For example, special arrangements must be made to have an EE student work on an EPICS project being offered in an ME capstone class. To address this issue, and to make it easier to form multi-major teams, discussions are starting to develop and

offer a new ENGR4XX - Capstone Design course that students from different majors could enroll in with the intent to be able to work with students in other departments.

Capstone Design at the Lehigh University

Integrated Product Development (IPD) at Lehigh University is a comprehensive integrated program that focuses on technical entrepreneurship through experiential learning. The program focuses on new product/process development process as a means to the end of preparing our students to lead companies in innovation, creativity and the commercialization of intellectual property. The IPD mission is to develop a truly cross-disciplinary entrepreneurial environment and culture at Lehigh.¹ The program's objectives are student-faculty focused and include personal, interpersonal and professional development, curricula development, and facilities development and implementation. The main tenets of our program include: 1) innovation, fueled by creativity, is a powerful engine for local, national and global economic development, 2) the greatest number of opportunities for innovation occurs at the intersection of disciplines, 3) Innovation is a process, 4) the best way to learn innovation is by doing it while guided by mentors, 5) the best ways to do innovation is within a diverse interdisciplinary team, 6) entrepreneurs are needed and need to be developed to lead these teams. The IPD approach is to engage the entire campus community and attempt to have positive impact on the region, the nation and the world with our efforts.

In 2006 IPD engaged 180 undergraduate and graduate students, working in 30 teams of six students with sixteen faculty advisors and twenty-five industry sponsors. In addition Lehigh's IPD program's experiential-learning approach to capstone courses has expanded in other curricula across campus that include six student teams in Lehigh's honors program in Integrated Business and Engineering, four student teams in Computer Science and Business and six student e-teams in our entrepreneurship minor. Along with additional graduate teams over fifty student teams were actively engage in new product/process development in 2006.

Assessing the learning process is often difficult, especially in an area like entrepreneurship where objective measures are not readily available. This difficulty is perhaps exacerbated in team-based courses, where learning is, in large part, unstructured and the body of knowledge expected to be learned is variable. As a result, novel techniques need to be developed to assess the value of team-based learning. In the paper by Linn² we describe the experiences and lessons learned in assessing student performance in team-based, project capstone courses focused on technical entrepreneurship. The tools used to assess a student's performance should represent all meaningful aspects of that performance as well as provide equitable grading standards. In a curriculum that focuses on technical entrepreneurship through experiential team-based learning, there are often no paper assignments or final exams that accurately measure the learning that has occurred. What are the "gradeable" moments? Which are appropriate assessment tools for each segment of the technical entrepreneurship/product development process? What about a student's understanding of the underlying process and their willingness and ability to immerse themselves in the entrepreneurial/product development "journey"? Assessment tools developed over the last ten years including rubrics, surveys and evaluation forms, address this need and these are being constantly refined and improved as they are adapted to other capstone courses as additional curricula are developed.

The Accreditation Board for Engineering and Technology (ABET) and the Association to Advance Collegiate Schools of Business (AACSB) have both made assessment for the purpose of continuous improvement mandatory in their accreditation criteria. By developing and

implementing innovative and appropriate assessment models, programs can insure their continued achievement of the specific accreditation standards against which their programs are measured; effectively guaranteeing the future of our capstone programs and the quality of the educational experience the students will take with them into the future.³

Capstone Design at Rowan University

Established in 1996, the College of Engineering at Rowan University is composed of four programs: Chemical Engineering (ChE); Civil and Environmental Engineering (CEE); Electrical and Computer Engineering (ECE); and Mechanical Engineering (ME). Each program has been designed to serve 25 to 30 students per year, resulting in 100 to 120 students per year in the College. The size of the college has been optimized such that it is large enough to provide specialization in separate and credible programs, yet small enough to permit the creation of a truly multidisciplinary curriculum in which laboratory/design courses are offered simultaneously to all engineering students in all four disciplines.

