

2006 Mechanical Engineering MQP/Capstone Review
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The Mechanical Engineering Department intends that MQPs satisfy the goal stated in the WPI catalog. Projects “should demonstrate application of the skills, methods, and knowledge of the discipline to the solution of a problem that would be representative of the type to be encountered in one’s career.” Most ME MQPs are certified by advisors as satisfying the capstone design requirement. However, the ME Department does not discourage basic research or theoretical analysis.

Several outcomes may be found within a given MQP. Again, we do not expect that each project will demonstrate all such outcomes, but hope that a majority does.

PROCEDURE

Particular items were emphasized:

- Is the report written at the level of an entry-level professional?
- Was this a group project?
- Were modern engineering tools used within the project?
- What was the level of experimentation and/or realization within the project?
- Did the project truly satisfy “capstone design”? Was the design in thermofluids, mechanical systems or both?
- Would the project serve as an integrative experience in mechanical and/or thermofluid systems?

For this review, all 59 projects completed in 2005-6 were randomly divided to be read by one of two reviewers. A meeting was held to discuss the focus of the review and to agree on levels associated with each rating. A meeting was also held at the end of the reviewing to discuss general trends.

For this review, the team did not have sufficient outcome sheets submitted by advisors to use them with any statistical significance. The practice of having faculty submit these sheets at the completion of each project should be reinforced.

FINDINGS

Grading

Grades were assembled by aggregate for all completed ME MQPs. The reviewers did not know which grade a particular project received. The grade distribution, consistent with 2003, was as follows:

A 76%
B 16%
C 8%

This is not unreasonable based on the quality of the project reports, but the reviewers suspect that grading remains inconsistent among faculty. Some standardization of expectations might be helpful particularly since a student expectation of high grades exists.

Team Work

One of the Department's stated goals is that students should be able to work in a team. We encourage this within the MQP but do not require it. The 2001 review showed that 97% of all our projects involved at least two team members, which was a dramatic increase from 79% in 1999. However, 2003 and this year found a shift back to single member projects. While a large number of projects involve single students (20%), only 7.4% of students work in this mode. The mean team size is 2.8 students per project and the mode is 3 students. Anecdotal evidence points to more single student projects in the fifth year of study or at some off campus centers. Smaller projects tended to be analytical in nature. The following shows a distribution by size for all ME projects.

	% of Total Projects	% of Total Students
1 student	20%	7%
2 students	19	13
3 students	44	48
4 or more students	17	32

Written Communication

All students should produce a report of the quality expected from an entry-level engineering professional. No project report was found to be seriously weak in terms of writing and organization. Of the 59 reviewed projects, 89% were rated good or better; this is consistent with 2003 which showed a steady improvement from prior reviews.

A continued difficulty is finding clear statements of Objectives and Conclusions. Many projects do not reflect upon what they accomplished or tried to accomplish; rather they tend to dive into analysis and never evaluate their findings.

In addition, Web literature searches have become even more dominant, even to the exclusion of archived journals or books. Online searches for research articles should emphasize reviewed journals, not just Web pages that may or may not have scientific basis.

Modern Tools

Fully 75% of projects are using modern computer tools of one type or another, including Matlab, TK Solver, Labview and A/D data acquisition, CAD, CAM, and FEM. Other tools include high end sensors, microscopy, and materials testing. It is likely that more projects actually employ such tools, but this is not evident directly from the reports.

Capstone Design

Capstone Design must involve some evidence of most of the following elements: open-ended need for a device, system, or process; problem definition and the establishment of

design criteria; the creation and review of alternative designs; analysis; and comparison to design criteria for critique and refinement.

The department needs to continue its discussion of what constitutes design and what is acceptable as Capstone. The reviewers decided to use a simple yes/no scale in the same way that the advisor must.

Some 72% of students should have met capstone design requirements; this is a significant decline from 2003 (85%). It was noted that many of these non-design projects were single students, including those working off campus. Some of these were outstanding theoretical analyses but not design in nature. There continues to be a disproportionate number of non-capstone in materials and manufacturing; the former are often experimental, and the latter may be system design (process or plant layout) but the elements of design are not clearly found.

Thermofluid Capstone	26%
Mechanical Capstone	46%
NOT Capstone	28%

It is not known what fraction of the projects was certified as Capstone by the advisor of record.

Elements of Design

Before the 2003 review cycle, the ME Department voted that each Capstone experience should address a majority of the following elements: Economics, Environmental Impact, Sustainability, Manufacturability, Ethical, Social or Political Issues.

Most of these were not appropriate to many of the projects reviewed. In very few cases were any of these addressed in any meaningful manner. In a few cases, Economics was used as a design criterion. While these topics may have been discussed during the project experience, they were not documented in any way. Based on reports only, some 18% of students seemed to satisfy the full Capstone experience for ABET; this is consistent with 2003.

