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Students' perceptions of an active learning approach to capstone projects

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ABSTRACT: Engineering graduates, local and international, need to communicate effectively. The requirement of better communication skills is recognised as important generic skills applicable to all graduate engineers. Evidence shows that communication skills of engineering students, particularly, in producing reports, poster, and giving oral presentations are often below their expected level in an industrial environment. The final year capstone project in the engineering curriculum addresses the need for communicating effectively. These skills have been incorporated into the early stages of the final year capstone project, as an active learning process, in a series of seminars and practical applications to provide the students with these capabilities. These are very important for international students, whose first language is not English and who may not have had the appropriate training or experience. This article provides the results of a survey conducted among final year engineering students, who enrolled in the final year capstone project. It examines the effect of an active learning process to boost their communication skills. The outcomes show that the majority of students, both international and local, found intensive tutorial activities to be most useful as an adjunct to their learning.

Keywords: Capstone, active learning, international students, non-English speaking backgrounds and cultures

INTRODUCTION

Final year engineering projects are regarded as being important in the training and education of professional engineers [1]. In particular, students themselves have identified generic skills as important to their academic training for the outside world [2]. These skills encompass report writing, oral presentations and overall confidence in communication. The mechanical engineering final year capstone project addresses these skills which are applicable to all graduate engineers [3][4]. All students including those from non-English-speaking backgrounds and cultures (NESBC) are expected to write a major thesis as part of their capstone experience in the ultimate year of their mechanical engineering studies. This is particularly important for the international students who may not have had the training or experience in their country of original education.

It is well established that the zenith of capstone project work is the writing of a thesis or report and an oral presentation of the work. Often an e-poster is developed and presented to peers and to members of relevant industries or professions [5]. The ability to deliver an effective presentation is prominent on lists of graduate attributes, but the development of effective teaching practices to develop such skills has received little attention in the scholarship of teaching and learning. Since all capstone students are new to writing and oral presentations in the research and development environment, the ability to deliver an effective presentation and write an effective report is one of the main generic skills which students learn [6][7].

Ku and Goh emphasise that literature reviews, oral presentations and written reports or dissertations were important elements in the assessment schemes for capstone projects, as well as in the basic needs of an engineer [1]. Capstone and graduate students have little experience of writing for an audience of examiners, or industrial based reviewers, who have definite expectations of just how a report should be structured and delivered, both structurally and in an engineering manner [8][9], and it is seen that all students have these difficulties [10][11].

Writing and literature evaluation skills have been incorporated into a formal subject in the early stages of the final year capstone project to provide a systematic approach to the writing process [12]. A series of seminars and active tutorial actions have been developed to provide the students with these capabilities [13][14]. The academic subject matter is delivered with the support of active learning in both tutorials and lectures, and incorporate aspects of e-learning. In the context of subject content delivered in lectures, e-learning involved extensive use by students of the LMS (Blackboard™) for research, communication and peer group responses. The use of the LMS was not assessed, nor moderated. The students learnt to upload copies of a preliminary poster, parts of their written manuscript, and would

then be able to comment on their colleagues' input. In addition, the convener uploaded copies of previous years' posters, reports and video-capture of past oral presentations. Current students then, also had an opportunity to comment and learn from previous work undertaken by students of similar backgrounds in a similar engineering discipline.

Again, no assessment was undertaken, with the learning aspect being considered of prime importance. E-learning was used especially during the lecture time as a vehicle for both peer-to-peer learning and asynchronously as a depository of information and communication activities. Implementation of writing, reviewing and evaluation takes the students through the process of comprehensive project proposal writing, including the evaluation of appropriate literature, the confidence in delivering an oral presentation and the ability to review their work on a poster [15].

The current work involved students in their capstone year of mechanical engineering. They were asked questions about their experiences in developing writing and presentation skills. This article provides data on the outcomes of these experiences as measured from student surveys together with *free comments*. Independent sample *t*-tests were conducted to compare the benefits between international and local students. The data were analysed to determine both local and international students' perceptions of the benefits of each of the teaching and learning activities.

