

Industry Sponsored Final Year Engineering Design Projects: A Template for Success

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Abstract

This paper describes a course (designated “MME499 - Mechanical Engineering Design (Industrial)”) that has been developed over the last several years to integrate industrial sponsorship into the final year of the Mechanical Engineering design course sequence at The University of Western Ontario in London, Ontario, Canada. The paper highlights the overall course objectives, the course structure and the methodology employed as well as the benefits to the students and the companies involved. Course support provided by the participating companies, a local government agency and the Faculty/University are also detailed including strategies for soliciting support for this kind of initiative. Student evaluation techniques are discussed including feedback mechanisms for individual assessment within groups and for course improvement. Finally, a list of tips are presented and discussed that should help ensure the continued enthusiasm of all participants and the success of the course.

Introduction

MME499 - Mechanical Engineering Design (Industrial) is the final year capstone design course in the Department of Mechanical and Materials Engineering at the University of Western Ontario. This course offers students the opportunity to work on realistic design projects that are proposed and supervised by professional engineers and are of significant interest to local industries. The purpose of this course is to introduce fourth-year students to the industrial environment in order for them to gain experience and training in the practice of engineering, an appreciation of market-driven priorities, exposure to various corporate structures, experience interacting with suppliers, clients and support staff as well as experience working within a group and further development of their written and oral communication skills. The emphasis is placed on small and medium-sized companies, where an engineer's duties require versatility and competence in a variety of tasks.

A course coordinator, who is responsible for establishing and maintaining links with the industrial sponsors, administers the course. In addition the course coordinator also schedules regular seminars and safety training, oversees coordination of resources, signs for expenses, and

organizes the annual technical presentation day. The course coordinator also solicits assistance from appropriate faculty colleagues to act as academic advisors. Advisors are matched to projects based on specific area of technical expertise and the needs of the project. Coordination of project tasks and maintaining steady progress on the project during the academic year are the joint responsibility of the academic advisor, the industrial supervisor and the students involved.

Projects are selected based on three primary requirements. First, the industrial supervisor must be a professional engineer. Second, there must be a direct benefit to the industrial sponsor. These benefits may take the form of product development, design implementation or problem solving. Third, the projects must be suitable for a group of two to four fourth-year mechanical engineering students. The underlying goals of this strategy are two-fold. Students are exposed to a relevant engineering design experience and in this way are better prepared to enter the work force and begin making a useful contribution from an early stage. Ties are established or strengthened between companies and the academics in the Department of Mechanical and Materials Engineering. This could potentially lead to further collaboration in terms of corporate sponsored research activity.

In addition to the supervisory role, the industrial sponsor is to provide the students with technical support, on-site access to resources as required, direct contact with the production floor and personnel as well as supplier contacts. Confidentiality issues, if they arise, are settled at the start of the projects, usually through a non-disclosure agreement. Projects that focus closely on confidential or proprietary aspects of a company's business, while they may be exciting and challenging, are discouraged as they may inhibit open evaluation of the students' work.

Course Structure

Currently there are two choices for final-year students in the Department of Mechanical and Materials Engineering at UWO in regard to their capstone design project. They can choose MME499 – Mechanical Engineering Design (Industrial) or MME419 - Mechanical Engineering Design. The MME419 course involves individual and group projects with academic supervision only. The 1999/2000 academic year saw these two courses brought more closely into alignment with the reporting format and schedule being the same. Both courses are only open to students in their final year. All projects must contain a minimum of 50% design content (Canadian Engineering Accreditation Board guidelines). The course involves companies of all sizes, but it is expected that the projects will all be of similar scope.

This course started as a pilot program in the 1993/94 academic year with two manufacturing related projects. The 1999/2000 academic year saw 15 separate projects. The groups consist of two to four students. Students are expected to invest at least eight hours each per week. Each group must designate one of its members as a group manager whose responsibilities include group coordination and liaison between all parties involved.

