CHEMICAL ENGINEERING MQP REVIEW

FOR THE 2005-06 ACADEMIC YEAR

Submitted by
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ATTACHMENTS
1. List of Project Titles
2. MQP Department Review Form (Summary)
3. Review Summary Sheet

1.0 INTRODUCTION

This report summarizes a review of the Major Qualifying Projects in the Chemical Engineering Department conducted in the fall of 2006. It covers projects completed in the 2005-06 academic year. A total of 19 project reports completed by 32 students were read and evaluated.

The goals of the review were to:

- Compile statistical data on several aspects of project management and content.
- Evaluate the overall quality of the reports based on the department's and WPI's educational goals.
- Compare the results to the findings of previous reviews.
- Evaluate the reports according to the ABET criteria for program outcomes.
- Make recommendations for improvements.

2.0 METHODOLOGY

All reports were read and evaluated using an objective list of criteria, as has been done for previous reviews (see Appendix A). MQP CDR forms provided information on grades and the total credits granted.

Advisor/co-advisor data were obtained from the project cover sheets. The project inter- or sub-disciplinary content and the extent to which various course content was used were determined by qualitative evaluation by the reader.

Qualitative evaluations were made from a reading of the project reports to determine the degree of use of material from the core Chemical Engineering courses, as well as the use of math and computers. These evaluations were subjective, and are discussed below. The Chemical Engineering Department objectives and the ABET criteria for program outcomes were also evaluated subjectively.

3.0 RESULTS AND DISCUSSION

3.1 Grade Distribution

Table 1 shows the grade distribution for the past period, and then for each year separately. Also given are percentages from the last four reviews[1,2,3,4].

Table 3.1
Grade Distribution

Grade	No. of Projects	% of Projects					No. of Students	% of Students				
		05/06	99/01	97/99	95/97	93/95		05/06	99/01	97/99	95/97	93/95
A	15	**79**	**59**	**73**	**66**	**55**	26	**81**	**60**	**77**	**62**	**61**
B	3	19	26	18	28	28	4	13	32	16	32	27
C	1	5	15	9	6	18	2	6	9	8	6	12

There has been a long-term concern in the Chemical Engineering Department over grade inflation. In previous MQP reviews, however, it had been noted that there is a tremendous amount of guidance and advice given by the faculty throughout the students' project work. This input is given in an effort to maximize the quality of the projects. Therefore, higher average grades would be expected for project work vis-à-vis academic courses. This review shows that any previous correction in the inflationary trend in grades has been reversed again. It may, however, be worthwhile to observe that four students received B's and two (in two separate groups) received C's, thus indicating that there is still a recognized range in the quality of the projects, and that the high percentage of A's may be justified.

Of the four projects not receiving an A, three consisted of single students. It appears that teammates tend to bring up the quality of the project, with students generally appearing to work well in groups.

3.1 Grade Distribution (Cont.)

10 of the 19 projects (just over 50%) had off-campus sponsors. This is consistent with the last review period (a large increase over previous periods) and demonstrates success in continuing to meet one of the goals from past reviews. This has been accomplished in large part through collaborative programs with ENSIC (Nancy, France) and Gallo Wineries (other sponsors also participated). Over the years, new sponsors are added, and others no longer participate. This is probably a healthy situation for both the students and the sponsors in that the projects continue to address topics that are meaningful, significant and current. 80% of the sponsored projects received A's, approximately the same percentage as the total number of projects. In the past, sponsorship increases the probability of having a meaningful as well as successful project, although this is not reflected in the grades for this review.

3.2 Student and Advisor Data

Table 3.2.a summarizes the student group sizes and number of advisors involved. The average group size was 1.7, lower than the 2.1, 2.3 and 2.6 of the most recent reviews, and continuing the downward trend. Previous reviews noted that, while it may not be possible to avoid single-student projects, it is undesirable and should be minimized. The nature of many of the topics of the projects, however, lend themselves to single students. In the past, the quality of these projects seems not to have suffered. This period, however, almost half of the single-student projects received B's or a C. It must be repeated that single-student projects should be minimized.