Over a period of five years, the capstone subject has been developed to a mature stage for delivery [16]. The intention of this study is to evaluate the perception of capstone students of the active learning process and to distinguish the particular outcomes of international students whose first language was not English. The result of this work will enable engineering educators to learn how to implement active learning procedures to assist final year students in their undergraduate final year projects.

OVERALL STRUCTURE OF THE SUBJECT

The capstone subject is delivered over two semesters. The first semester involved lectures, tutorials and activities to enhance the students' writing, presentations and research capabilities, together with sessions on statistical research methods. The lectures deliver only core topics, whereas the tutorials are the working environment. At the end of both these sessions, the students develop the project and formulate the problem. Intensive student involvement took place in the tutorial sessions, whereas the lectures were implemented as a support activity, which is a turnabout of the usual processes in teaching.

The second semester subject is composed of a pure research and development approach, where all the activities occur in the laboratory - be it experimental, modelling or industry-based. Responsibility for the gains in educational knowledge has now shifted to the students. The capstone project now becomes the focal point for e-learning.

Details of the Active Tutorial Process

The tutorial sessions were spread over six weeks. Each week had a specific topic and activity assigned to it. The students were informed of the requirements of each activity at the beginning of the overall six tutorial sessions. Each week developed along an agenda, the outline of which is shown in Table 1, and specific details elaborated upon in the following sections.

Table 1: Outline of weekly tutorial agenda.

Agenda Week	Agenda Content
1	Project discussion; stages of a research journey
2	Project discussion; structure of proposal; critique of previous proposal; content importance. Two minute oral presentation
3	How to approach a literature review; periodicals, conferences, WWW; one page summary of literature review approach. Short presentation to group
4	Thesis topic and summary of own literature review; importance and validity of citations. Two minute oral presentation
5	Criticise previous e-posters; develop e-posters
6	Criticise previous e-reports/thesis; develop report contents. Three minute oral presentation

During week one, the tutor explained the stages of a research journey and handed out information which shows the common approaches to research. The first stage involves selecting a thesis topic based on theoretical dilemma or personal interest followed by refining the topic into research questions. The next stage is to design a study which needs to identify specific variables and consideration of the hypotheses. This stage overlaps with an empirical level for validation of the thesis. A further stage involves a theoretical level focusing on the interpretation and presenting of data.

This process starts with reviewing the literature and developing research questions and conceptual framework followed by designing a research thesis and analysing the data and presenting the findings. The students were asked to participate in a discussion regarding this approach and provide an example related to their research - either work they have conducted in another subject or have known about that was similar.

In week two, several research proposals submitted by students in previous years were distributed during the tutorial. All the students critiqued these reports. This led to discussion of the structure of a research proposal, including thesis sections such as executive summary, introduction, background and literature review, statement of problems, objectives, methodology, milestones and time schedule, resources and budget, summary/conclusion, and references. The students were asked to read and scan a few previous proposals and evaluate these based on the structure discussed. As part of the overall oral presentation experience, they had two minutes to present their observations regarding previous proposals. As a corollary, the tutor explained the evaluation criteria for the previous research proposals. The two approaches were then compared.

By week three, the students finalised their research topic. To help the students to enrich their research sources (list of peer reviewed articles), an exercise was conducted during the tutorial to show how students should find more relevant articles or sources by developing a *mind map* based on an existing article. Then, a pair of articles, one a conference paper and one journal paper, were handed out to students. They were required to scan those articles and explain the structure of the papers, their contents, and how the authors presented their findings. The students presented their views regarding both the quality and number of references.

For week four, the students were required to provide a one-page preliminary literature review of their own thesis topic, and had to include at least five references. They had to present their findings regarding the initial literature review in two minutes during the tutorial class in week four.

During week five, the students worked on their e-posters (electronic posters) during the tutorial class. The students and the tutor reviewed and commented on previous e-posters submitted over the past few years.

In week six, the student presented their initial research proposal to a panel of judges, as well as their peers for five minutes. The judges included the lecturer/convenor of the subject, the tutor, and student peers for overall evaluation.