Instead of the traditional culminating capstone design experience employed in most engineering programs, Rowan University employs a just-in-time approach to design education wherein all engineering students take a project based design course each semester called the Engineering Clinic. The multidisciplinary, project-based Engineering Clinic sequence is the hallmark of the engineering program at Rowan University. In the Engineering Clinic, which is based on the medical school model, students and faculty from all four engineering programs work side-by-side on laboratory experiments, design projects, applied research and product development. The following table contains an overview of course content in the 8-semester engineering clinic sequence. As shown in Table 1, while each clinic course has a specific theme, the underlying concept of engineering design pervades throughout^{4,5}.

Table 1. The 4-year Engineering Clinic Sequence at Rowan University.

Year	Fall	Spring
Freshman	Introduction to Engineering	Competitive Assessment Laboratory
Sophomore	Quality / Written Communication	Entrepreneurship / Public Speaking
Junior	Multidisciplinary Design Project	Multidisciplinary Design Projects
Senior	Multidisciplinary Design Projects	Multidisciplinary Design Projects

Comment: Suggestion- move "Writing" so that the W it is directly under the T in Total.

Comment: Suggestion- move this section so that the E in "Example" is directly under the E in Entrepreneurship.

Most engineering programs currently include a traditional, culminating capstone design course to meet the design needs, but this approach has some shortcomings. In a one- or two-semester long course, the need to include such varied skills as communications, project management and teamwork takes away from the focus on design skills development. Furthermore, a traditional capstone design course is not multidisciplinary, which is a valuable experience for preparing students in the workplace. Finally, since the capstone project occurs at the end of a student's undergraduate career, it does not allow students to continuously apply skills learned in the supporting coursework. The Engineering Clinic allows students to practice a wide range of engineering skills in a multidisciplinary environment while honing their design skills throughout their four-year career.

In the first semester of the freshmen year, students learn basic engineering skills and are

introduced to the variety of activities in each of the four disciplines at Rowan. In the second semester each student engages in an intense study of engineering design through reverse engineering and competitive benchmarking of a consumer product. In the sophomore year, the emphasis of the Engineering Clinic shifts toward formal training in technical communications skills and the application of design. The students are organized into “corporations” that design and build products using advanced design and prototyping tools, and they develop speaking and writing skills through embedded assignments. Professors from the College of Communication at Rowan provide joint instruction with the engineering professors during this year and are responsible for evaluating the students’ progress on achieving the communications objectives for the course.

Although it is part of an 8-semester sequence, for the purposes of the present paper, the Junior/Senior Engineering Clinic is presented herein as the capstone experience at Rowan. In the Junior/Senior Engineering Clinic the format of multidisciplinary teamwork continues with the added dimensions of year-long projects and the inclusion of both Junior- and Senior-level students in 3-5 member teams. Each multidisciplinary team works closely with one or more professors who act as Project Managers to guide the team. The faculty body includes 32 full-time members, eight from each of the four engineering disciplines. Each faculty member advises two Junior/Senior teams per semester, which is counted as 1 full time course per semester toward the course load for each faculty member.

Junior/Senior Clinic projects are inspired by a mix of industry-sponsored activities or faculty research interests, and are typically centered on a technical problem, product or process. Funding comes mainly from government and private sources in the form of industry and research grant sponsorship. Each department in the College of Engineering devotes significant time throughout the year to make industry contacts and develop proposals to seek funding for the Junior/Senior Clinic projects. Since 1998, when the Junior/Senior Clinic was first offered, the portion of projects that are externally funded have risen from approximately 20% to over 90%. In addition to the industry and grant sponsored clinic projects, approximately 4 projects per year are internally supported by the Rowan Undergraduate Venture Capital Fund, which was created to promote the development of student intellectual property. The Venture Fund has been generously supported by a series of grants by the NCIIA and private donors. To date, over \$120,000 has been raised and awarded to over 30 project teams, resulting in numerous student patents and startup companies.

Deliverables for each Junior/Senior Clinic project include a mid-semester design review presentation, final design presentation, final design report and prototype or product. Presentations include an Introduction/Background, Project Goals and Objectives, Design Development and Calculations and a Summary of progress and future work. Mid-term presentations are evaluated by at least two faculty members, and final presentations are evaluated for technical and communication merits by faculty and peer students. The final reports contain similar elements as the presentations and also must include a Technological Impact Statement that address societal, economic, and environmental impacts; sustainability; manufacturability and health and safety.