The percentage of projects with single advisors has continued to drop, which seems to be a good trend. Increased faculty input to projects gives students a broader perspective on their work. Also, perhaps having advisors working in teams yields benefits analogous to those of students working in teams.

Table 3.2.a
Student Group Size and Advising Data

	'05-'06		'00-'01		'97-'99		'95-'97	
Group Size	No. of Projects	% of Projects	No. of Projects	% of Projects	No. of Projects	% of Projects	No. of Projects	% of Projects
1	7	37	8	30	13	29	5	15.6
2	11	58	9	33	8	18	11	34.4
3	1	5	9	33	22	49	9	28.1
4	0	0	1	0.4	2	4	7	21.9
No. of Advisors								
1	5	26	16	59	39	87	24	75
2	14	74	11	41	6	13	8	25

3.2 Student and Advisor Data (Cont.)

Table 3.2.b shows the distribution of MQPs among the faculty (including co-advising). The mean was 2.8 projects per faculty member in this period, with a range of 1 to 6. The previous period showed 3 projects per faculty member and a range of 1 to 8. It appears that the load continues to be split more equitably, but some imbalance is to be expected given the differing opportunities for MQPs in the various faculty members' areas of research.

Table 3.2.b
Distribution Among Faculty

Faculty Member	No. of Projects
1	6
2	5
3	4
4	4
5	2
6	2
7	2
8	2
9	1
10	1
11	1
12	1

3.3 Credit Earned

All project reports were consistent with at least 9 credit hours earned. The majority of the students (53%) earned more than the minimum of 1 unit (9 cr hrs). This is consistent with the last few review periods. Granting of additional credit was based on the level of effort over an extended time frame. In this review period, each student in a team received the same grade and credit, with one exception where the student received a lower grade.

Table 3.3
Credit Earned

Units Earned	No. of Students	% of Students
9	16	50
9 ¾	2	6
10 ½	9	28
11 ¼	4	12
12	1	3

3.4 Type of Project

The projects were classified by the major specialty within Chemical Engineering. There was considerable overlap in many cases, which adds to the broad distribution, shown in Table 3.4.

Table 3.4
Distribution of Projects by Topic

	’05-‘06		’99-‘01	’97-‘99	’95-‘97
Subdisciplinary Area	No. of Projects	% of Projects	% of Projects	% of Projects	% of Projects
Catalysis	1	5	15	24	31
Biochemical	3	16	26	5	6
Environmental	2	11	11	3	12
Heat or Mass Transfer	1	5	0	8	31
Materials	0	0	30	19	0
Miscellaneous	12	63	19	41	19
Unit Operations	4	21			
Zeolites	2	11			
Other	6	31			

This period, the category labeled “Other” includes fuel cells, drug delivery, mathematical simulations and quality control. Each of these is a traditional (even if new) Chemical Engineering area. Shifts from prior periods show an increasing variety in the topics. In the past, projects were more heavily weighted in the areas of faculty research. Lately, more opportunities for off-campus project work has resulted in a greater variety.

Six projects (32%) had some design content, and half of those had a significant amount. Many more projects, however, involved the design of experimental equipment or procedures. These design activities included the use of some design principles, but none approached qualifying as capstone design. The Plant Design Project, CM 4404, should be maintained as the capstone design experience.

The experimental/research nature of a significant number of the projects continues to reflect the department faculty’s commitment to involve undergraduates in state-of-the-art projects. It provides all students with the opportunity to work on exciting topics that would not be possible if the MQP were a capstone design project. The breadth of topics is evident in the list of project titles in the appendix. The students’ MQP experience is further enhanced by the fact that many projects build on work that was done in past years’ projects. This was evident in a majority of this period’s reports.

3.5 Off-Campus Sponsorship

As mentioned above in Section 3.1, 10 of the 19 projects (53%) had off-campus sponsors. This is is consistent with past years (63% sponsored projects in the previous review), and demonstrates maintaining success in meeting one of the goals from past reviews.

