Incorporating Engineering Challenges into Capstone Design and Senior Project Courses

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Abstract

The Engineering & Design Department of Eastern Washington University (EWU) recently added a Mechanical Engineering (ME) degree to the existing Mechanical Engineering Technology (MET) program. The ME program is more theoretical and requires more advanced mathematics where the MET program is more hands-on with mathematics requirements up to Calculus II. However, the programs are taught side-by-side and complement each other. When we developed the ME program we wanted to maintain as much of the strong hands-on aspect of MET program as possible. Therefore, we teach the required Capstone Design and Senior project courses with a mix of ME and MET students. Prior to creating the ME program, we taught these courses to a mixture of MET, Applied Technology, and Manufacturing option students where the emphasis was given to product development and completion of a small production run. With the development of the new ME program, we decided to teach these classes with a combination of ME and MET students and take advantage of the strong research and development approach. We designed the stronger R&D approach to expose the MET students to applications of the theories taught to the ME students. On the other hand, we expose the ME students to the hands-on shop skills involved in prototype development taught to the MET students. We have taught these courses four times with the new R&D focus, and would like to present our findings and plans.

Literature Review of Capstone Projects

Yousuf and Mustafa [1] at Savannah State University conducted a capstone project that dealt with Electronic Name Tag (ENT) system that can be used for conferences, visitors' badges, and other purposes. The basic project requirement was to design and build an ENT system using the PIC16C57 microcontroller. The main objective of the project was to familiarize students with Embedded Systems, which is a combination of computer hardware and software, and additional mechanical and electronic parts. Students were required to design the system to perform a dedicated function. The 3D modeling software called Autodesk Inventor was used to design and assemble the case for the ENT system. Students provided the formal presentation with the opportunity to conduct tests with a Stamp Microcontroller, PBASIC compiler and other interfacing devices. This capstone project was implemented within one semester in the Department of Engineering Technology in Spring 2012 for the Civil and Electronics Engineering Technology majors. This project served as a reference for providing students with challenging and exciting hardware and software design experiences that are involved with various fields of 3D modeling, electrical, and physical layout design concept. It provided opportunity for both faculty and students to work in an application oriented environment.

Gene Dixon [2] described how to formulate capstone project problem statements, and how to assess and evaluate them. Formulating a problem statement in any engineering project seems challenging for senior capstone students. Gene described the findings from a qualitative exploration of problem statements and problem statement assessments and evaluation directed at determining what characteristics are valued in developing a problem statement. The exploration was undertaken in an effort to align faculty and students in understanding the value and content of a quality design problem statement for use in a two-semester senior design capstone sequences. The research found that problem statements and associated characteristics vary with programmatic requirements and preferences. In order to understand the rigors of developing problem statement skills across industry and academia, a survey was conducted among academicians and industry sponsors to determine the key points desired in a quality problem statement. A simple questionnaire was developed and distributed to the capstone community. This community was primarily developed from academics and their willingness to invite industry contacts. Participants included capstone instructors/coordinators, and capstone sponsors as well as other industry representatives. The survey was initially developed to gain insights on how to structure both pedagogical materials and assessment rubrics to improve the capstone experiences for senior design students.

Bannerot et al. [3] identified some of the issues and their resolution associated with the development and implementation of a new, one-semester, interdepartmental, multidisciplinary capstone design course involving the seniors from four engineering programs at the University of Houston. The revised course curriculum incorporated the usage of website to enhance information transfer, use cohorts to modularize the large number of students and teams, use a studio/critique teaching format, integrate communications professionals into the teaching of the course, and allow students to be involved in establishing the final expectations for their project. The "studio/critique" teaching environment provided a less threatening environment which allowed students to informally discuss their projects. This also encouraged teams to discuss common areas of concern with other teams, and provided opportunity for teams to become acquainted with other projects. Students reacted positively to these changes in the course. Subsequently, all projects were completed in satisfactory manner.

Alan Cheville [4] outlined what aspects of design projects lead to successful capstone design experiences for students at Oklahoma State University. The author reviewed six years of evaluation data on Electrical Engineering capstone projects and outlined several characteristics of "successful" capstone projects. One characteristic included projects that were able to be repeated, or iterated, several times during the semester in which the project was conducted. A second characteristic of successful projects were that they did not fall to either extreme of the technology readiness level (TRL). The third characteristic is that projects did not draw on knowledge beyond which students had been exposed to or outside the discipline. For this capstone study, success was defined as a project that was judged by both students and faculty to have been completed successfully, allowed meaningful contributions by most students on a team, and satisfactorily met written/or oral reporting requirements.