Commonalities and Differences among Capstone Design Experiences

Table 2 is a summary of the main features and deliverables of the capstone design experiences at the different institutions. The table underscores the wide variation in scale and scope in the capstone design experience at these institutions. For example, the total number of students

simultaneously engaged in the capstone design experience varies from 45 up to 670. The total number of concurrent projects varies from 10 to 134. At Rowan University and the University of St. Thomas, all faculty members supervise capstone design projects as part of their built-in course load whereas at Penn State University, approximately 33% of the faculty supervise capstone design projects. The duration of the capstone design experience varies from 1 semester to 4-semesters and, depending on the institution, the projects involve a single discipline, multiple engineering disciplines or, as in the case of Lehigh's IPD program, involve disciplines outside of engineering, such as the design arts and/or business.

The deliverables required for completion of the capstone design experience vary as well. At Lehigh, each project requires weekly team reports to the sponsor, two draft and one final team report per semester, a team binder, personal notebooks for IP documentation, a working prototype, a technical model and financial model. At Rowan and UST, the requirements include only a final written report, mid-semester and final presentations and working prototypes. The deliverables at Penn State are similar to those at Rowan and UST, but also include a project proposal and web site.

Delivery of the course also varies among the panel institutions. For example, the capstone design experiences at Rowan and UST are 100% project-based and include no formalized instruction on design or project management. At Rowan, these topics are covered in earlier semesters of their 8-semester clinic sequence. Conversely, the capstone design courses at Lehigh and Penn State devote up to 33% of course contact hours to formalized course instruction.

One issue that adds to the difficulty of standardizing the capstone design experience is the inherent difficulty associated with grading criteria in project-based learning. For programs in which all faculty members supervise capstone design projects, it is not reasonable to expect all faculty members to have similar styles of project management styles and documentation requirements (over and above the minimum requirements shown in Table 2). Moreover, since projects are initiated via wide variety of sources (industry, faculty research funding, internal sources, design competitions, etc.) there is a wide variety of differences among the size and scope of the projects themselves. The difficulty in grading standards is a source of anxiety for students as well as faculty. In a course that relies on written homework and written examinations, a "C" can be quantified analytically. But, in a capstone design course, it is much more difficult for the student and faculty to differentiate between "B" and "C" work.

Included in Appendix A is the Standard Grading Rubric employed by Rowan University for the Junior/Senior Engineering Clinic. Although it does not satisfy the objective of developing a standard rubric for evaluating the quality of the design experience itself, this rubric is used as a contract between students and faculty so that both parties recognize the definition of an "A" through "F" work. This rubric is handed out to students each semester and students are advised to work with their project supervisors to develop a clear set of objectives for the semester with multiple check points so that students can effectively gauge their performance during the semester. The positive aspect of using this rubric is that it works well for the diverse variety of project types that are found in capstone design experiences.

Table 2. Resources and Scale of Capstone Design Experiences at Various Engineering Programs.

	Lehigh (IPD Program)	Penn State	Rowan	University of St. Thomas
Students/Semester	180	670 **	240	45
Length of Capstone Experience	2 semesters	1 semester (except for Architectural Engineering)	4 semesters	2 semesters
Discipline(s)	Mechanical, Materials, Bio, Engineering minors, a few EE's and some environmental Engrs Marketing, Supply Chain Management, Business information Systems, Design Arts	BioEngineering, Civil, Architectural, Computer Eng, Computer Sci., Electrical, Engineering Science, Industrial, Mechanical, Nuclear	Mechanical, Electrical, Civil and Chemical	Mechanical and Electrical
Number of Simultaneous Projects	38	134	60	10
Avg. Students per Project	6	5	4	4
Faculty Supervisors	16	33	32	7
% of Faculty who Supervise Projects	100%	~30%	100%	100%
% Funded by External Support	100%	40%	85%	100%
Minimum Funding per Project	\$6,000 per team per year – ½ to team- ½ to IPD program overhead	\$2500/ semester for industry-related projects	\$2500 / semester	\$2000/year
Project Deliverables	<u>Each Semester:</u> -10 Weekly team reports to the sponsor - 3 tack board/ posters sessions - 2 draft team reports and 1 final report - One team binder - One personal notebook for IP documentation - 3 team and personal peer review <u>2nd semester –</u> - Working prototype - Financial model - Technical model	Project proposal, Preliminary Design Review, Critical Design Review, Final Written Report, Hardware, Web page	Mid-Semester Design Review, Final Oral Presentation, Final Written Report, Working prototype	Mid-Semester Design Review, Final Oral Presentation, Final Written Report, Working prototype
% Lecture	33% on IPD process	20%	0%	0%
% Project	66.6% implementing IPD process	80%	100%	100%