There has been a healthy shift in the sponsoring organizations noted this period. Last period the major sponsors were NASA and UMass Medical School. This period, although NASA sponsored a project, ENSIC (France) and Gallo Wineries were major sponsors with 4 and 3 projects, respectively. Fallon Clinic and Wachusett Brewery also sponsored projects.

3.6 Oral Presentations

Not evaluated for this review.

3.7 Format and Presentation

The overall presentation of all projects continues to improve, to the point that they were generally excellent. As would be expected, there is an extensive use of word processing and graphics, making for a more professional-looking and easy to read report. Graphics included charts, graphs, diagrams and copies of photographs. The length of each report was consistent with significant content.

All reports without exception followed the same general format. This is the American Chemical Society Style Guide, adopted by the Chemical Engineering Department for MQP and Unit Operations Lab reports. Once again, however, there were the same inconsistencies noted in the prior reviews regarding the preparation of the abstracts. While many abstracts were good, there is a need for more uniformity, and higher quality in those that fell short.

As mentioned in the previous reviews, the project objectives, while always present, could not be easily found for each project. Some were found in separate sections of the reports, some were in the introductions, and some were only clearly laid out in the abstracts. Again, clear guidelines would be helpful. This comment was also made in the last three reviews. Organization of lengthy report sections, however, has improved over the last period.

3.8 Content

The technical level of all projects was acceptable, and in most cases quite high.

Tables 3.8.a and b summarize the assessment of course material integration into the projects. Because this is a highly subjective measure, there is a high degree of potential error. The criterion used was relatively harsh: an evidence of a significant amount of material from other courses. The truth is probably that all projects drew on knowledge gained from several courses. The results show that 95% of the projects used significant material from at least one Chemical Engineering course, and 59% from 4 courses or more. In Table 3.8.b, the other courses are physics, chemistry, biology and material science.

3.8 Content (Cont.)

Table 3.8.a
Integration of Chemical Engineering Course Material

	’05-‘06		’99-‘01	’97-‘99	’95-‘97
No. of Courses	No. of Projects	% of Projects	% of Projects	% of Projects	% of Projects
0	1	5	4	16	12
1	2	11	15	46	59
2	3	16	19	24	16
3	2	11	33	11	12
4	6	32	19	0	0
5	2	11	4	3	0
6	0	0	4		
7	3	16	4		

Table 3.8.b
Integration of Other Course Material

	’05-‘06		’99-‘01
No. of Courses	No. of Projects	% of Projects	% of Projects
0	2	11	4
1	6	32	44
2	9	47	26
3	0	0	22
4	2	11	4
5	0	0	0

Table 3.8.c shows the assessment of math use in projects. These results indicate that 63% of the projects used little or no significant math – an increase from the previous review. Some projects simply presented derivations of equations used in the studies. Many projects, however, used math to the extent of data reduction and error analysis. Several used a significant amount of advanced math. As noted in the previous reviews, all students would benefit by an increase in the computational aspect of their projects.

3.8 Content (Cont.)

Table 3.8.c
Use of Math

Usage	'05-'06 No. of Projects	'05-'06 % of Projects	'99-'01 % of Projects	'97-'99 % of Projects	'95-'97 % of Projects
None	3	16	7	49	44
Little	9	47	41	27	19
General	7	37	33		
Calculus	1	5	15	24	38
Statistics	1	5	11	0	0

As was done for the use of math, an analysis of the use of computers was attempted (see Table 3.8.d). Computers were used extensively for word processing, data analysis, and the preparation of graphics, as would be expected. Several groups used specialized packages, or a math package. Several used computerized data acquisition.