All final-year engineering students are required to meet three major reporting deadlines. All reports require written documentation and an oral presentation. The approximate schedule and content of the reports are as follows.

1. Project Proposal.

- i) project description and scope
- ii) project timetable
- iii) individual responsibilities
- iv) resource requirements
- v) tentative budget

2. Progress Report.

- i) review of project description and scope (including modifications if necessary)
- ii) progress to date (analysis work, design alternatives, preliminary designs, etc.)
- iii) timetable for remainder of project (revised if necessary)
- iv) budget review

3. Final Report.

- i) review of project description and scope
- ii) report on results (final design, analysis, modeling, prototype, testing, etc.)
- iii) resources used (materials, services, time)
- iv) final budget
- v) group performance self-assessment

The projects are defined and supervised directly by an engineer working for the sponsoring company. A meeting is scheduled in early September at which the supervisors and student groups are to further define the project scope and expected outcomes. A faculty advisor is designated to act in a consulting capacity. The main responsibility of the academic advisor is technical advice, project troubleshooting and generally keeping the students on track. The MME499 course coordinator oversees all projects.

The project work is supplemented during the term by a series of seminars organized within the Department. Guest lecturers with a variety of backgrounds provide information on business practice, market priorities, group work coordination, presentation skills and technical topics. Attendance is mandatory for all MME499 students.

The course coordinator, an academic advisor or a sponsoring industry can initiate a project proposal (see Appendix A for a sample project proposal form). Canvassing starts in March or April of the preceding year. Projects are selected according to the following criteria.

- i) Feasibility
- ii) outcomes are of significant interest to the company
- iii) minimum design content (50%)
- iv) infrastructure capabilities
- v) access to company site
- vi) quality of projects
- vii) company commitment

The initial project definition process is generally completed by July and the first meetings between students and company are scheduled for early September shortly after the projects have been assigned. Students are allowed to choose their own groups and then the groups choose their

preferred project. When forming groups and selecting topics the students are asked to consider carefully the different options within Mechanical and Materials Engineering being followed by each team member, the academic standing of each team member, and the project description. The goal is to allow students to choose teams that are likely to work well together and yet provide each project with a well-balanced team. The course coordinator is responsible for resolving all conflicts and his/her decision is final. While this process does not accurately reflect the likely situation facing most newly graduated engineers, it increases the likelihood of project success in this situation.

Performance assessments are based on the technical merit of the work performed, the quality of the report submitted, the effectiveness of oral presentations and individual contributions. The industry supervisor is provided with standardized evaluation forms to be returned after reading all interim reports and the final report. The faculty advisor submits a similar evaluation. The course coordinator reviews the separate assessments and provides a final individual mark. Towards the end of the academic year, a technical presentation day is held during which all industry participants, faculty, third-year and fourth-year engineering students are invited to attend seminars. Students present their project overviews and final results. A panel, consisting of three individuals, of which at least one is from the Faculty and one from industry, judge each presentation. The panel members are external to the project being judged. On this occasion, industry guests are invited to tour the University facilities. Breaks during the day for lunch and coffee are geared towards facilitating personal contacts.

In the week following the final report submission, students are to complete a form evaluating whether the course objectives have been fulfilled and if supervision was adequate. Recommendations for course modifications are also requested. The company supervisor is also asked to fill out a standardized form to assess the perceived student deficiencies, course strengths or shortcomings, as well as recommendations for future modifications. A summary of these evaluations is provided to the students in the subsequent year and to the supervisors upon request.

The results of these evaluations are also discussed at the Departmental Council. Where appropriate, modifications are made to the course and supporting courses. In particular, strengths and weaknesses perceived in the student training are addressed and incorporated directly into the third-year design course (MME359) to benefit students in following years. MME359 is specifically geared towards design strategy, group work structure and project management. This feedback loop has proven to be very beneficial to both students and industry supervisors.

Course Benefits

The industry-university cooperation that exists in the MME499 course results in many mutual benefits.

