Changing a 4th Year Team Design Project Course to meet expectations from Regular and Returning Internship Students

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Abstract

Over the past two years, our Department has taken a unique approach to meet Canadian Engineering Accreditation Board requirements for a compulsory 4th year design project. Rather than allowing loose interaction between group members, we attempted to formally introduce the team forming techniques required in industry. The students are introduced to "the theory, practice and experience of project management". In this paper we shall report on the current format of the course and how it overcomes many of the problems with our initial offering. Although only part way through the second offering, we recognize the need for new changes in order to account for the increased maturity and experience of the students returning from their 16-month internship experience. The changes needed to handle the 80% of our students who will return from internship in September 1999 are discussed.

1. Introduction

Two years ago the Canadian Engineering Accreditation Board (CEAB) placed a requirement that all engineering students experience an extensive 4th year design project. With accreditation looming, the Department put on an experimental team project plan with the forty 4th year students who had not taken advantage of our Faculty's 16-month internship program between 3rd and 4th year.

In this paper, we report on the current format of the team design project courses and how we have attempted to overcome the difficulties from the first year's offering. Although only partway through our second year, we can already recognize a new problem. About half of our project enrolment involves students who have come back from their 16-month industrial internship. Next year, provided there is not a significant down turn in the economy, we expect this ratio to rise to closer to 75% -- 85%. These students have an increased maturity and different experiences from our regular students. The returning students claim considerable, informal, exposure to project management concepts. We detail how we will attempt to balance the course to take advantage of these experiences.

2. Outline of the Basic Team Design Project Course

Figure 1 provides curriculum details for our current team design project course. The format of our 3½ day Block Course was designed around the concept of a business seminar with speakers. There were opportunities to experience the initial stages of team forming built around sponsored meals and BarBeQues.

ENEL007 Block Course:- *This four day block course is intended to provide the necessary background material to prepare students for the 4th year Team Design Project. Topics covered will include:*
Personal responsibilities and interpersonal relationships involved in a team project
Team projects from a current industrial perspective
CAD tools to automate Project Management, i.e. PERT charts, critical path analysis, resource management, report generation and project tracking

ENEL 583 – 4th year Team Design Project, Part A (3-0-6). *This course introduces the theory, experience and practice of project management. Theory includes generally accepted project management principles, the structure of both project and team, together with ancillary topics that commonly affect project outcome. The experience is gained from a series of engineering relevant case studies and guest lectures by industrial practitioners with engineering background. The practice is obtained through the performance of a 'customer suggested' team project through the stages of project requirement and specification analysis, high level and detailed low level designs. The project is executed, and progress measured against, a plan developed by the team participants.*

ENEL 589 – 4th year Team Design Project, Part B (3-0-6). *This course continues the theory, experience and practice of project management from ENEL 583. The detailed low level project design developed by the team in ENEL 583 will be implemented, unit tested, integrated and system tested before under going customer acceptance. The project is executed, and progress measured against a plan developed by the participants.*

Figure 1. Curriculum details for the introductory and technical course components associated with the 4th year Team Design Project Course

Rather than having a fixed project for all students, the department decided to spread the workload, with small groups of professors being responsible for several different project teams. This approach provides a choice of project areas and justification to use the project course to replace two technical electives. *Team Design Project*s rather than a *Group Design Project* were used A group project involves a number of individuals producing several related items that together constitute a final product. A team project involves more collective decisions, actions and sharing of knowledge.

Project management concepts, including formal "Team Forming" techniques, are introduced to the project class as a whole, rather than on an ad-hoc basis by individual professors. This should produce greater uniformity in the progress through the projects even when individual professorial project management experience or work-load in a given term fluctuated. It was anticipated that this approach would provide the skills to allow more of the student teams to drive their project rather than simply following professorial dictates.