The project proposal reports were submitted at the end of the semester and were assessed according to a *standardised* format, which was given to all the students during the first week. These criteria correlated with the themes developed during the tutorial sessions and were an attempt to formalise the content of the report. An example of the criteria employed for assessment is given in Table 2.

Table 2: Assessment criteria for report.

Criteria	Not Done	Very Poor	Poor	Fair	Good	Very Good	Excellent	Specific Comments
Equivalent Grade		Low N	N	P	C	D	HD	
Introduction								
Problem(s)								
Literature Review								
Methodology								
Research Plan								
Time Schedule								
References								
Summary								
Figures and Tables								
Budget								

SURVEY OF THE ACTIVE APPROACH TO COMMUNICATION SKILLS LEARNING

To determine the effectiveness of the active approach to communication skills in the tutorial and lecture sessions, a specifically focused survey was conducted amongst all of the 57 capstone students enrolled in one year. There were 12 questions asked which required a response of 1-5 on a Likert scale (1 - indicating strongly agree, to 5 - indicating strongly disagree). Responses 1 and 2 were grouped as overall agree and responses 4 and 5 were grouped as overall disagree. All the questions were paraphrased by the term:

...my understanding of the requirements of the Research Project in this subject has improved because of,

The results of the survey are given in Table 3. The questions are grouped according to the students' perceptions of their learning about writing; presentation; e-learning (from the Blackboard™ Learning Management System); poster presentation and development; and information retrieval.

Table 3: Results of the survey.

…my understanding of the requirements of the Research Project in this subject has improved because of…	Overall Agree (responses %)	Neutral (response %)	Overall Disagree (responses %)
Lecture attendance	70.2	17.5	12.3
Tutorial attendance	68.4	22.8	8.8
Accessing the lecture material on Blackboard™	57.9	29.8	12.3
Attempting literature reviews in tutorials	63.1	24.6	10.6
Preparing for oral presentation in tutorials	50.8	22.8	26.4
Preparing for the e-poster in tutorials	59.7	21.1	19.3
Writing the project proposal	73.7	21.1	3.6
Writing the e-poster)	73.7	17.5	8.8
Referring to text books or the Internet	71.9	15.8	12.3
Asking questions from fellow students	59.7	31.6	8.8
Asking questions from my supervisor	59.7	31.6	8.8
Accessing Blackboard™ information (LMS)	64.9	22.8	12.3

From 57 students surveyed, 96.5% (55) declared that they had completed all the requirements of this subject. Eleven students were international students (19.3%) and the rest were local students. Out of 57 responses, only three participants (5.3%) claimed that they had undertaken a similar subject before. They commented that it was *useful to do it again*. Initial impressions of the data analysis suggest considerable diversity amongst the students. They differed in their understanding of how to develop and implement both an oral presentations and a written report, especially about the usefulness of receiving assistance in their work.

There appears to be little influence of any particular one style of teaching (lecture or tutorial), accessing of information (Blackboard™) or in active participation in the classroom. Even though there was no statistically significant difference between the various activities within the classroom lecture or tutorial, there was a general perception that more was more learnt in the tutorial activities of writing documents, (report and e-poster) than in the lecture environment, or accessing the learning management system or even asking for information from lecturers or fellow students. However, it appears that the lecture material together with the other activities supplemented and contributed to the effectiveness of the in class tutorial writing sessions.

Perceptions of Local and International Students

The survey data was further analysed to determine both local and international students' perceptions of the benefits of each teaching and learning activity over a period of two years with 140 students. An interesting series of phenomena occurred for the international students (whose first language or first mode of instruction was not in English) and their perception of the benefits obtained from the content and structure of the course. Independent sample *t*-tests were conducted to compare the benefits between international and local students.

The results of the survey questions asked produced the outcomes shown below. However, as some of participants did not answer all questions, the following statistical results for the *t*-test show slightly different response numbers for each question.