Benefits for the Industrial Partner:

1. The course offers the potential for a low-cost (no salary expenditures, minimal infrastructure requirements) solution to basic design and manufacturing problems.

2. Access to faculty expertise and problem-solving services, provided free-of-charge within the scope of the projects.
3. University infrastructure and resources, including machine shop and computer facilities, are made accessible for the purpose of the student projects.
4. The sponsor industry is given the opportunity to explore the different capabilities and services offered by the Faculty of Engineering Science.
5. Student performance can be observed over an extended period. The feedback provided by the companies is incorporated in the curriculum in the hope of better meeting the future needs of local companies.
6. A pathway for technology transfer is established.

Benefits for the Students:

1. The opportunity to coordinate and carry out an economically relevant industrial project.
2. Exposure to professional practice and training.
3. Development of interpersonal skills.
4. Exposure to the industrial environment and structure.
5. Contacts with suppliers and clients.
6. Employment potential (many students are hired directly by the sponsor company upon graduation).

Benefits for the University:

1. Helps establish and strengthen contacts with local industry.
2. Complements the Industrial Internship Program (IIP) where students participate in an extended work-term (12 to 16 months) between third and fourth year.
3. Excellent teaching aid: provides "real life" exposure that would otherwise be impossible to achieve in a normal classroom setting.
4. Feedback mechanism helpful in focusing the curriculum.

Course Support

Industry Support

Starting in the 1999/2000 academic year sponsoring companies funded MME499 projects with \$1,500.00 contributions to the capital budget. During discussions with various industry representatives this figure was agreed upon as one that represents a reasonable contribution, given the benefits to the company. Major material and equipment costs are also provided by the sponsoring companies.

Government Agency Support

Throughout the tenure of this course varying degrees of support have been provided by different government agencies. Currently, Materials and Manufacturing Ontario (MMO - a provincial government agency) provides an ongoing operating budget of \$1,500 per project per year (maximum of \$22,500). These funds are used to offset expenses such as the MME499 Design Studio consumables (computer and software upgrades, telephone and fax lines, scanners, digital

camera and white board, etc.), machine shop time, liaison and travel costs, miscellaneous materials and devices as well as testing and calibration costs.

Faculty Support

The MME499 program is supported by the Department of Mechanical and Materials Engineering and the Faculty of Engineering Science at the University of Western Ontario. Departmental machine shop time and technician time are available. The Faculty of Engineering Science has contributed a room for use as a Design Studio/meeting room, computer network access and IT support. A total of 17 advisors are available to accommodate an expected 10 to 15 projects each year. Additional support is potentially available from the University Office of Industry Liaison. This office could provide assistance by matching industry needs with appropriate faculty expertise.

Budget Justification

Each year the annual operating budget must be justified. This is done through a proposal to MMO each spring. The proposal outlines the requirements for the maintenance and slight expansion of the ongoing program. MMO support is intended to provide operating support for technical services, travel, communications and miscellaneous expenditures. Support from the participating companies will provide one-time funding for design studio infrastructure upgrades. This facility is for the exclusive use of the MME499 students and provides them with access to several of the most current design and analysis software tools as well as a dedicated meeting/working space. A wide variety of other technical equipment is already available within the Department. Expensive, project specific, equipment is supplied by the sponsoring company. Consumables and project materials have been included in the operating budget.

Last year for the first time there were sufficient funds to offset most of the students and the course coordinator for travel and liaison costs. Funds were also available to pay guest lecturers (seminars) a small honorarium. Equipment and software support were also expanded. The Faculty of Engineering Science machine shop has agreed to a preferred charge out rate for MME499 project work and the MMO funding last year made possible extensive use of this facility.