3. Setting Course Milestones

A "V-Shaped" Life cycle model, figure 2, is used to set the basic milestones for the students, their faculty advisors and industrial customers. The V-shape emphasizes the relationship between
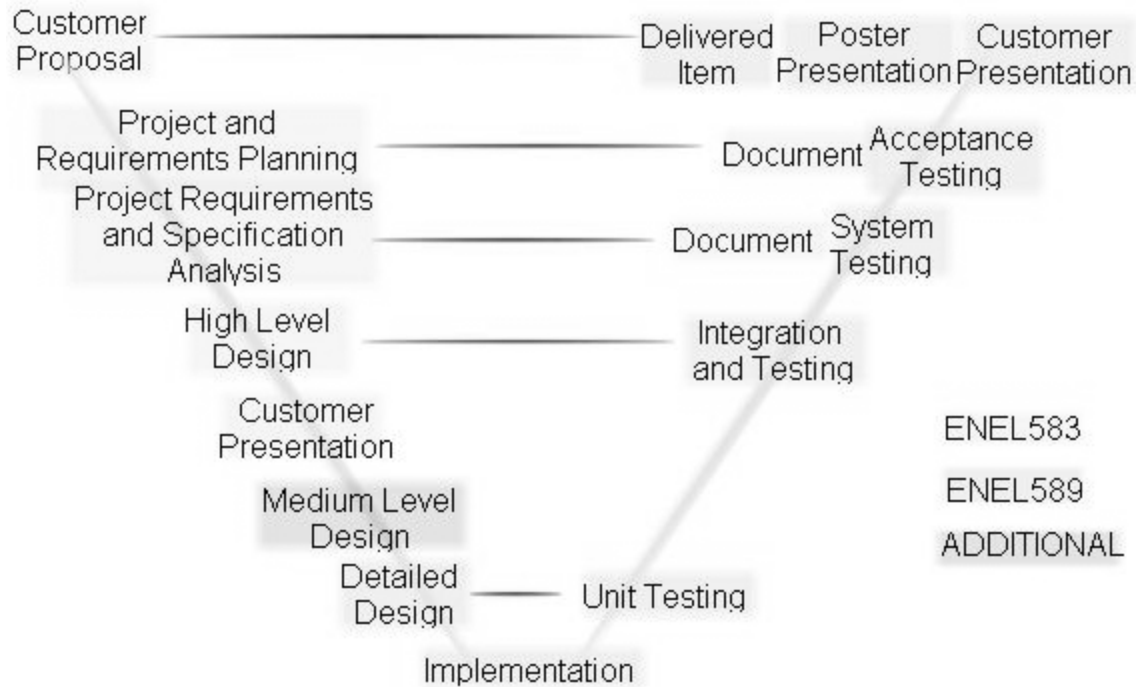
Customer Proposal ——————————————— Delivered Poster Customer
Item Presentation Presentation

Project and
Requirements Planning ——————————— Document Acceptance
Testing

Project Requirements
and Specification ——————————— Document System
Analysis Testing

High Level ——————————— Integration
Design and Testing

Customer
Presentation ENEL583

Medium Level ENEL589
Design

Detailed —— Unit Testing ADDITIONAL
Design

Implementation

Figure 2. The "V-shaped life-cycle" model indicates a series of detailed deliverables. By specifying how to test deliverables as part of the planning stage, this project management model enables both the customer and the project team to agree upon project behaviour and recognize when the project has reached its conclusion. (The V-shaped life-cycle is based on concepts from a Motorola University Software Engineering Management Course.)

the analytical and design phases that precede implementation with the testing phases that follow implementation.

The **Customer Proposal** is the information provided by the customer. The **Project and Requirements Planning** phase determines the system requirements, and the tests that will be performed later during the **Acceptance Testing** phase. This planning stage is a critical if both the customer and the design team are to how to recognize when the project is complete.

The **Project Requirements and Specification Analysis** phase includes analysis of the problem at hand. It concludes with a complete specification of the external behaviour of the system to be built, and test definition for the **System Testing** phase. The **Architecture or High-Level Design** phase defines how the components are used to implement the design. Details of the interface between project components should be sufficient to allow individual team members to work through their own **Implementation** and **Integration and Testing** phases.

Team presentations to class and customer at the end of first technical course allow initial progress to be judged. Presenting the **Deliverables** near the end of the course permits the

customer to perform **Acceptance Testing** where the functionality of the system is compared to **Project Requirements**. The deliverables include

- final documentation for the customer
- a formal oral presentation by all team members to the customer and other students in the course

The **Departmental Showcase and BBQ** involves a formal poster presentation. The showcase is both a time of pride for the students and their customers, and an opportunity for next year's team project players to see the fun, and hard work, associated with the 4th Year Team Design Project.

Industrially applicable project metrics are added by requiring the use of regular Team assessment reports, Team meetings and CAD tools for project planning and scheduling.