Nuttall et al. [5] developed capstone projects at California Polytechnic State University, where student leadership sought industrial collaboration. While models for including industrial partners in capstone projects are common, these models focus on faculty leadership in developing industry partnerships. Conversely, the authors developed capstone projects that encouraged students, not faculty, leadership in engaging industry partners. Factors that influence successful project teaming of students and industry partners are identified and described using case study examples. Dave and Dong [6] at University of Cincinnati discussed one of the capstone design projects where students had to build a Basic Utility Vehicle (BUV). Students were required to complete the design, build and test phases as requirements of Senior Capstone Design class. This project was geared to meet the needs of developing countries for an affordable transportation. The BUV competition was sponsored by IAT – Institute of Affordable Transportation, a non-profit organization in Indianapolis, IN. The BUV project offered Mechanical Engineering Technology students the opportunity to develop the additional skills needed to be successful in a team oriented business world. Students enjoyed the personal satisfaction of working on a technically complex project from concept to a final working vehicle, and competing against other university teams.

Introduction

The EWU Engineering & Design Department is composed of four programs – Mechanical Engineering and Technology, Electrical Engineering, Applied Technology, and Visual Communications Design. The Mechanical Engineering program at Eastern Washington University (EWU) grew out of the Mechanical Engineering Technology Program, a program accredited for over twenty years. EWU approached the Washington State Legislature in 2002 to allow Bachelor of Science in Electrical Engineering (BSEE) programs to be taught at additional universities. House Bill 1808 was approved and signed into law by the governor on July 27, 2003. Shortly after this, and given the success of the BSEE program, a Bachelor of Science in Mechanical Engineering (BSME) program was applied for and approved. The first graduating class of 7 students was in the spring of 2012. As a result of this new program, the Capstone course in the already existing MET program faced some drastic changes in both content and objectives.

Prior to establishing the new BS ME program, a typical Capstone class included MET and Applied Technology students and focused mainly on production. Twenty-five specimens were originally required, and then we dropped the number to fifteen a few years afterwards. The type of projects performed reflected the nature of the Applied Technology and MET programs, both of which are primarily hands-on programs. Much emphasis was on production, quality control, and timely delivery. When possible, we considered industry projects and gave them higher priority over school-sponsored ones. Traditionally, the department has maintained a close relationship with the local industries. Because of this collaboration, many industry-sponsored Capstone projects came to be. In the absence of industry-sponsored projects, we offered the students the option of choosing an appropriate project. Experience has shown that when students choose their project, they tend to be much more dedicated and enthusiastic about the outcome. The project itself must satisfy a set of standards before it is approved. In addition, the course content itself should satisfy the University's and the Department's requirements for Capstone Design. Since this course is a culmination of their education, they take the course late in the program, during their senior year. The students have a total of ten weeks to execute and present the project. The number of students per team is governed by the nature of the project, groups of as few as four and as large as ten are common. Each team is also required to nominate a president, vice president, and treasurer. We took student majors, backgrounds, and interests into account to ensure that the teams formed are diverse enough to allow a successful completion of the project. Funding for these projects comes from student fees, and in case of an industry-sponsored project, from the industry.

In addition to the actual product, a thorough and comprehensive documentation of the process is required. A Capstone final report is required from each team at the time of presentation. This report goes beyond a simple chronological review of the process to include a study of the availability of comparable products on the market, financial viability, layout design of an ideal production line, company bylaws, safety, and training, as well as the necessary technical data of the product itself (drawings, plans, parts description and numbers, inventory, workflow etc.). This should ensure that the students are familiar with the many aspects of production that go beyond the manufacturing process.The teams present their work to fellow students, faculty and industry members. The students' final grade is a combination of their performance in tests, the quality of the product and the final report, peer evaluations and faculty/industry final presentation evaluations.

The decision to change the Capstone course from a "Production Laboratory" to a "Research and Development Project", to better meet the needs of the MET and ME students, was first implemented in the fall of 2010. This was possible because the course was split into two separate Capstones, an R&D based course for the MET & ME students and the traditional production based course for the Applied Technology students. During the 2010-11, the new R&D capstone course was taught to the MET students since none of the ME students were sophomores and juniors. The switch to an R&D focus allowed the department to reach out to industry partners to work on their back burner projects. The new R&D Capstone course requires only one working prototype. The changing nature of the projects required the students to learn new concepts and build on knowledge acquired in their courses. Critical thinking was emphasized, with modeling and numerical simulation encouraged as part of the design and analysis effort when possible. The students often had to research topics that they had not seen in class and learn how to use some modeling software for the first time. The final report is still required, however, the emphasis shifted from production to R&D while retaining many of the remaining requirements. The final project is presented by each team to students, faculty and industry representatives.

Experience to Date

Capstone Fall 2010

The fall of 2010 was the first time we offered the revised Capstone course that focused more towards research and development than production. There were twenty students enrolled that were divided into two groups. The groups were a mixture of MET and Electrical Engineering majors (there were not yet any senior ME students in this new program). The first project consisted in analyzing the transient thermal response of a complex body experimentally and using Finite Element Analysis. The second one consisted of designing and building an earthquake simulator with a data acquisition system. We describe both projects in more detail below.