Continued expansion and maintenance of the course requires continued support in the following areas:

- i) Existing communications facilities are sufficient for current needs. The Faculty has agreed to provide the room on an ongoing basis, but only if it is put to good use. There is, however, a need to cover the cost of a variety of consumables such as paper, toner, and line rental charges.
- ii) Six PC workstations and disk space on a server were purchased last year to accommodate the design and analysis work as well as algorithm development. A variety of other support hardware was also purchased in order that the project teams could function at a near-professional level. The Faculty of Engineering Science supplies a network link

(hardware and software), IT services to support these computers as well as site licenses for a variety of software programs. In order to upgrade and slightly expand this facility to accommodate most of the teams at any one time, a further four PCs and two more specific software items will be requested in the future.

- iii) Last year for the first time, projects that required Faculty machine shop access were supported. Some project work is also carried out in the Departmental machine shop at little or no cost. Last year it is estimated that four hundred hours of Faculty machine shop time would be required. Funding for this work has been requested again this year at a slightly increased level (shop preferential rate of \$29 per hour - or 50% of normal charge out rate).
- iv) Liaison and travel expenses for the course coordinator include; mileage charge or car rental for site visits, long distance telephone and fax charges, generation and printing of information packages and correspondence. Last year the operating budget was also used to offset some of the students' travel expenses, especially for those students having to travel out of town. The students were particularly thankful for this relief and the out of town companies felt that this encouraged the students to visit more regularly.
- v) Miscellaneous material and instrumentation costs are included in each year's budget. There is no doubt that the effectiveness and market value of the MME499 projects was enhanced by the ability to finance some minor tool, instrumentation and material acquisition on a case by case basis. Major material and equipment costs are provided by the sponsoring company.

Companies and Projects (1999/2000):

<u>Company</u>	<u>Project</u>
3M Canada Ltd.	Oven Threader Cable Drive System
Borg Warner Automotive	Link Stacker
Cooper-Standard Ltd.	Creep Machine Re-Design
GM Diesel Division	Automated Locomotive Load Test Analyzer.
Meridian Magnesium Products	Molten Metal Transfer Device
Siemens Automotive	Commutator Fusing Optimization
Timberjack Inc.	Electronic Load Sensing with Engine Antistall Controller
Trojan Technologies	Disinfection Reactor Design
Unifin International	Stress Analysis of Pressure Vessels
Van-Rob Stamping	Vibration Analysis of Stamped Automotive Parts

Companies and Projects (2000/2001):

<u>Company</u>	<u>Project</u>
3M Canada Ltd.	Oven Threader Cable Drive System
Cooper Standard	Focused Powertrain Mounting System
Dofasco Steel	On-line Width Measurement Gauge for a Tube Mill
General Motors Diesel Division	Automated Locomotive Load Test Analyzer
Meridian Magnesium Products	Automatic Dressing Device
Siemens Automotive	Choke Loops Bending Process

Siemens Automotive
Timberjack
Trojan Technologies
Van-Rob Stamping

Ultrasonic Detection of Bearing Presence
Feller Buncher Boom Set Design
Design of Portable Collimated Beam Apparatus
Vibration Analysis of Multi-layer Stamped Auto Parts

Summary

Many undergraduate engineering students manage to get excellent industrial experience during the time they are at university. This experience comes through summer jobs, industry co-op placements or company internships. However, there are still many students in engineering programs who do not receive adequate exposure to the industrial environment that they will be entering upon graduation. The course described above is one that addresses this need. Students taking part in MME499 are required to complete a project that is similar in scope to one that would be expected to undertake as an engineer-in-training working in an industrial environment.