4. Current Customization of the Team Design

After the first offering of the team project course we realized certain critical issues needed modification to handle the needs and the interests of the Departmental members and the students (19 teams). One group of Departmental Members organized a fixed project that was undertaken by approximately a quarter of the project teams. Other Departmental Members still employed a looser co-operation to tackle a much wider range of projects.

Students returning from the 16-month internship program brought back many of this year's projects. The varieties of projects made available give further justification for using the team design project course as a replacement for technical courses. Industry appears willing to provide time and money to support students with whom they are already acquainted. This is either community spirit or because the firms recognize the advantage of the students returning to them with considerable team experience.

The V-shaped life cycle model is appropriate for many small projects, but not all. To allow components from other life cycle models to be adopted, 15% of the term mark is allocated as "faculty advisor choice". This allows for prototype or other concepts to be negotiated between students and their advisors.

A bonus scheme (2% per report) was introduced to encourage students to complete their milestones as early as possible. This was an attempt to overcome the tendency of students, given other time pressures, to leave things until the final part of the course. This scheme turned into a major disaster!

Although initially apprehensive, the students now find the team evaluation reports useful. In these formal team, and confidential individual reports, team members can detail the problems of the team environment and attempted solutions. The students also can provide input to the marks allocated to the team's reports. They can allocate a maximum of ±10% to all team members (including themselves) according to their perception of the effort the respective member put into the project work. The sum of the percentage marks needs to be zero. This evaluation approach partially compensates for the different expectations of the team members as not every body is willing to consider the course important enough to work for an A grade.

5. Successes, Failures and possible Future Solutions

The basic concept of formally introducing students to the theory, experience and practice of project management remains one of our firm goals. We feel, against some student and faculty opposition, that these concepts are directly related to the industrial relevant experience that the CEAB was trying to introduce. Our second offering of the project course is closer to these goals in some areas than our first course, but further away in others.

Some of the problems currently experienced can be expected to remain in all future offerings. As in real life, considerable negotiation needs to occur between the team and the customers before both understand the expectations of the other. Some professors are unwilling to permit that negotiation to occur. Certain teams feel intimated by having the opportunity to negotiate with a professor responsible for their grades.

Many instructors have no formal project management background, and given time constraints and interest level, are unlikely to pick up this knowledge other than through experiences had in the course. Some professors and students recognize the tremendous advantage that project management provides. Others simply state that the efforts associated with the formalized planning at the start of the course gets in the way of their efforts to get on with the project. This bimodal interest in project management techniques is also typical of industrial experiences.

Many of these issues raised by professors and students simply echo the very problems that the project course is intended to overcome. Students are typically very skilled in working on their own and have considerable experience with laboratory groups on very short-term projects. They do not appreciate that the initial planning stages are necessary for every body on a team to understand their role within the project. In addition, initial planning requires communication and negotiation skills in which the students, and faculty advisors, are not sufficiently skilled.

A major complaint concerns the perception by students and faculty advisors of a poor balance between effort spent on project management and the technical aspects of the project. Some students state that they spend 95% of their time writing.

There are two aspects associated with these perceptions. First, many students do not recognize that much of the initial planning is simply associated with the development concepts that they would have to tackle later on under any circumstances. Better education and experience can solve this attitude. The second is associated with the very high project management overhead at the start of the project course. In addition to the workload associated with all their other courses, the students have to do their first team report and negotiate with their customer to produce their planning, specification and acceptance documents. A further complication is that the team reports and negotiations are concepts with which the students are both uncomfortable and inexperienced.

To overcome this problem we are adopting several approaches. First is one of attrition. With 75% -- 85% of students in future courses returning from industrial internship, it can be anticipated that there will be a critical mass of students with negotiation and team reporting experience. We also intend to provide the students with better tools and experiences to produce a

smaller number of reports. This new format may also solve many of the complaints from the returning internship students who complain that they have seen, and experienced, all of this project management material.

One technique will be to move the initial customer negotiations into the block course that occurs prior to the start of the standard term. The challenge here is to persuade faculty members to give up preparation or holiday time to be available during this time slot. In addition, the tools for formalized brainstorming, project planning, error recognition and resolution will be introduced.

We intend to remove the bonus mark scheme which proved very counter productive. The students did deliver their reports early, but the reports were often of poor quality in order that they could be submitted in time for the bonus marks. The rush to produce this material increased the time pressure on the students, the faculty advisors and the course instructors.