The first project examined a small, aluminum, weed-wacker engine block as the test piece. The engine block and the rapid prototype is shown in Figure 1. The students measured the engine geometry and developed a computer model. They then checked the validity and accuracy of the modeling by generating a 3-dimensional print using our rapid prototyping system. Next, they modeled the heat flow in the block using both numerical and experimental methods. The numerical method used the finite element analysis (FEA) software ANSYS to perform the transient response with constant parameters. The experimental approach involved placing thermistors in selected places on the engine block to measure the temperature using a student developed acquisition system. The entire project took nine weeks, from brainstorming to execution. Some of the students had some experience with heat transfer, while others did not. This project exposed the students to new concepts and processes including advanced heat transfer analysis, dimensioning and creating a computer model, use of FEA, placing thermistors and developing appropriate data acquisition systems. The lack of analytical solutions to such a problem presents an additional challenge to the students, as it does not allow for a theoretical solution. The results obtained from the FEA analysis and experiments were discussed.

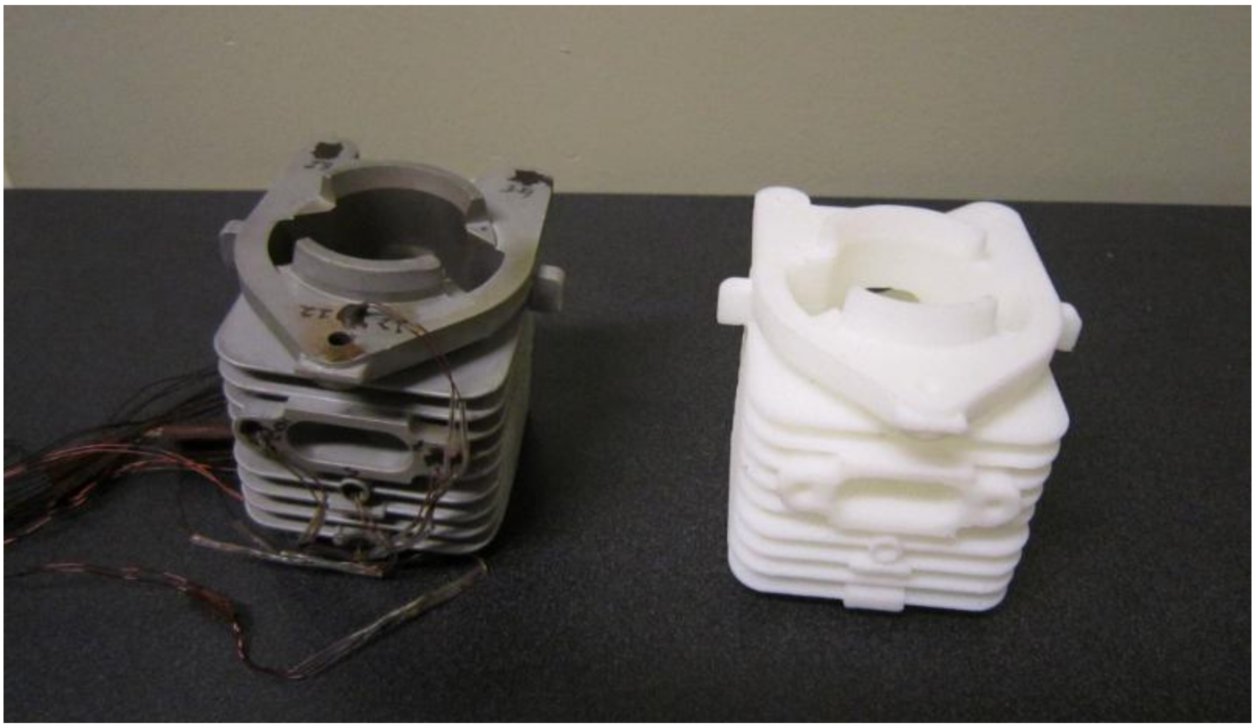

Figure 1: Engine block and rapid prototype used for Senior Capstone in 2010.

The second project involved designing and building an earthquake simulator. It consisted of a base that can vibrate at an adjustable frequency. A thin vertical metal strip was fixed to the vibrating base to simulate a building. The students placed accelerometers on the base and at several spots along the metal strip, which was fed through a USB port to a laptop computer. The resulting accelerations were recorded and analyzed in an Excel spreadsheet. The students compared the response of the metal strip to the literature and discussed the results. The theoretical analysis of the response of a mutli-degree of freedom dynamic system is rather complex and requires additional mathematical concepts not covered in the MET program. The students faced two additional challenges. Data acquisition and analysis was not a topic familiar to most of the students. However, the presence of EE students helped the MET students get a better grasp on the topic. The response of the multi-degree of freedom response of the metal strip represented the second major challenge. Both EE and MET students do not have the necessary background to fully analyze the problem, and as a result, these topics had to researched and understood. Only one prototype was required, which was successfully completed.

The students' feedback on both of these projects was very positive. The challenges faced were theoretical as well as experimental. While we offer both Heat Transfer and FEA analysis as electives, vibrations and systems dynamics are both new concepts to the MET and EE students. Having to learn these theories quickly and learn how to implement them in an actual physical setup turned out to be a great challenge. It most certainly tested the ability of students to research, understand, and implement new theories and concepts in order to solve a well-defined engineering problem.

Sr. Project Winter/Spring 2011

Our senior project course can be very similar to our Capstone design course in that groups of students undertake an R&D project. The major difference is that they can undertake a larger project because they have more time – either two quarters or full time over a summer. During the 2011 winter/spring term a group of six students undertook a project to redesign and test the shipping package for a heavy cutter head sold by Freeborn Tool in Spokane, WA.

Freeborn Tool contacted the E&D Department to see if we could assist them after reading about the success of a previous project in the SME Chapter 248 newsletter. They ship the 50 – 60 lb cutter heads, as shown in Figure 2, to their customer in the Midwest and get them back for sharpening and refurbishment after two weeks of use. Their current packaging was a welded steel box that they found held up to the abuse of multiple cross-country trips. However, the shipper now required that all packages be covered in corrugated cardboard that rarely survived one trip. The project goal was to develop a packaging system that was lighter, covered in corrugated cardboard, and would survive multiple cross-country trips.

Figure 2: Freeborn Cutter Heads

The team visited Freeborn to better understand the issue and then spent time brainstorming the problem and investigating materials. They developed the packaging concept and modeled the stresses using finite element analysis for several loading conditions to determine the optimal material type and thickness – thick enough to protect the part, but thin enough to minimize the weight. Freeborn machined the end caps based upon the team's AutoCAD drawings and the team developed a mold and process for casting polyurethane around the central tube. They then assembled a couple of prototypes, loaded them with a mockup of the cutter head and conducted drop tests in the shop. This was used to refine the design, retested, and then shipped cross-country and back where it was

Figure 3: Prototype Shipping Container

found that shop test was more severe than shipment. Freeborn hired one of the students for the summer to assist with production of enough of the new boxes so they could use them for all of their shipments. The revised shipping container is shown Figure 3.

Capstone Spring 2011

We taught the Spring2011 ME/MET Capstone course in collaboration with the Electrical Engineering Capstone. There were twelve student teams working on various projects, most of which were based upon ideas brought forth by the students. The ones with the most ME/MET focus included:

- Development of a demonstration jet engine from a turbocharger,
- Analysis and fabrication of a composite hockey stick,
- Fabrication of a Pelton wheel to recover energy from low flow water sources,
- Data transmission and decoding from a rocket,
- Initial development of a rocket motor thrust stand, and
- An improved case hardening method for tractor treads.

The team sizes and complexity of these projects varied a great deal. Here we will discuss the project proposed by Spokane Industries to develop an improved method to harden the wear surface on the track pads they cast for one of their customers. The previous method involved two workers using torches to heat the pad area to be hardened and then quenching the entire pad in water. It took approximately ten minutes to heat the pad area and they could only quench one pad an hour without overheating the water, which would result in an inadequate quench.

The original plan after meeting with the client was to add cooling to the water tank to improve the throughput and optimize the torch design so that a single worker could place the burner head and run the process. However, a literature search brought the progressive quench process [7] to the team's attention and they decided to pursue it. They configured a progressive quench head from an acetylene torch and water spray head to demonstrate that the process would achieve acceptable hardness. They then modeled heating and cooling of the part in ANSYS to determine how fast the head could be moved over the part and achieve the proper hardness. Once this was completed, they mounted the quench head on a Fanuc robot as shown in Figure 4 and developed a program to move it over a mock up of the track pad. The remainder of their project involved conceptual development of a method to move the track pads into place for case hardening, the ladder logic to support the system, and the budget for implementing the system. The results were well received, but have not yet been deployed due to the relatively high capital cost.

Figure 4: Progressive Hardening Torch Tip [7]

Senior Project Winter/Spring 2012

The students are engaged in several projects including:

- Completion of the test stand of rocket propellant, which was started during Capstone last year,
- Development of data capture hardware for temperature, pressure, force, etc. that resolves some of the issues that are most problematic for ME/MET students, but still requires calibration,
- Measurement of the shear properties of several typical fin composites used in amateur rockets and determination if the fin flutter equations published for larger fins made from more homogeneous materials still hold for the these smaller, heterogeneous fins,
- Development of FEA models for the vibration of MEMS beams as a function of the density and viscosity of the fluid in which the tips are immersed.

Capstone Spring 2012

The Spring 2012 ME/MET Capstone Course had four projects that were all supported by local industry or government organizations.