The course has been well subscribed to by students and company sponsors. There is a continuous improvement feedback mechanism in place that will hopefully ensure the maintenance of a high quality course and help graduate engineers who are ready to “hit the ground running” upon graduation. Students have commented that the greatest benefit is being involved in a “real world” problem and actually working closely with industry personnel. On the negative side, some students have expressed regret that the facilities available within the University are far short of what is available in industry and that their experience in this course suffers because of that. Comments from industry are generally positive, but there is often an expectation that the students should be able to spend more time on the projects than they have scheduled. In general this exercise is obviously a learning experience for all persons involved and the course coordinator needs to keep people aware of this fact or risks never being to measure up to inflated expectations. More information is available at <http://hyperserver.engga.uwo.ca/mme499/>

Some hints that may assist others who are contemplating starting this kind of course or who are currently offering a similar course are stated briefly here. Start early looking for industry sponsors for each year’s new crop of projects. Regular communication between the students, the academic advisor and the company supervisor is essential. This requires a strong “buy-in” from all people involved. Multi-stage and multi-faceted projects are a good way to train students in the art of multi-tasking and may help in avoiding an all-or-nothing conclusion at the end of the project. Provide the time and the mechanism for rapid and effective communication between the industry supervisor and the academic advisor during the evaluation of the projects.

APPENDIX A: Example Project Proposal Form

The University of Western Ontario
Department of Mechanical and Materials Engineering

MME499 MECHANICAL DESIGN
Industrial Proposal
Session 2000-2001

INDUSTRIAL PARTNER: Company Name
 Street Address
 City, Province Postal Code

SUPERVISOR: Person Name
 Title
 Tel.:
 Fax.:
 Email:

ACADEMIC ADVISOR: Faculty member to oversee group and offer assistance if required.

PROJECT TITLE:

SHORT PROCESS/PRODUCT DESCRIPTION:

A short outline of the problems and an overview of the solutions hoped for.
If a particular piece of equipment is envisaged, a technical summary might be useful.

PROJECT SCOPE:

Should be a concise statement as to the purpose and end result expected. If the project is part of a larger plan, please include the preceding and the subsequent steps to provide a sense of purpose and continuity

DELIVERABLES:

1. Should be in list form
2. Prioritize
3. Length is not restricted
4. Include such items as:
 - blue-prints
 - software
 - design specifications
 - costing
 - report

ISSUES and CONSTRAINTS to be ADDRESSED:

List of items, which require special attention (eg. material selection; patent considerations, Cost ceiling? Ergonomic and safety concerns?, etc.)

MINIMAL CONTACT FREQUENCY: (recommended is 2 weeks)

NUMBER OF STUDENTS REQUIRED: (minimum 2, maximum 4)

TIMETABLE:

- First meeting: Early September 2000
- Student project proposal: Early October 2000
- Progress report: Early January 2001
- Final presentation: March 2001
- Final Report: April, 2001

UWO DISCLAIMER OF LIABILITY:

Although an Academic Advisor will be participating in the Project to supervise and evaluate the work of the students, the University of Western Ontario (“UWO”) assumes no responsibility or liability for the deliverables or results produced in connection with the Project. For greater clarity, UWO is not providing engineering consulting services or any other services to the Industrial Partner. Consequently, no warranty whatsoever regarding the deliverables or results of the Project, either express or implied is given by UWO. Furthermore, UWO shall not be liable for any direct or indirect costs, losses or damages which the Industrial Partner or any third party may incur or suffer in connection with the Project, nor for any incidental, special or consequential damages of any kind whatsoever.

Date

Signature of Industrial Advisor

APPENDIX B: Example Project Evaluation Form – Industrial Supervisor

The University of Western Ontario

Department of Mechanical and Materials Engineering

**MME499 MECHANICAL DESIGN
Industrial Supervisor - Project Evaluation Form
Session 2000-2001**

Evaluator's Name: _____

Student's name(s): _____

Company name: _____

Project title: _____

The following table provides suggested evaluation criteria. The criteria listed below are meant to serve as a guide, please feel free to add your own or ignore any of those listed below. Use the evaluation results and your best judgment to arrive at an overall mark out of 15. Please note that the Project Final Report counts for 50% of the student's final grade in this course.

Criteria	Evaluation (out of 50)
Project Definition and Background	
Project Scope and Deliverables	
Planned Methodology	
Milestones	
Budget	
English and spelling	

Overall mark (out of 50) _____

Comments: