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## **AC 2011-2789: USE OF CAPSTONE DESIGN PROJECT IN UNDERGRADUATE MATERIALS AND MANUFACTURING AND EXPERIMENTATION COURSES.**

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Richard B. Griffin, Ph. D., P. E. (TX) has been a faculty member at Texas A&M University since 1977. He earned his BS at Pennsylvania State University (1964) in Metallurgy/Metallurgical Engineering, and his PhD at Iowa State University (1969) in Metallurgy. His expertise is in the area of materials where he has taught and done research for more than 30 years. Dr. Griffin has worked in various areas of corrosion: erosion/corrosion, SCC cracking of high strength steels, and corrosion under organic coatings. He has also worked in tribology where he studied the compound wear process. For almost a decade, he was a member of the Foundation Coalition team, which developed and implemented freshmen and sophomore engineering programs at Texas A&M University. Recently, Dr. Griffin has helped in the establishment of a branch campus of Texas A&M University in Doha, Qatar. He has received the Texas A&M University Association of Former Students Faculty Distinguished Achievement Award for student relations, he has received a NACE Technical Achievement Award, and this spring he received a Halliburton Faculty Fellows Award. He is a member ASM ASEE, and NACE. Since 2008, Dr Griffin has been the Program Chair for Mechanical Engineering at Texas A&M University at Qatar.

## Use of Capstone Design Project in Undergraduate Materials and Manufacturing and Experimentation Courses.

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### Abstract

Texas A&M University has had a combined materials and manufacturing course (MEEN 360) that includes a design component and an experimentation course (MEEN 404) that requires students to design, build and analyze an experiment. A variety of different projects have been used during the years the courses have been taught.

This year, one of Texas A&M University at Qatar Mechanical Engineering (MEEN) capstone design projects is the Shell Eco Marathon (SEM) urban concept car. The students will participate in the contest held in Germany during the later portion of May 2011. The senior class size is less than 20 people, and they required help in completing the design. The management team for the SEM car project provided potential design projects related to the car to students in MEEN 360 and MEEN 404.

The resulting design projects will be evaluated with respect to their impact on the undergraduate course that it is being used in and how it supplements the senior capstone design class. Samples of student projects will be included in the paper.

### Introduction

Texas A&M University at Qatar (TAMUQ) is a member of the Texas A&M University System. The students earn the same degree as the students at Texas A&M University (TAMU) at College Station. TAMUQ earned full ABET accreditation independent of the main campus in the fall of 2009. Our next ABET visit will be in 2014. The curriculum is the same at both locations. There has been a junior Materials and Manufacturing course taught in the fall of the student's program for more than 10 years. The development of MEEN 360 has been documented at prior ASEE meetings. The topics covered and the laboratory activities were discussed at ASEE Annual Conference.<sup>1, 2, 3, 4</sup>

MEEN 404 is generally taken during the first semester of the student's senior year. In this course, students must design, build, test, and evaluate two to three experiments. Generally, the experiments build in complexity from one to three or

more independent variables. The students must develop the experiments themselves.

The Shell Eco-Marathon urban concept car was selected for MEEN's capstone design project for the 2010-2011 academic year. The team will participate in the European contest in May 2011. This is MEEN TAMUQ's second time in developing and automotive project. However, this will be the first time that a vehicle is taken to a competition. The class has 14 students in it and the instructor and the team project leaders thought that the senior capstone class could use help in the design process for some elements. Another teaming element incorporated in the class was by having a portion of the design team include students from the main campus. This was done because one TAMUQ-MEEN student was enrolled at the College Station campus. The three faculty decided to offer the students in MEEN 360 and 404 the opportunity to work on design activities that could potentially help the senior students in the capstone design class (MEEN 401, fall semester and MEEN 402, spring semester).