The Naval Surface Warfare Center, Acoustic Research Detachment, on Lake Pend Oreille approached the department with an excellent long-term project. The Navy has buoys placed on the lake and most of them are old and need repair. More importantly, these buoys, designed for the seas, do not have the capability of capturing the higher wave frequencies encountered on lakes. Since most of the electronics are outdated and can be improved, a heave sensor capable of measuring these frequencies were designed and built from scratch. This particular part of the project was scheduled for the Spring 2012 quarter. In addition, we are considering the following improvements for future projects; a more efficient solar panel and energy storage system, wind sensor (speed and direction), temperature sensor, pressure sensor, data acquisition and storage system and a wireless transmitter.

Two projects came from Matrical Bioscience, a company based in Spokane, WA. This company specializes in the development of products aimed at the life-science research field. One of their products is a fully automated low temperature storage unit. This unit is designed to pick (or retrieve) an array of small plastic test tubes, scan the bar code on each tube, and store it in the low temperature chamber for retrieval when needed. The test tubes are labeled with a 2 mm square QP code that needs to be read in order to be able to locate them. The company is currently using a high-end scanner and software that are very expensive. In order to cut costs, a scanner was built by the company and cheaper software used. However, their prototype was not 100% successful – it could read some, but not all of the bar codes in the array. Our ME/MET students involved with this project explored improvements in the optical conditions so that the cheaper software can be used which will reduce the cost of the scanner by a factor of 80%.

The second project from Matrical Bioscience, involved designing a shaking table station that will test the effectiveness of product packaging. Due to the nature of the products delivered, it is important to make sure that the packaging can survive the shipping. The table must be sturdy enough to support two hundred pounds and have a variable frequency and amplitude. This station must also be capable of testing the package for the standards of most shipping companies (USPS, UPS, FedEx, etc.). The students involved with this project designed and build a prototype shaking table for conceptual testing. The table included accelerometers to allow data acquisition.

The final project was an accelerometer package developed for the Spokane County Sheriff's Department to aid in accident investigation. The students developed a low cost, compact package that used a 2-axis accelerometer, Arduino UNO board, and two-line output display for less than $200. The team tested the system with a Detective from the Sheriff's Department and found it to perform as well or better than the $1,000 commercial package that the Department previously borrowed from another agency when needed.

Ongoing Efforts

Currently, the E&D Department is working with the Education Department to develop a green building that can serve as a classroom as well as a living laboratory. The building is designed to be completely autonomous and will have solar power (both for heating passively as well as electricity generation), energy storage, power generating wind turbine, exterior walls with different types of constructions and insulation, automated shutters and HVAC system, and temperature and wind sensors. This is a great opportunity for Capstone students to be actively involved in the design of many of these features. Furthermore, this facility will have multiple laboratories associated with it, especially in the heat transfer and thermodynamic courses.

The Winter/Spring 2013 Senior Project will be starting shortly and proposed projects include:

- Characterization of solid rocket propellants in collaboration with the University of Idaho and a chemical component manufacturer,[8 and 9]
- Measurement of the dynamic forces during opening of the parachutes typically used in hobby rocketry to determine the required strength for lines and recovery harnesses
- Testing of the fin materials evaluated last year by flying rockets at progressively higher speed until the fins catastrophically flutter. This will require development of a system to protect and recover the recording electronics when the rocket becomes unstable during supersonic flight.

The interests of one of the authors (Professor Weiser) and the former student who conducted the 2011 Spring Capstone rocketry project drive the two rocketry projects (and there are two more awaiting future students). A common thread of these projects is that they require hands-on research that pushes the students beyond their classroom and other background.

Assessment

The Capstone course transitioned from a production laboratory prior to the 2010-11 academic year to the current R&D focus starting in 2010-11 had a significant impact on some of the course objectives. The course objectives are listed in Table 1 for the production laboratory, the 2010-11 transition year, and the most recent year. Examination of the table shows that this was an evolutionary process where the objectives were adjusted to meet the new requirements. In addition to the transition of the capstone course we added a 2 credit course on Contracts, Patents, and Ethics in this time frame to both strengthen our program upon the advice of our Industrial Advisory Board and to insure that the students are familiar with corporate structure after the capstone transition. It should also be noted that the students had to complete their lifelong learning portfolio during 2010-11 even though it was not one of the official course objectives.

We use a range of assessment tools during the capstone course including but not limited to team efforts via the design reviews, final report, and final presentation along with individual efforts via peer evaluations, ethics tests, a paper on constraints, and the lifelong learning package. The instructors use these to evaluate how well the students met the course objectives while the students complete a survey to evaluate how well they felt the course met the objectives. EWU uses a decimal grading scale of 0 to 4 and we use the same scale in the overall course and program assessments. Subjective criteria are evaluated using the 5 point Likert Scale as shown in Table 2. Averages are reported using the same system as EWU uses for grades 0 and 1.0 to 4.0 with an increment of 0.1.

Table 1: Capstone Course Objectives – Sorted by Current R&D Order

Production Lab 2009-10 and earlier	**Transition to R&D Focus 2010-11**	**Current R&D Focus 2011-12 & later**
		1. Create a Research & Development Plan for a project or device.
2. Explain product design and development process	2. Explain the product development process and the role of marketing	2. Explain the product development process.
6. Define professional ethics and explain its role and expectations		3. Understand the importance of Engineering Constraints and Ethics on the Product Development Cycle
3. Demonstrate cost accounting, cost control and the engineering economic decision process used to design and develop a real-world project	3. Demonstrate cost accounting and cost control in development processes	4. Demonstrate cost accounting and cost control in development processes
4. Demonstrate effective multidisciplinary team building and team dynamics	4. Demonstrate effective team building and team dynamics	5. Demonstrate effective team building and team dynamics
7. Plan, design, implement, analyze, and improve a product and production process	6. Complete a prototype build, then analyze and improve upon the process	6. Complete a prototype build, then analyze and improve upon the process
8. Prepare effective technical presentations and documentation for the design project	7. Present the final project in an oral presentation	7. Present the final project in an oral presentation
10. Demonstrate an appreciation for Lifelong Learning and its role in an engineer's career		8. Develop a resume, cover letter, and lifelong learning plan
1. Describe the different types of companies and advantages/disadvantages of each	1. Describe the different types of companies and advantages/disadvantages of each	
5. Organize a corporation with bylaws, and articles of incorporation	5. Organize a corporate with bylaws, and articles of incorporation	
9. Demonstrate independent learning by using unfamiliar tools and processes to design, evaluate, verify and implement a project.		

Table 2: The 5 Point Likert Scale used in this work

Description	Score
Very Satisfied or Excellent	4
Satisfied or Good	3
Neutral or Average	2
Dissatisfied or Poor	1
Very Dissatisfied or Not Observed	0
Not Applicable	Not Included

Figure 5 plots the instructor's evaluation of how well the students met the course objectives during the two years prior to and 2 years after the transition. Figure 6 shows the student's perception of how well the course and instructor covered these objectives during the same period. The scores for those objectives that were evaluated during a given period ranged from 2.4 to 4.0. The overall average score for both the instructors and students was 3.3 although the instructor's evaluations were significantly more variable.

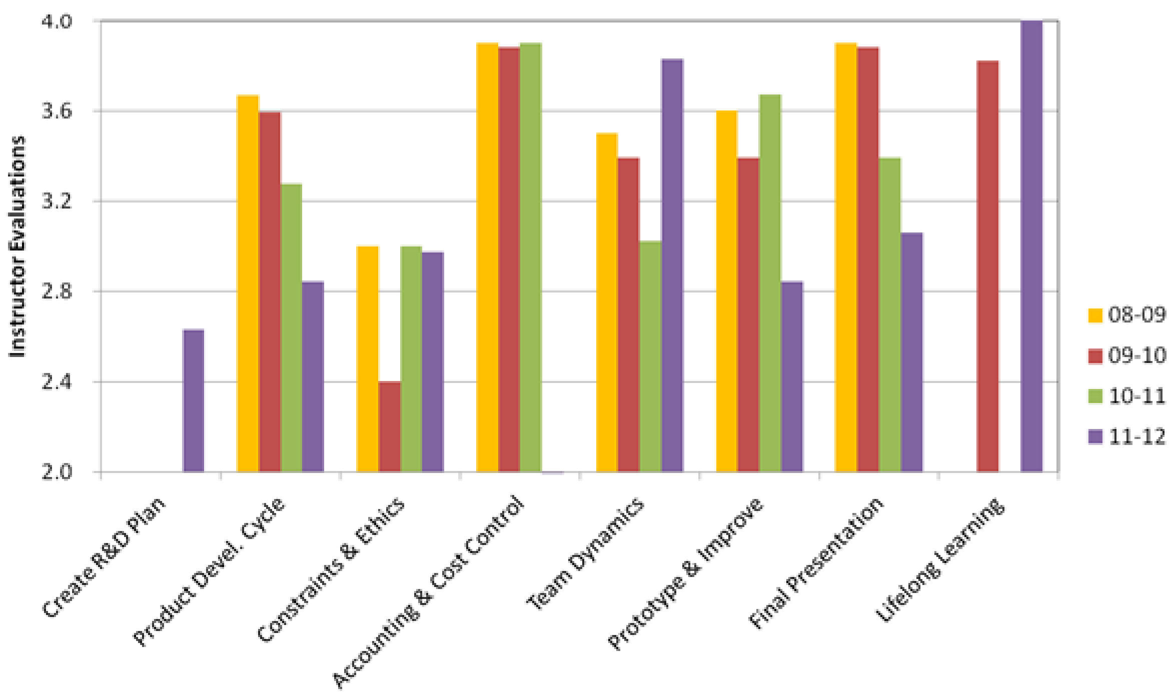

Figure 5: Instructor's evaluation of how well students met the course objectives.

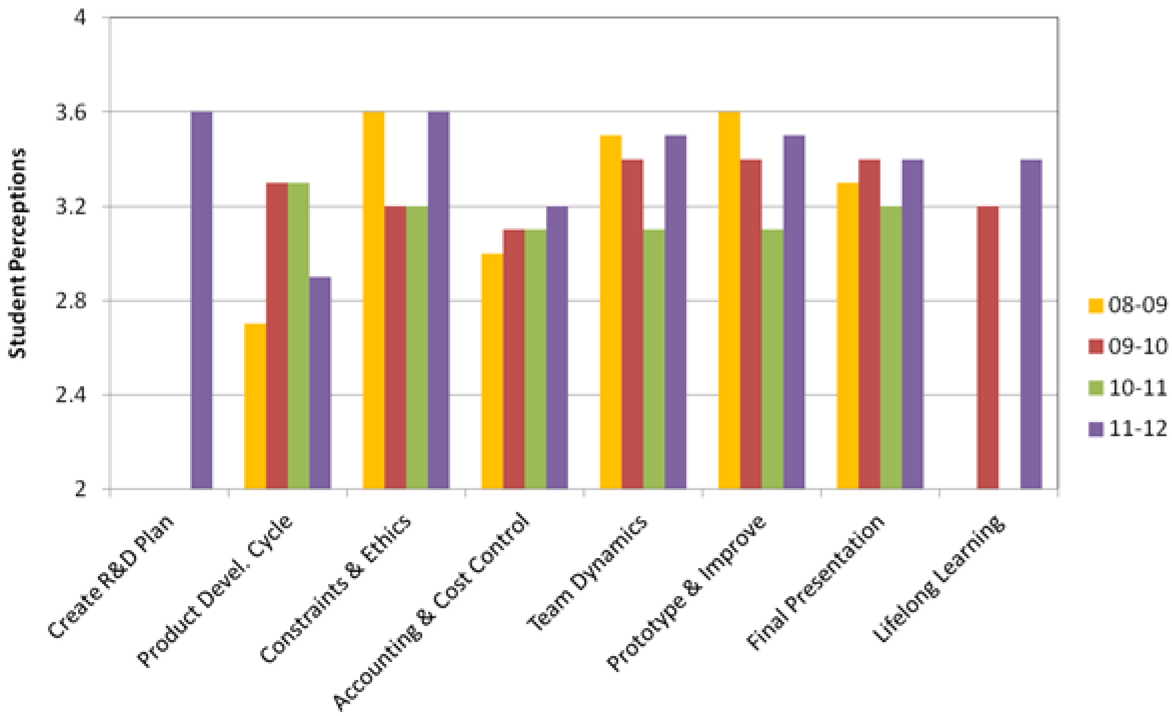

Figure 6: Student perception of how well the course and instructor met the course objectives.

Both the student and instructor scores are more consistent during the production laboratory period (08-09 and 09-10) than during the initial R&D period (10-11 and 11-12). Some variation is expected during such a transition, but there are several factors that we believe increased the variation as listed below.

- This was a period of very strong growth for the ME/MET program with the declared majors increasing from 130 to 170.
- The 10-11 capstone course was taught in the fall using a pair of well-defined project by Professor Saad who had taught this course before and in the spring using several student defined projects by Professor Weiser who had not taught it before.
- Capstone was only taught during the spring during 11-12 and the instructor had to step aside due to illness and it was covered in an overload mode by two instructors (all authors of this paper)

The most significant trends were that the instructors saw a decrease in evaluation of the student's demonstration of their knowledge of Product Development Cycles, Prototype & Improve, and Final Presentations while the student perception remained nearly constant. We attribute this to an increase in the instructor's expectations as we transitioned to the new R&D format, so it appears that we need to spend more time working with the students to insure they meet these higher expectations.

In addition to the evaluation of the course objective presented above we also conduct an exit survey for the program during the capstone course. This is a survey for the entire 2 – 4 years the students spend in the EWU ME/MET program, but the results tend to be driven somewhat by their capstone experience since they are spending a large part of that term immersed in the project. This is summarized in Figure 7 and shows improvement in some of the more technical aspects of the ME/MET program areas and decreases in some of the softer skills such as communication. A portion of the increased student perception in the technical skills is probably due to additional math and engineering courses required in the ME program. Analysis of the results for the first three exit survey questions showed an average of 3.5 for the ME students and 2.9 for the MET students so there is a moderate, but not statistically significant difference for this small sample that will need to be monitored and acted upon in the future.