Table 3.8.d
Use of Computers

Usage	'05-'06 No. of Projects	'05-'06 % of Projects	'99-'01 % of Projects	'97-'99 % of Projects	'95-'97 % of Projects
Little	2	11	52	41	56
Moderate	10	53	19	46	22
High	7	37	30	14	22

Most, if not all, projects contained evidence (strong in most cases) of incorporation of new material and technology, indicating learning in areas other than their Chemical Engineering courses. The Chemical Engineering MQP, whether research or process/product development oriented, proves to be an opportunity for students to effectively begin their careers of continual learning, while under the controlled conditions of the Institute and guidance of the faculty.

Additional topics covered in a few reports include error analysis (this has been on a downward trend) and safety. Most of the projects involved experimentation, and so were subject to both topics. As noted in the previous reviews, an effort should be made to better cover them in the project reports. As of now, there is still a wide variation in the format and in the extent to which they are reported.

3.9 External Measures of Quality

In an effort to obtain a fresh viewpoint and additional input to assess the Chemical Engineering Department's MQP performance, this review was prepared by an adjunct professor in the Chemical Engineering Department.

3.10 Departmental and ABET Objectives

The following is a listing of the Chemical Engineering Department's objectives[5] and the ABET criteria for program outcomes and assessment[6], and a brief discussion of how the Chemical Engineering MQPs meet them. Overlaps, of which there are several, have been combined. Many of the criteria are not applicable because of the necessarily focused nature of the projects. As expected, no project was so broad in scope as to involve the entire engineering experience.

Items (a) through (k), below, are the ABET criteria. Items (l) through (n) are additional Chemical Engineering Department objectives not covered within the ABET criteria.

(a) Ability to apply knowledge of math, science and engineering.

All reports clearly showed the use of specific aspects of science and engineering, and 37% included math to a significant degree. Whereas it is a stated objective to increase the use of math, some projects simply don't lend themselves to mathematical analyses. Also, see Section 3.8, above.

(b) Ability to design and conduct experiments, as well as to analyze and interpret data.

Most projects (84%, or all but 3) involved experimentation to obtain data to reach conclusions. The experiments were designed to that end. The data were analyzed and interpreted in all cases, with extensive discussion. There was a generally excellent appreciation of the quality of the data, or lack thereof. See also Section 3.4, above.

(c) Ability to design a system, component or process to meet desired needs.

Most projects involved design only to the extent of the experimentation involved. In many cases, the required test set-ups required some design, and at the very least, thorough understanding. Several had the opportunity or need to design components, and six included some aspects of process design, half of them containing significant design.

(d) Ability to function on multi-disciplinary teams.

None of the projects involved the opportunity for involvement with other disciplines, other than biochemistry. Some of the projects touched on other areas, but it would take a truly unique project to involve several disciplines. This is more commonly found in IQP's.

Worthy of note, 11 of the projects (58%) involved branches of chemical engineering not covered in routine course work. For the portion of these projects with outside sponsorship, it can be safely assumed that the expanded teams (including contacts in the other organizations) were essentially multi-disciplinary.

3.10 Departmental and ABET Objectives (Cont.)

(e) Ability to identify, formulate and solve engineering problems.

Each project clearly showed the ability to identify, formulate and solve engineering problems. The statements of objectives and background for each project showed clear understanding of the issues involved, and a well thought out plan of attack. Several of the projects reported the need to revise the objectives as intermediate results were obtained. This showed the ability to evaluate progress, and focus on obtaining meaningful conclusions.

(f) Understanding of professional and ethical responsibility.

With few and minor exceptions, the MQP reports display a high degree of professionalism. They also display a general consideration for ethics as appropriate (only 3 projects had subjects that presented the opportunity to touch on ethical considerations). There are typically more opportunities to discuss ethical concerns in the IQP reports.

Provisions for safety aspects were mentioned in 6 projects, but only one project discussed safety in a significant manner. Given the experimental nature of most projects, further discussion of both safety and the environment would be warranted.

Eight projects touched on environmental concerns, including 5 that were focused on environmental topics.

(g) Ability to communicate effectively.

The written project reports displayed a generally excellent ability to communicate in writing. All reports were easily read, with thoughts clearly conveyed (see also Section 3.7, above). The proven capability to work effectively in teams and to work closely with advisors, both faculty and outside sponsors, also required the ability to communicate verbally.

While most reports were well written, several would have benefited from a simple proof reading. The occasional grammatical error and incomplete sentence are understandable given the time pressures of the final report schedule, but they take away significantly from the impression of the otherwise high quality of the MQP. The importance of a final check, especially for readability, should be emphasized in the future. Again, this applied to a minority of the reports.

(h) Evidence of the broad education necessary to understand the impact of engineering solutions in a global/societal context.

All of the projects dealt with issues of current interest, as explained in the report introductions. Two applied to society in general, and although 14 touched on global issues, only 2 did so in a significant way. These areas are more clearly demonstrated in the IQP and Sufficiency requirements.

(i) Recognition of the need for and an ability to engage in life-long learning.

Essentially all projects dealt with current, even cutting-edge, topics. This involvement in areas that required the development of new information demonstrates the need for continual learning. The projects themselves demonstrate the ability. (See also Section 3.8, above.)

3.10 Departmental and ABET Objectives (Cont.)

The Background sections of each report were exceptionally thorough, with many benefiting from MQPs completed in prior years. The number of reference materials used ranged from 8 to 106, with a median of 31. The background sections of the reports gave a clear indication of the students' understanding of their topics.

(j) Knowledge of contemporary issues.

As noted in (i), above, the Chemical Engineering MQP deals with current topics and their technical issues. Eight of the projects (42%) dealt with issues that are truly of contemporary interest. Contemporary issues are also dealt with in the IQP.

(k) Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

Essentially all projects required the use of modern engineering techniques, skills and tools. The research projects used state-of-the-art laboratory equipment. All projects used computers in varying degrees, including as a tool for data acquisition. Other courses, such as the Plant Design Project, complete the demonstration of this objective.

(l) An understanding of the broad discipline.

More projects involved several areas of chemical engineering than in recent review periods (see Section 3.8, above). The MQP, however, does not usually meet this objective by itself.

(m) An ability to routinely use computers.

This ability was clearly demonstrated (see Section 3.8, above). Computers were used extensively for word processing, data analysis, and the preparation of graphics, as would be expected. Several groups wrote specialized programs, used specialized packages, or used a math package. Several made extensive use of spreadsheets, and several used computerized data acquisition.

(n) A demonstration of a mastery of science and math fundamentals through innovative technological applications.

Essentially all projects involved current technology and developed new information. Math and science were used to varying degrees. Mastery of their fundamentals was not obviously demonstrated in the project reports, but was inferred by the nature of the topics and the depth of the project content. The reports showed clear understandings of complex subjects, not possible without a mastery of science and math fundamentals.

4.0 CONCLUSIONS

According to WPI's published[5] description of the MQP,

> *The qualifying project in the major field of study 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. The projects' content area should be carefully selected to complement the student's total educational program. In defining the project area within which a specific topic is to be selected, the student and academic advisor should pay particular attention to the interrelationships that will exist between the bodies of knowledge represented by courses, independent studies, and Preliminary Qualifying Projects; and by the Interactive Qualifying Projects.*
>
> *MQP activities encompass research, development, and application, involve analysis or synthesis, are experimental or theoretical, emphasize a particular subarea of the major, or combine aspects of several subareas. In many cases, especially in engineering, MQP's involve capstone design activity.*

Based on the above statement, the department's traditional role of the MQP in the Chemical Engineering curriculum, and this review, the following conclusions were made:

1. All projects completed in this review period satisfied the Institute's stated objectives and were valuable educational experiences for the students.

2. The Chemical Engineering MQP does not, by itself, meet all of the department's educational objectives. Other course and project work completes the experience.

3. All projects met or exceeded the minimum standards generally accepted for chemical engineering projects. Many were excellent as judged by both internal and external measures.

4. Nearly all incorporated significant new material and technology not generally available in our course structure.

5. No projects involved significant capstone design.

6. The trend toward grade inflation appears to be back, after having been reversed in the prior period. (Note that this trend is not believed to be a problem.)

7. The students appear to work well in groups.

8. There still is a percentage of students (22%, representing 37% of the projects) who work alone. This has been noted in the past to be undesirable.

9. Eight of the eleven ABET criteria are shown to be met by the MQPs for this review period. The three criteria that are not clearly met are:

    c. Ability to design a system, component or process to meet desired needs.
    d. Ability to function on multi-disciplinary teams.
    f. Understanding of professional and ethical responsibility.

5.0 RECOMMENDATIONS

The following recommendations are made to improve the quality of the reports and to further enhance the educational benefits of the project experience. Some of these recommendations are repeated from the last review period, since progress was not clearly evident in those areas.

1. A more detailed required report format should be established. Clear guidelines should be given for:
    a) The abstract
    b) Safety considerations
    c) Reporting of error analysis

2. Faculty should be continually encouraged to solicit off-campus sponsors.

3. Single student groups should be highly discouraged.

The Chemical Engineering Department undergraduate committee should review and discuss the implementation of these recommendations.

6.0 REFERENCES

1. DiBiasio, D., *Review of Major Qualifying Projects Completed During the 1993-94 and 1994-95 Academic Years in the Chemical Engineering Department*, Worcester Polytechnic Institute, Worcester, MA, **1995**.

2. Starr, T., *Chemical Engineering MQP Review for the 1995-96 and 1996-97 Academic Years*, Worcester Polytechnic Institute, Worcester, MA, **1997**.

3. Starr, T., *Chemical Engineering MQP Review for the 1997-98 and 1998-99 Academic Years*, Worcester Polytechnic Institute, Worcester, MA, **1999**.

4. Starr, T., *Chemical Engineering MQP Review for the 1999-2000 and 2000-01 Academic Years*, Worcester Polytechnic Institute, Worcester, MA, **2001**

5. *The Undergraduate Catalog*, Worcester Polytechnic Institute, Worcester, MA, **2006**.

6. *Chemical Engineering Department Report for ABET Review*, **July 1, 1996**.

ATTACHMENTS

1. List of Project Titles
2. MQP Department Review Form (Summary)
3. Review Summary Sheet

LIST OF PROJECT TITLES

Alterations in Flow Patterns Through Nasal Passages
Droplet Separation Model
Modified Dextran Polymers for Drug Delivery
Batch Adsorption Using Granular Activated Carbon
Biofilm Development and Characterization
Increasing the Efficiency of Fermenter Area Operations
Ab Initio Studies of Cyclohexane Adsorption in Zeolites
Theoretical Studies of MTBE and Chloroform Adsorption In Zeolites
Foundations for the Exploration of Trace Metals in Flue Gas
Alternatives to Diatomaceous Earth in Filtration
Lysozyme Crystallization on Chemically Modified Surfaces
Pall Oeno Flow Crossflow Filtration
Characterization of Diatoms
Modified Alginate Drug Delivery
QC Improvement Project for Wachusett Brewing Company
Investigation of Direct Methanol Fuel Cell Catalyst Synthesis
Supercritical Storage of Hydrogen and Oxygen for Fuel Cell Space Applications
Computer Simulation of a Microreactor Using the DSMC Method
Diffusion and Reaction in Microchannels

MQP DEPARTMENT REVIEW FORM

(Summary)

Department: **Chemical Engineering**

Reviewer: **Thomas Starr**

N (# of total MQPs in review period) = **19**

R (# of MQPs reviewed) = **19**

S (# of students) = **32**

T (# of students reviewed) = **32**

Use of survey form by reviewer: **Copy attached**

Use of oral presentations? (Indicate when)

A. Report Format

   Refer to review Section 3.7

B. Report Quality

   Refer to review Section 3.3

C. Faculty and Students

   Refer to review Section 3.2

   Team Size: 1-3, mean = 1.7

   Student/faculty ratio = 2.7

D. Grades

   Refer to review Section 3.1

E. Connection to Profession

   Refer to review Sections 3.10 and 5.0