It is worth noting that most of the students in the MEEN 404 course were enrolled in the MEEN 401 course. By coordinating activities between the two courses it would allow the students to work on experimental elements that could support their design or for future testing needs. Entering into the SEM project was not seen as a one off project, but it is hoped that this could become a legacy project. Therefore, by enlisting the MEEN 360 students early, it is hoped that interest will be generated for future involvement. Additionally, the bigger intrinsic benefit of engaging the MEEN 360 students is that they will have a foundation in the design methodology. Also, the design methodology extended into the MEEN 404 class and this helped reinforced the design process. In some aspects, the MEEN 404 students were their own client.

#### Procedure

For MEEN 360, the team leaders from MEEN 401 came to class and made a presentation of what their needs were. Table 1 lists the seven projects that were presented.

Table 1. Projects give to MEEN 360 students by the senior capstone design class.

Projects	Component
1	simple chain and sprocket
2	material for an engine mount
3	steering system
4	Rims of the SEM vehicle
5	roll bar
6	exterior shell
7	bars that serve as the chassis main building units

A more complete description of each project is given on e-learning (A&M's electronic learning interface).

Examples of the project statements are given below.

**“Project 4**

The rims of the SEM vehicle need to be ductile, light, and able to withstand cyclic loading. The rims surface should be uniform and smooth, to increase the effectiveness of the rotation. Price and availability of the rims are important factors as well. Your job is to select the material of the rims.

**Project 6**

The shell eco-marathon is a competition where college students are given the opportunity to design the most fuel efficient car. An important part of the vehicle is the exterior shell. The shell is important since it protects the vehicle components and the driver from impact. Also, for a fuel efficient car, the shell should reduce drag as much as possible by having a low surface roughness. The shell surface will have curves rather than straight edges for aerodynamic purposes. An appropriate material and manufacturing process needs to be selected for this shell design.”

The 16 MEEN 360 students worked in pairs and were allowed to list the top two projects of their choice. Six of the seven projects were chosen and two, the roll bar and the exterior shell, had two groups of students working independently on the same project.

Because of the small class sizes and uniformity of the curriculum, most of the senior MEEN students are in several classes together. For example, of the 14 students in MEEN 404, 12 of the students were also in the capstone MEEN 401 class. The faculty met early in the semester to coordinate on potential projects from 404 that could “feed” into the 401/402 design project. The students in 404 agreed to the cooperative nature of the projects. The first project was a uniform experiment meant to be a common platform allowing introduction of an

experiment proposal, construction of an apparatus, execution of the experiment, and writing a report detailing results of the experiment.

The student teams then developed proposals for experiments germane to the EcoMarathon project. Most teams consisted of three members with one two person team. The projects selected are shown in Table 2.

Table 2. MEEN 404 Projects for Fall, 2010.

Project	Description of Multi-Factor Experiment
1	Studying Factors Affecting Drag Coefficient on Different Car Models
2	Effect of Heat Treating Heat Affected Zones Resulting from Welding
3	Effect of Braking Pad Area and Braking Arm Length on Braking Torque
4	Three-Point Bending Testing of Tubular Chassis Frame Members
5	Factors Affecting Rolling Resistance of Small Footprint Tires

For MEEN 404, the projects all tied very tightly to the 401 project. In all cases, the students working on these projects were also active in the 401 capstone project and saw the applicability of what they were doing to support their design project.

The students had about five weeks to do the project. In MEEN 360, the students were required to turn in weekly progress reports. They were encouraged to interact with MEEN 401 students. In most cases relatively limited contact occurred. The last week of the semester, the MEEN 360 students went to the MEEN 401 class room and made their presentations.

A separate set of questions was prepared for the MEEN 360 and 401 students. Examples of the questions are show in Tables 3 and 4. Fourteen MEEN 360 students responded. The number of meetings between the two classes was one to many with the average being two meetings. Eight out of 14 students in MEEN 360 thought the MEEN 401 students were helpful, while seven of the 14 students indicated the MEEN 401 students were not able to supply the information that they requested. However, 13 of the 14 students recommended continuing the activity.

A similar set of questions was asked of the MEEN 401 students; however only five of the 14 students returned the questions. All five MEEN 401 students responded that the MEEN 360 students had contacted them and that the results were helpful. Although, two of the five commented that the results were too late. The five MEEN 401 students said the students did an adequate job and four of five recommended continuing the activity

Table 3. MEEN 360 evaluation form.

Design Project

MEEN 360 has been cooperating with the Capstone Design Project, MEEN 401, by providing design information to individual groups working on the Shell EcoMarathon car. The following questions are intended to help us determine the benefits of this type of design project approach

Design Project Title \_\_\_\_\_

1. Did you have any contact with the MEEN 401 students about the design project?
  - a. How many times did you have contact? \_\_\_\_\_
  - b. Would you briefly comment on what was discussed?
2. Were the MEEN 401 students helpful?
  - a. Why or why not?
3. In your opinion, were the MEEN 401 students' able to supply the information that you needed?
  - a. Why or why not?
4. Would you recommend this type of design project in the future for MEEN 360?

Table 4. MEEN 401 evaluation form.

Design Project

MEEN 360 has tried to cooperate with the Capstone Design Project, MEEN 401, by providing design information to individual groups working on the Shell EcoMarathon car. The following questions are intended to help us determine the benefits of this type of design project approach

Design Project Title \_\_\_\_\_

1. Did you have any contact with the MEEN 360 students about the design project?
  - a. Would you briefly comment on what was discussed?
2. Were the MEEN 360 students' results helpful?
  - a. Why or why not?
3. In your opinion, did the students do an adequate job?
  - a. Why or why not?
4. Would you recommend this type of design project in the future?
  - a. Why or why not?

Discussion

Both sets of students recommended that the project be continued. However, to be most useful, the results needed to get to the MEEN 401 earlier in the semester. An

interesting comment that came from the MEEN 401 students was with regard to determining or estimating values. They appreciated what the MEEN 360 students had done and they felt that it helped them.

The senior students had to identify areas that would benefit from having additional people look at a design issue and then prepare need statements for the resulting design projects.

From the instructor's perspective, the project was useful because it helped make junior MEEN students aware of what the capstone design class was doing. The difficulties in obtaining information and making yourself clear as to exactly what was needed became apparent.

As stated earlier, essentially the same set of students taking MEEN 401 was also taking MEEN 404. Thus, the experiment based projects that were developed in the MEEN 404 laboratory course were explicitly designed to mesh with the MEEN 401 Capstone project. Any survey instrument would not have revealed any deeper relationship. However, the students were clearly able to see how a complex project (design of a concept vehicle) could be broken into smaller and more manageable pieces to facilitate analysis and design.

The perspective from the MEEN 401 instructor's standpoint is as follows. Enlisting the MEEN 360 teams made the MEEN 401 students become the client. The fact that the MEEN 360 students were able to come up with reasonable estimations and feasible designs although their "client" provided limited and vague information gives them an excellent foothold of experience when they do enter into the capstone design class. Also, a couple of the divisions did reference the work done by the MEEN 360 class in their final report. There was a challenge for the MEEN 401 divisions to integrate the results from the MEEN 360 class into their final end of semester reports. For the MEEN 404 involvement a few of the divisions were able to generate results that helped them with their design selection and they did reference their MEEN 404 results in their final report.

## Conclusion

Junior engineering students helped in the SEM design project by selecting materials and manufacturing processes for the Shell Eco-Marathon car. The instructors' opinions were that the activity was useful and contributed to a better understanding of the design process and the interactions required.

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<sup>4</sup> R. B. Griffin, K. T. Hartwig, R. Barber, T. New, and I. Karaman, “Development of a Deformation Processing laboratory,” National Educators Workshop New: Update 2001, Oct. 2001, College park, MD.