Results of the Multi-Institution Peer Assessment of Capstone Design Reports

One way to move toward a common standard rubric for capstone design experiences is to develop mechanisms to share and assess outcomes via external review. Perhaps the most appropriate candidates for evaluation are the project deliverables from capstone design experiments. In this section, the results of a pilot study are described wherein final reports from capstone design projects were exchanged and evaluated externally by peer institutions⁶. Specifically, faculty members at the University of St. Thomas (UST), Rowan University, and the Milwaukee School of Engineering (MSOE) carried out a pilot peer-to-peer assessment of student work in capstone courses. The first year of the assessment process was performed by a comprehensive review of a representative report from the capstone course. Feedback was obtained by a survey which was provided to the participating faculty.

Valuable information was obtained from the first year of the assessment. Both strengths and shortcomings of the capstone course were identified. In addition, the feedback from the assessment was mutually supportive. Common themes were evident and were incorporated into the senior design course in the following year. In addition, it was seen that a refinement of the assessment process was required to account for differences in courses at the respective universities.

The inaugural peer-to-peer assessment was performed on a UST student report from a project involving four students (two mechanical, two electrical) for the company Toro. The project involved the design, fabrication, and evaluation of a device used to sense flow maldistribution in a fertilizer spraying system. The final prototype included fluid flow sensors, controls, and a display which reported the flow distribution to the operator.

Upon reading the final report, faculty members at the reviewing universities (Rowan and MSOE) were asked to complete a survey form that was an abbreviated version of that used for student evaluation at UST. The form requested input on nine key aspects of the report:

- (1) breadth of resources used,
- (2) level of technical analysis,
- (3) appropriate use of experiments,
- (4) the design process,
- (5) project scheduling,
- (6) risk assessment,
- (7) ability to break down projects into component tasks,
- (8) quality of the written report, and
- (9) achievement of customer requirements.

In each category, the work contained in the report was evaluated on a 1-5 scale. Scores of 1 indicated no activity related to a key aspect whereas scores of 5 reflected extensive activities in an area.

As mentioned earlier, the survey results were mutually supportive. The student work generally received uniformly high or low marks in the individual categories. This finding was reassuring and suggested that the survey was effective and that the evaluations were carried out in a thoughtful, detailed manner. It was apparent from the preliminary results that differences between the senior design courses at the three universities was reflected in the product of the peer-to-peer evaluation. For instance, at UST, the primary audience of the reports are the company sponsors. These sponsors are typically interested in issues related to achievement of customer requirements including cost and scheduling targets and in the overall management of

the project and identification of future risks. There is less interest in technical details and analytical work which supports the design. As a consequence of this focus, UST student reports were generally rated below average by faculty at MSOE where a greater expectation is given on the technical content in the final report.

The result of the first year peer-to-peer evaluation led faculty at the participating universities to refine the evaluation process. The refinement is being carried out in the current academic year and is expected to lead to significant improvements to the process. First, video-recorded presentations will be included in the dossier which is subject to review. Video of student presentations will enable faculty at other universities to observe both the quality of oral presentation as well as the general environment in which the presentations are given. Second, a new survey report is being generated which will accommodate the unique aspects of each university's capstone course yet will enable a comparison study to be performed between the universities. Finally, faculty are working to develop a standard by which student work from any school may be judged. This standard will enable the establishment of "best practices" in capstone courses.