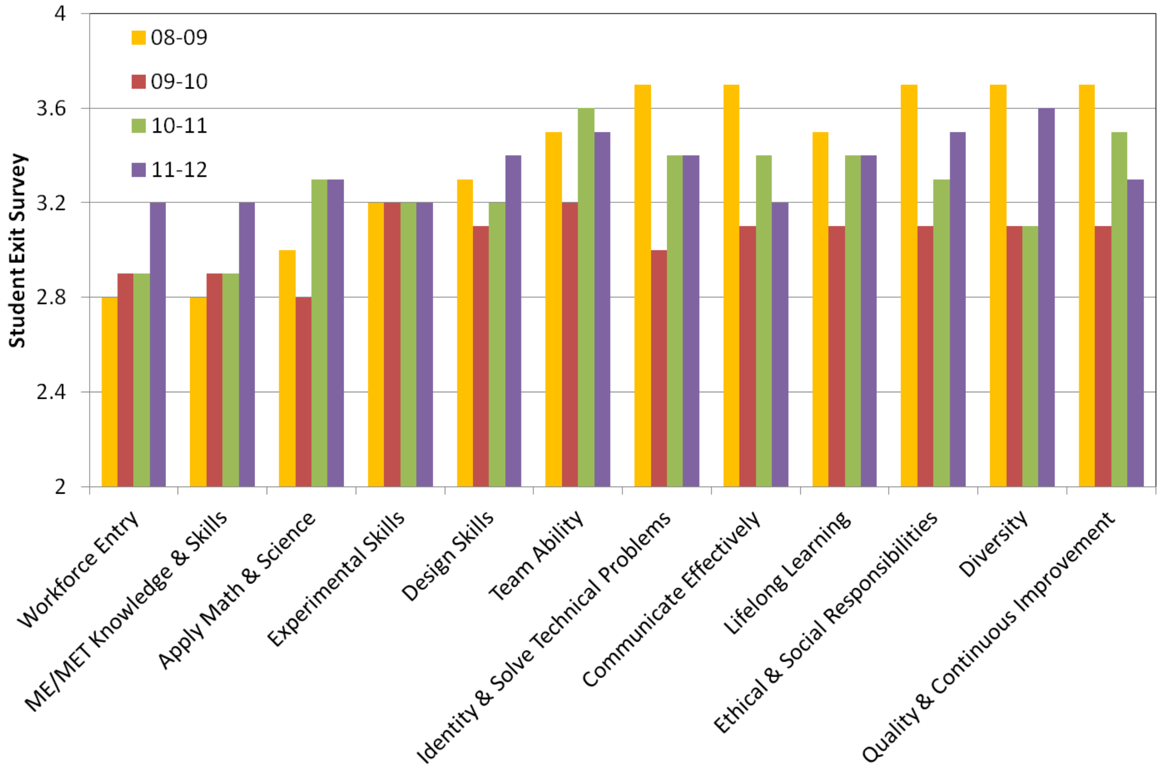

Figure 7: Summary of student responses to the exit survey conducted for ME and MET students during the capstone course.

Future Plans

After conducting the R&D version of the combined ME/MET Capstone course over the last 2 years, we have determined that one quarter (10 weeks) is not enough time to complete the projects at the desired level. During the spring 2013 term, we will offer two sections of the ME/MET capstone course. Officially, one will be for ME students and the other will be for MET students, but we will encourage projects that are based upon teams of ME and MET students. The addition of a second faculty member with additional laboratory/shop time will facilitate the fast pace of the quarter system. We have submitted the paperwork to convert both the ME and MET capstone courses to a two quarters sequence and anticipate that this will be approved for the 2013-14 academic year. Winter quarter will focus on research and design of the project so that materials and supplies can be obtained before the start of the spring quarter. This will allow the students to fabricate their first prototype at the beginning of spring term and have time to go through at least two evaluation and improvement cycles before they have to prepare their final report and presentation.

The transition to a two-quarter capstone sequence will make it much easier to address some of the weaknesses that were uncovered during this analysis. Using the first quarter to focus on research, addressing constraints, project development will improve the student's understanding of these key aspects of the R&D cycle. Having the second quarter available to do two or more prototype build and test cycles will further strengthen understanding of the R&D cycle and allow the students to develop their presentation with instructor and peer feedback in a more informal setting than the formal final presentation to other faculty and the industrial partners.

Conclusions

We have determined that that projects need a certain level of complexity to meet the R&D goals, but one quarter is not long enough. We are currently looking to expand the Capstone Design course to two quarters. The first would focus on the developing the concept and researching the literature to determine what has been done in the past while the second will focus on developing and testing the prototype. We already do this to some extent in our Senior Projects course, but this would be new to the Capstone Design course.

The R&D projects over the past two years have forced the students to expand their horizons beyond the classroom and are the future for our program. The key is finding projects that engage the students, engage local industry, and we can manage given the time and resource constraints that we face. We are aware of other schools that conduct similar projects for industrial partners for a significant fee, but those fees are beyond the current reach of many of our partners. Perhaps as we demonstrate the utility and quality of our student's efforts we can obtain a larger buy-in from our partners and other funding sources.

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