Integrative Experiences

The reviewers did not evaluate “integrative” as ME uses it in its degree requirements, but rather looked at general competence in the area. Consistent with previous reviews, some 48% of students could have used the project to meet the mechanical integrative experience, 29% met the thermofluid experience, and 5% met both. Very few students actually use the MQP to satisfy these degree requirements, but these data show a reinforcement of completed courses.

Projects which demonstrated an **acceptable** ability to work professionally in:

Thermofluid Systems	24%
Mechanical Systems	48%
Both	5%

Experimentation and Realization

It is not a stated goal of the MQP to contain experimentation or full realization of a prototype. However, since we require only a single course in that area, it was hoped that many projects would build on this background. Approximately 28% of students worked on projects with a reasonably large experimental component, including the design of their own set-ups, and over 50% constructed some prototype or test bed. This is consistent with the last four reviews.

External Sponsorship

Of the 59 projects, 29 had some form of external sponsorship or affiliation. This 50% exposure to the external world is a strong reflection on the project system.

Academic Value

No project was found to be worth less than a unit, although several were borderline IQPs in content and showed minimal engineering.

Sub Disciplines

The following is a rough estimate of project focus. This should assist in planning MQP loading in the future. It is difficult to characterize some projects; for example, structural design of a wing is both aero and design and likely involves materials, thermofluids, mechanics, and manufacturing.

Sub-area	Number of Projects	Number of Students	% of Total Students
Aero	14	33	20
Biomechanics	5	17	10
Mechanical Design	12	42	26
Fire Protection	5	19	12
Manufacturing	13	31	19
Materials	6	15	9
Thermofluids	4	6	4
(not in other areas)			

Comparison to the Previous Reviews

Previous reviews (1997, 1999, 2001, 2003) examined many of the same areas as did this study, although the questions have been refined to be more closely aligned with the Department's expected educational outcomes.

The number of projects involving only a single student dropped from 38% to 21% to 3% before returning to 43% in 2003; this review finds the number of solo projects at 20%, but this involves only 7% of students. In the early 1990's, over half of our projects were solo efforts. The growth of off campus project activity and the need to complete projects "off cycle" appears to create a need for solo efforts.

Writing quality had improved over the past two reviews and continues to be strong. While references remain weak, somewhat due to the reliance on the Web, objectives and conclusions have improved, although they could still be clearer.

This study emphasized the components of capstone design; these were endorsed by the department in 1998 and were expected to appear at higher levels in this review. The last two reviews show that approximately 15-28% of MQPs do not satisfy Capstone Design requirements. Further only 18% of projects satisfy the full ABET Design Criteria.

Projects with experimental design have stabilized so that approximately 78% of MQPs have an extensive experimental or realization component.

Only 24% of projects demonstrated an ability to work professionally in thermofluids while 48% showed this in mechanical systems with 5% showing proficiency in both.

SUMMARY

In general, the project reports were of a professional level. The objectives, conclusions, grammar and spelling have all improved over the past eight years. Approximately 28% of the projects did not appear to qualify as Capstone Design. These project students have the option of completing a Capstone Design course, but this may be difficult to implement midstream in a project. Only 18% of projects addressed the Design Elements in any meaningful manner; hopefully that will change in the next review. A majority of students are completing one or two Capstone Design courses which focus on ABET Design Elements.

Experimentation and fabrication are found in about 78% of the projects. These objectives do not have to be met within the MQP; this review provides a benchmark for the level of activity within projects. Fully 75% of projects are using modern computer tools of one type or another, including CAD, CAM, FEM, etc.

Overall, the MQP activity is at a solid level. Improvement has been seen in writing, design content, and technical content. However, the number of excellent projects can certainly be increased. Department discussion of Capstone Design and grading consistency is needed. It is clear that the MQP cannot be used to satisfy numerous program outcomes; these can be achieved via coursework or the sufficiency and IQP.

Department Action

This report has been presented to the M.E. Department for discussion and action. The ME Curriculum committee will address a discussion of Capstone Design expectations with the faculty, particularly the Design Elements.

COURSE REVIEW

A Capstone course file was also reviewed: ME 4710 Aircraft Design.

The course addresses most of the key requirements for Capstone Design, although the adopted Design Elements are not obvious in the material seen. Student work demonstrated a significant mastery of the Outcomes. The course is being used to satisfy both integration of mechanics and thermofluids. The Department should review what is intended for the latter; while the course deals heavily with aerodynamics, thermodynamics and heat transfer appear lacking, especially in terms of demonstrated outcomes.