Many of the major advantages and disadvantages of our current course are intimately related. All three project course components involve industrial speakers to provide that important combination of theory and industrial relevance. However, tying in this expert experience with the very wide-ranging technical aspects of the projects will remain difficult. During the initial "block week" course we intend to combine industrial speakers with an immediate interactive tutorial on topics associated with team forming, initial project planning and formalized brain storming. We hope that this will focus the industrial speaker without requiring these volunteers put their talks under a review by an academic instructor. Perhaps another solution would be to find the funds to rehire a project management expert to co-teach the course.

The true effectiveness of industrial sponsorship is not yet apparent. Industrial, and faculty advisor, expectations have put pressure on a number of groups. Whether the students, or sponsors, feel that they have got "value for money" will become evident right at the end of the course. The industrially sponsored 4th year projects are not truly contract work, nor are they fully academic. The Engineering Faculty, as a whole, is currently investigating the legal issues of intellectual rights and student/faculty responsibility.

With 19 – 24 projects to be handled, the project course effectively involves many more people than just the course instructor and project co-ordinator. This leads to misunderstandings and contradictions. Assigning a single project to all students under one faculty advisor would avoid this. However, this is an approach the department does not want to take even if it were to become possible to find a faculty member willing to give up an already developed course to concentrate on the project course. As this paper goes to press, our provincial government has just funded two new degree programs within our department. Additional students were already in the 1st year program in anticipation of the funding and will double the number of students in our programs. By 2001 we will need 36 projects, and by 2003 the number will rise to 48 if we decide to keep the same flexibility!

Further faculty education will be required over a number of years so that the assignment of individual and group responsibilities becomes clearer. This will not be straightforward as faculty members have different expectations of what the students should provide in return for the additional time commitment that participation in the project course requires of the faculty

member. Problems arise simply through the names of the reports. In the first term, does the team produce a *Requirements Analysis* document (used by the students to explain to the customer what the team believes is necessary) or produce a *Requirement's Review* document (used by the customers to ensure that the team is doing exactly the correct things)? The different names suggest various perspectives as do the two possible names for the major second term document -- *Low Level Design* or *Detailed Design*?

The wide variety of faculty interests also makes it difficult to make instructions, reports and timings suitable to different kinds of projects. We are going to provide increased flexibility in milestone delivery dates and content. For example the robot hardware or software team may want to replace the *High Level Design Document* with the demonstration of an initial prototype (Faculty Advisor Marks) and the production of an *Implementation Review Document.* Both documents have many common features, but fulfil different purposes. Project guidelines must also balance the desire of some faculty advisors who want total freedom to adjust the timing of, or simply remove, the reports against the need for students to have milestones to spread their workload reasonably through out the year.

6. Conclusion

In this paper we have discussed many of the advantages and disadvantages of our current format for the three components of a 4th year Team Design Project Course. Some solutions are offered to the problems. However with so many faculty members involved in managing 19 – 24 student projects it will be several more years before the course format stabilizes to meet the majority of needs, perceived and actual, of the faculty and students. In the fall of 1999, we shall also find out whether any of it meets what the Accreditation Board had in mind in the first place!

MIKE SMITH
Mike Smith is a professor at the University of Calgary, Alberta, Canada. He teaches undergraduate courses in introductory and advanced microprocessor concepts. In addition to doing biomedical and software engineering research, Mike takes his "hands-on" microprocessor laboratories and reworks them for commercial magazines such as Circuit Cellar Ink. This approach is useful for generating practical class notes and encouraging industrial sponsorship. Mike is responsible for the current format of the Team Design Project course and co-ordinates the projects used within the Team Design Course.

ARMIN EBERLEIN
Armin Eberlein graduated with a Diplom-Ingenieur (FH) from the University of Applied Sciences in Mannheim, Germany in 1993. He then spent time working as hardware and software developer in Siemens in Munich, Germany. Post graduate studies at the University of Wales, Swansea, UK lead to a M.Sc. and Ph.D. and work as a Senior Research Assistant. In 1998 he joined the University of Calgary, Canada, where he is an Assistant Professor teaching project management and software engineering. His research is concerned with formal methods in system design, AI in telecommunications and new methodologies for service design. Armin is responsible for the theoretical aspects of the Team Design Project Course.