- There was no significant difference in means between international and local students in their perceived gain from attending lectures. For international students M = 3.85, SD = 0.9, and for local students M = 3.85, SD = 0.852 t (140) = 0.006, p = 0.995.

- However, there was a significant difference in means between international and local students in their perceived gain from writing the e-poster. For international students M = 3.88, SD = 1.066, and for local students M = 3.46, SD = 0.844 t (137) = 2.388, p = 0.018.
- There was also a significant difference in means between international and local students for the perceived benefits of:

  – Tutorial attendance (international students, M = 4.12, SD = 0.808 and local students, M = 3.364, SD = 0.915; t (139) = 2.749, p = 0.007);
  – Attempting literature reviews (international students M = 4.00, SD = 0.829 and local students M = 3.64, SD = 0.869 t (135) = 2.071, p = 0.040);
  – Preparation for oral presentations in tutorials (international students M = 4.09, SD = 0.753 and local students M = 3.31, SD = 0.936; t (139) = 4.422, p = 0.000);
  – Writing the project proposal (international students M = 4.26, SD = 0.751 and local students M = 3.79, SD = 0.709; t (135) = 3.36, p = 0.001);
  – Preparing the e-poster (international students M = 3.88, SD = 1.066 and local students M = 3.46, SD = 0.844; t (137) = 2.388, p = 0.018).

Active participation, which occurred in the tutorial environment, was perceived as being of significance. These responses seem to be similar to those obtained for a similar intervention programme, but for first year students in their oral presentation skills [16].

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When summing the appropriate responses in their respective categories, the perception of students was that the capstone course in research methods had developed their skills in oral communication and improved their ability to use both written and visual communication skills [17]. Bias free open-ended comments implied that students could identify and so improve the relationship in their generic competencies and key generic skills [6][7][18]. Referring to the specific subject/unit of study, students commented favourably on its continued implementation for future years.

The results of the survey questions asked indicated that there was *no significant difference in means between international and local students; in their perceived gain from attending lectures and writing the e- poster*. However, there was a significant difference in means between international and local students for the perceived benefits of tutorial attendance; writing literature reviews; preparation for oral presentations in tutorials; writing the project proposal and preparing the e-poster.

In the case of international students, the data suggested that they perceived a greater gain from actively participating in writing and presentations in a small class environment than in attending large classes for preparing for report writing, e-posters and oral presentations.

CONCLUSIONS

The culmination of the capstone project is typically the writing of a report and a presentation of the work. The ability to deliver an effective presentation is prominent on lists of graduate attributes. The active learning approach received by students in their capstone work, has been shown to be well received. In particular, the majority of students agreed that their main form of learning was in the actual writing process supplemented by information attained during lecture and tutorial attendance. The survey results indicated that the majority of international students found that intensive tutorial activities of most use as an adjunct to their learning and producing necessary outcomes.

The importance of Internet access was not considered to be of the same import as actively implementing the writing requirements. These initial results and impressions need careful investigation, and no doubt, other relevant information will emerge in the data analysis. Furthermore, future stages of the study will include interviews with the academic staff, observations of the tutorial and student interaction session together with the poster presentations. It is anticipated that a larger project should help inform the definition of exactly what generic skills and competencies can be effectively taught with appropriate metrics in the classroom. An informed approach to designing the communication skills and experiences is needed, so that students can recognise and work towards enhanced generic communication skills.

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BIOGRAPHIES

Aaron Blicblau is a senior lecturer at Swinburne University of Technology, Melbourne, Australia. He graduated as a materials engineer and worked in an industrial complex before becoming interested in the pedagogical aspects of engineering. Currently, he is the convenor of both the mechanical engineering capstone project, as well a first year subject, giving uncommon insight in to student development and learning from first to final year.

Dr Kourosh Dini concluded his educational milestones by completing his PhD degree at Swinburne University of Technology, Melbourne, Australia, in 2009. He possesses a wide range of qualifications ranging from engineering (as a professional engineer qualified by Engineers Australia) to management and social science, and he has been actively involved in both research and teaching activities at Swinburne since 2005.