

Promotion of Final Year Capstone Projects

Aaron S Blicblau

School of Engineering and Science, Swinburne University of Technology,
Hawthorn, Australia

Introduction

In many engineering courses around the world one of the key aspects required of the students is that they complete an independent project in their final year of studies. Project work is now considered to be an important part of an engineer's training⁴⁻⁶. Students enrolled in their final year of mechanical engineering at Swinburne University of Technology are required to undertake and complete a final year project (major capstone project). Students may select a project from a list prepared by academic staff, or may suggest their own topic based on individual interest, or arising from their period of Industry Based Learning. The project may be university based or industry based. The project may take various forms involving technology research and development, experimental work, computer analysis, industry liaison and business skills^{7,8}.

Students are expected to conduct literature and state of the art surveys, formulate and define problems, generate and select solutions, and analyze and prepare designs. Where appropriate, students build and test their design. Projects are undertaken under the close supervision of a staff member who meets regularly with the students to discuss and assure progress.

Total student time spent on the project is expected to be a minimum of 160 hours which is expected to be 25% of their final year of studies (over two semesters). Either a major report or a technical paper is prepared and submitted for assessment, a poster is prepared for display and an oral presentation is delivered in a conference format.

Format of Capstone Projects

The timeline of the projects extend over two semesters. During the first semester the students define their project, often in discussions with various staff members. However, if they wish to propose a project, that is often also accepted for their capstone work. This is done in consultation with a staff member. The next step in the project organization is the development of project proposal which may include a business plan, a research project or a design proposal. Those proposals all require intensive searching of the literature, and culminate in a substantial "literature survey" as part of the project proposal. Once the project proposals have been submitted the task of determining the structure of the project is also completed.

The semester commences early March, the topics for the project are finalized by early April, and the proposals are completed by the end of May. The process takes approximately 10 weeks before any "real work" can be commenced. However, once the proposals have been

submitted the project work commences. The students are encouraged to utilize all the resources available to perform research. They are given a limited budget and provided with technical assistance in the workshop. If the project involves computer simulation or analysis, then appropriate software is made available to the students. Similarly, if there is a large amount of design involved, then workstation and computer package facilities are made available. The major difference between postgraduate work and this form of project is that students work in teams or groups of two or three, depending on the project theme or topic. Because, at the same time as the students undertake their project, they are also enrolled in at least three examinable subjects. By having a group of two or three students work on one topic, an extensive amount of work can be achieved.

From the commencement of the project the students are given the choice of submitting either a formal engineering report (of approximately 35 pages) or preparing a technical paper in accordance with guidelines of the ASME⁹ or SAE¹⁰. These two organizations provide extensive information on the preparation of manuscripts for submission to conferences or journals. Should the students decide to submit a “paper” they are also required to submit a detailed laboratory manual for corroboration of their work.

Very few students from an average cohort of 75 choose the “paper” writing path. It is often at the suggestion of the academic staff supervisor that a “paper” is developed and submitted for consideration for publication. This is often achieved after the completion and submission of the final report. Consequently, the academic supervisor is able to assess the quality of the students’ work. If deemed appropriate the students are invited to continue with their work, perform additional analyses and prepare the manuscript.

For those students who choose the “paper” writing path, the goal of the project is very oriented towards manuscript preparation for conference submission and follows different guideline from those preparing a report. These students must now ensure that their results are experimentally accurate, can be statistically validated and the literature review is comprehensive. Often the students who contemplate postgraduate studies undertake this path. However, the publication of their work is not dependent on the course which they choose to submit their capstone project results. It is usually their supervisor’s recommendation which determines whether the preparation of a manuscript is appropriate. The students often do not have sufficient experience in the “publish or perish” field.

Context of the Capstone work

The Institution of Engineers Australia places great emphasis on project work as a core enabling aspect of engineering education, extending from freshman year (first year) to senior year (final year). In view of these requirements, and as a requisite for accreditation, Swinburne has also developed generic attributes appropriate to all of engineering an example for the final year project is given in Table 1. It is recognized that not all students will achieve all the generic attributes to the same extent, where some will concentrate more on the team work skills and oral presentations for example, whereas other students may concentrate on the planning, management and research aspects of the project. This is common within a complex work or research and development environment.

For those students enrolled in the capstone project the assessment is composed of four sections. The first being a project proposal, the second a written report (or paper/manuscript), the third an oral presentation and the last, a poster preparation. Each form of assessment is undertaken by two independent assessors (who may not be the students’ supervisor) and

cumulative grade is developed. In this way, bias is minimized for each section of the assessment, as well as not applying any penalties to those students who do succeed (or wish) to develop a manuscript for publication considerations. There are some instances where student work is published within a university environment.

To develop collaborative and team work skills.
To develop project management skills.
To develop skills in planning and executing an innovative project.
To undertake a major project and complete the task satisfactorily within time and budget
To develop an understanding of the processes of research
To demonstrate the ability to integrate knowledge and skills acquired during the course.
To develop advanced skills in literature review, report writing and oral presentation.
To develop skills in writing and presenting a major project report.
To demonstrate the ability to communicate by presenting a professional seminar.

Table 1. Institution of Engineers Australia and Swinburne attributes for capstone projects.

Aspects of Capstone Project Outputs

For both the written report and the manuscript, the students consult with their supervisor, who also acts as a referee for the written work. The main purpose of the research paper is to help students learn how to write a scientific and technical paper in a specific area of research. As well, it is important for the student to understand the importance of writing succinctly, and with care and correctness. The students consult with their supervisor about the format of the paper submission as it often varies from project to project and depends on the field of work being undertaken. For example, projects that deal with automotive engineering follow the format of papers for conference presentation Society of Automotive Engineers⁹, (SAE), those dealing with mechanical engineering, the American Society of Mechanical Engineers¹⁰, (ASME), whereas those that are concerned with materials science and engineering follow the guidelines set out by the Journal of Materials Science¹¹.

The general format used for research papers published in the various learned societies (e.g., SAE or ASME) for journals is specified at various web sites on the WWW so access by students is not difficult. Especially for the paper manuscript, the supervisor provides extensive comments and queries for consideration by the students. This is very comprehensive, similar to a set of formal referees. The criticism of the written report is not as extensive, and allows for leeway in the overall assessment of the written work. In many ways the criticism of the paper is more severe, as only eight manuscript pages are allowed. And there are also criticisms on the method of the paper setup in relation to the guidelines set by the professional engineering societies (e.g. ASME, SAE for the mechanical engineers).

The oral presentation of the capstone projects is encompassed in a “conference” day, which occurs a few days after the end of all the exams. The majority of students and staff attend these sessions. In addition, external personnel, who may have sponsored the project or were acquainted with the work, are invited to listen to the presentations. All students must present their work in accordance with strict conference guidelines, 20 minutes is allocated for each presentation. Each student must take part in the presentation. The work is presented utilizing Powerpoint[®] or another form of presentation software (overheads or transparencies are kept in

reserve in case of computer failure. At the end of each presentation two minutes is allowed for questions. At the same time as the presentations are being given, the posters are displayed in a specially prepared room. At the end of the presentation session, the students are required to attend their posters and answer any questions.

A schematic representation of the capstone project writing and associate procedures are shown in Figure1. Although the paths may seem complex, to arrive at a similar output, a number of different conduits may be applicable.

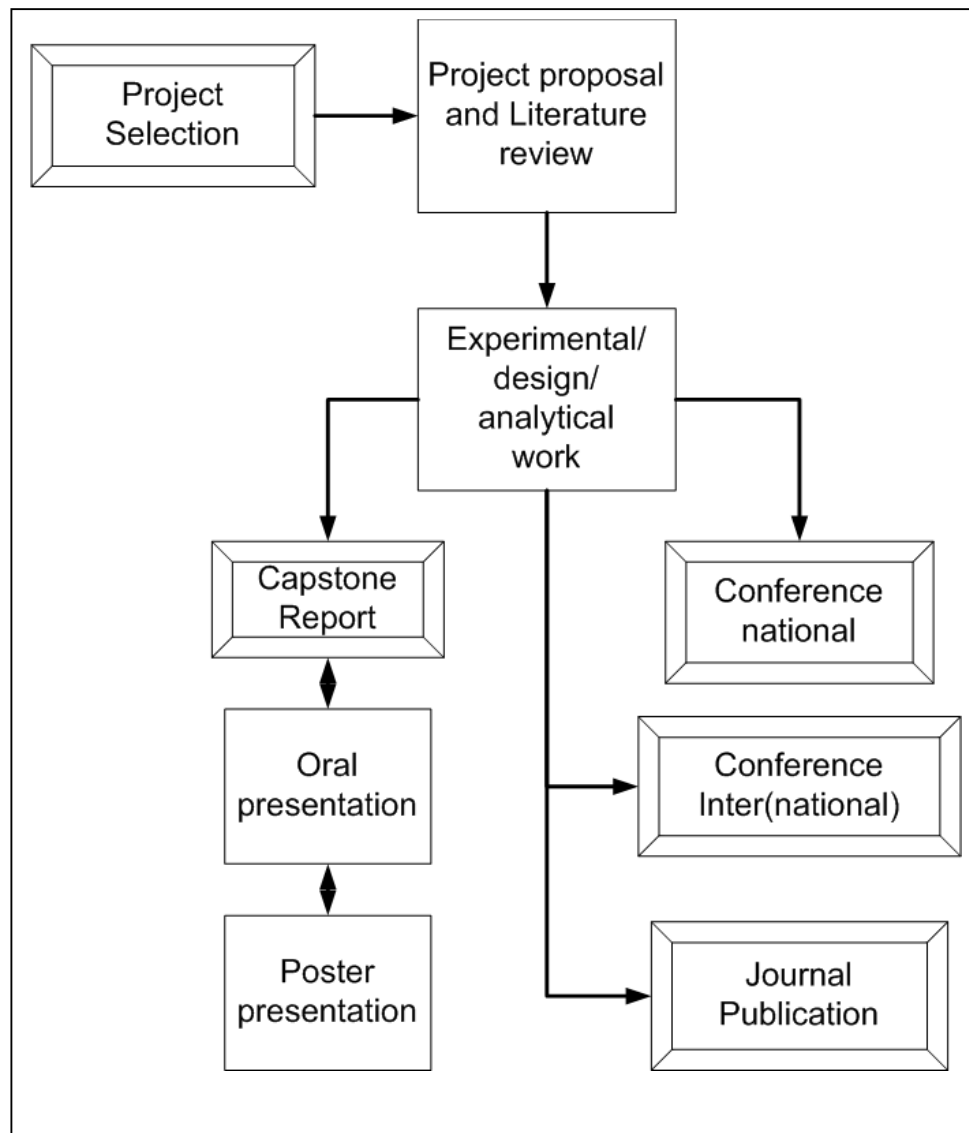


Figure 1. Schematic representation of the capstone projects paths to various outcomes

Student Experiences

The students gain experience in many aspects of manuscript preparation, conference preparation and poster development. For a select number of students' work there is still one further step, outside of the faculty environment, and that is the submission of the work to a national or international conference (which is refereed and satisfies the guidelines for refereed

conferences). The work chosen by academic staff comes from both the specially prepared manuscripts and from the written reports submitted by the students as their capstone project. Although there is an alternate avenue for undergraduate publication¹², both the students and their supervisors decided to attempt the general academic literature. It should be noted that there was no guarantee that the capstone work would be accepted.

Listed below are examples of work supervised by the author, and submitted for consideration for presentation and publication are given in Table 2. Shown are details of papers presented at national¹³ (Australian) conferences, international conferences³, and journal publications^{1,2} as well as two papers which were deemed unsuitable.

Capstone Project Title	Conference/Journal Submission
Sisal reinforced Cement Sheeting	Journal ¹
Laminate Box Beams	International Conference ³
Wool Composites	Journal ²
Polycarbonate Pull through Tests	Unsuccessful submission
Stress distributions in timber sections	Not suitable*
Automotive gear Shift Vibration Problem	Not appropriate**
Armour plate glass	National conference ¹³

Table 2. Examples of successful and not successful publication outcomes by the author's students, colleagues and the author

*collection of data and interpretation of past work.

**design approach for confidential industry sponsored work

It is emphasized that not all manuscripts succeeded in being accepted for conferences or journals, but the experience by the students was positive and encouraging!

Student Outcomes

A depiction of one of the papers published with respect to the sisal work listed in Table 2 is shown in Figure 2. Another student scored a *coup* by having a photograph from his work chosen to be on the cover of a journal. For this student, recognition in the international arena was of a different format to that required for academic purposes to pass the subject. The outcome of this major capstone project was that one of the scanning electron micrographs from the paper concerned with wool composites was chosen for the cover of the issuing journal, as shown in Figure 3. Requests for copies of the paper were received from many researchers from around the world. The students in both instances were overwhelmed by the acceptance of their capstone work and recognition in the academic publishing world.

In another case, where a student paper was accepted to a refereed international conference, the student author informed the university that he would be in the vicinity of the conference (near Lemnos Greece) at about the time it was to be held¹⁴. So university funding was provided for student registration, student's travel and (cheap) accommodation.

Reports back from the student who attended and presented his paper in Lemnos were very exciting. He was amazed at the level and standard of work being undertaken by Swinburne capstone students, such that it could be presented and accepted at an international conference. Similar comments were received from previous students who had their work presented at national (Sydney) conferences.

Because much of the evidence of student satisfaction with the outcomes of the capstone project is anecdotal, an *outcomes survey* of both students and industry will be implemented over the course of the next three years. The survey will involve four major themes including, “how well was the capstone project taught”, “what skills did the students gain which helped them in industry”, “what improvements could be implemented in the management of the project”, and lastly, “how could industry involvement affect the outcomes of the capstone project”. These questions can only be asked after the student has graduated and been involved with industry for a number of years. As well, a comparison with peer institutions that undertake capstone projects is being considered for future work to be reported upon.

Final Remarks

Results from the capstone project have provided students with skills in project proposal, project execution, experimental work and communication skills. The outcomes of some of the capstone projects have seen undergraduate student work accepted and presented at local and international conference, as well as a number of international journal articles. Anecdotal reports by students indicated a high level of satisfaction with the management and outcomes of the work in the form of conference participation, presentation and publications. Work for the future will involve an outcomes survey with both students and industry. The details presented in this paper may help junior staff to get some ideas about what to do at their institution for the implementation of final year (capstone) research projects in mechanical engineering.

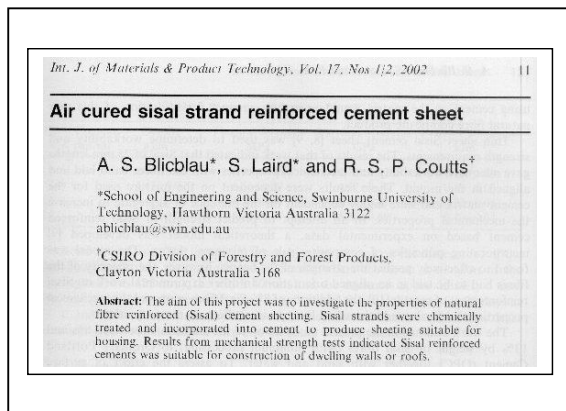


Figure 2. Example of student publication resulting from capstone project work in collaboration with an external organization and the author¹.



Figure 3. Example of student capstone project (scanning electron microphotograph) on the cover of the issuing journal².

Bibliography

- (1) Blicblau, A. S., Laird, S., and Coutts, R. S. P., Air Cured Sisal Strand Reinforced Cement Sheet, *International Journal of Materials Processing Technology*, 2002, 17.
- (2) Blicblau, A. S., Coutts, R. P. and Sims, A., Novel Composites Utilizing Raw Wool and Polyester Resin, *Journal of Materials Science Letters*, 1997, 16, 141417.
- (3) Blicblau, A. and Wallace, D., "Methodology for Designing Composite Laminate Box Beams", International Conference on Composite Materials, ICCM/11,14-18July, 1997, Gold Coast.
- (4) Hurst, K. S., The progressive use of projects in an engineering degree course, *International Journal of Mechanical Engineering Education*, 1993, 21, 373.
- (5) Ihsen, S. and Brandt, D. Changing the Curriculum towards project orientation-The Aachen experience. In *Educating the Engineer for Lifelong Learning*; Maffioli, F., Horvat, M., Reichl, F., Eds.; SEFI: Vienna, 1996.
- (6) Sjorberg, A. Project Oriented Courses in Scientific computing with applications from natural sciences and engineering. In *Engineering Mathematics: Research Education and Industry Linkages*; Yuen, D., Broadbridge, P., Steiner, J. M., Eds.; Institution of Engineers, Australia: Canberra, 1996.
- (7) Blicblau, A. S. HES5106 Research project guidelines. in http://www.ses.swin.edu.au/~ablicblau/2004HES5106/hes5106_overall_%20subject_details.htm, (accessed 3rd Dec 2003).
- (8) Blicblau, A. HES5106 Research Project, in http://www.ses.swin.edu.au/~ablicblau/2004HES5106/hes5106_overall_%20subject_details.htm, (accessed 3rd Dec 2003).
- (9) ASME. Journals Digital Submission Site. in <http://www.asme.org/pubs/journals/>, (accessed 3rd Dec 2003).
- (10) SAE. Paper presentation. in <http://www.sae.org/products/papers/papinfo/present.htm>, (accessed 3rd Dec 2003).
- (11) Kluwer-on-line. Journal of Materials Science Letters. in <http://www.kluweronline.com/issn/0261-8028/current>, 2003 accessed 3rd Dec.
- (12) Journal of Undergraduate Science and Engineering. in <http://www.undergraduatejournal.org/> (accessed 8th December 2003); University of Texas at Austin: Austin, 2003.
- (13) Blicblau, A. S. and Sabey, S., "Modelling the Ballistic Impact performance of Lightweight Composite Armour", Australian Engineering Mathematics conference 96 (AEMC96), 1996, Sydney.
- (14) Korolis, J., Young, M., Blicblau, A. S. and McManus, K. J., "Image analysis applied to discriminate between sealed and unsealed roads.", Urban Transport 2001, 14-16 May 2001, Lemnos Greece.

Biography

Aaron Blicblau is a senior lecturer of materials engineering at Swinburne University of technology. He teaches engineering materials to freshman engineering students from a variety of engineering disciplines. For sophomore and later year students he teaches materials engineering failure analysis, manufacturing processes and selection of materials. His teaching in senior year is focused on capstone mechanical engineering courses.