Enabling Technologies for Peer-to-Peer Assessment of Capstone Design Projects

The logistics involved in conducting a peer-to-peer evaluation of student capstone design work such as that described above can be overwhelming. It is difficult enough to find the time to grade your own student capstone design reports, let alone finding time to grade capstone design work of students from other institutions. Video presentations using streaming media platforms such as YouTube, with which most students are already conversant, provide a convenient enabling technology for peer-to-peer assessment.

Beginning in Fall 2006, a pilot project was undertaken within the Electrical and Computer Engineering Department at Rowan University wherein all Junior/Senior Engineering Clinic projects were given the option of creating a YouTube video of their final presentation in place of the standard PowerPoint presentation. Specifically, the student teams were encouraged to upload their presentations – which may be a mix of PowerPoint slides, movies of laboratory experiments or field work, Matlab simulations, etc. to YouTube. The YouTube presentations are limited to 10-minutes, which students can augment with an additional 5-minutes of "live" interaction with the audience. The department owns two video cameras, which are lent out – however, we have noticed that most students have ready access to video capture equipment and editing software. Faculty advisors ensure that the content is appropriate before the students are allowed to upload their videos. There several benefits in using this approach –

- The presentation is hosted and archived off-campus – no server-space issues arise.
- The YouTube video links can be provided on the department website – which is an excellent recruiting and publicity tool. Prospective (and current) students are extremely familiar with the technology.
- It is relatively easy to keep the department website current – all that is required is to update the links. Also, YouTube has a time limit on hosting the videos – so old content automatically expires.
- Students and faculty members from different institutions can compare and contrast the quality of their capstone design experience to those at other institutions.

Appendix

Common Grading Guidelines for Jr/Sr Engineering Clinic

The following are general guidelines for establishing grades for the Junior/Senior Engineering Clinic. These guidelines are further detailed in specific departmental grading guidelines and criteria that will be distributed by your Discipline Managers.

Grade	Guidelines
A	<ul style="list-style-type: none"> • Exceed Expectations • Take charge of the project and generate tasks from goals and objectives. • Think independently, ask questions and make suggestions. • Develop original solutions by combining theory and/or analytical techniques that demonstrate a mastery of engineering science and/or design principles from one or more supporting engineering courses. • Demonstrate the ability to engage in lifelong learning by applying engineering science and/or design principles that are not covered in your supporting engineering courses. • Complete all project deliverables and objectives. • Effectively communicate (via written, oral, engineering drawings, etc.) project deliverables to your project manager and/or external sponsor. • Exhibit consistently strong team and individual performance in terms of project deliverables and objectives as well as laboratory safety, team skills, record keeping, punctuality, etc.
B	<ul style="list-style-type: none"> • Take charge of the project and do all of the work that you are asked to do. • Ask questions and make suggestions. • Develop solutions by applying theory and/or analytical techniques that demonstrate a mastery of engineering science and/or design principles from one or more supporting engineering courses. • Complete all project deliverables and objectives. • Effectively communicate (via written, oral, engineering drawings, etc.) project deliverables to your project manager and/or external sponsor. • Exhibit strong team and individual performance in terms of project deliverables and objectives as well as laboratory safety, team skills, record keeping, punctuality, etc.
C	<ul style="list-style-type: none"> • Do all of the work you are asked to do. • Develop solutions by applying theory and/or analytical techniques. • Complete all project deliverables and objectives. • Communicate (via written, oral, engineering drawings, etc.) project deliverables to your project manager and/or external sponsor. • Exhibit average team and individual performance in terms of project deliverables and objectives as well as laboratory safety, team skills, record keeping, punctuality, etc.
D	<ul style="list-style-type: none"> • Do some of the work what that you are asked to do. • Complete some of the project deliverables and objectives. • Ineffectively communicate (via written, oral, engineering drawings, etc.) project deliverables to your project manager and/or external sponsor. • Exhibit poor team and individual performance in terms of project deliverables and objectives as well as laboratory safety, team skills, record keeping, punctuality, etc.
F	Do very little. Don't show up.

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