Interactive Learning – Is It Working?

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Abstract

This paper describes the process of implementing Interactive Learning techniques in an engineering course with the School of Mechanical Engineering, at The University of Adelaide. The School of Mechanical Engineering aims to match the skills developed in the Bachelor of Engineering Degrees to those required by industry of graduates. The justification and benefits for implementing Interactive Learning is discussed, and with feedback from students, demonstrators and the lecturer, the outcome of the technique is reviewed. It is in the opinion of the authors and informal feedback from students, that improvements in learning and skill development as applicable to practising engineers has been demonstrated to result from the introduction of Interactive Learning, and the provision of sufficient postgraduate course supervisors to make such tutorial sessions viable.

1. Introduction

It is clear from industry feedback to the School of Mechanical Engineering at The University of Adelaide that not only is technical competence a necessary ability for graduate engineers, but a broad base of generic skills is also highly desirable. This allows the graduate to be highly adaptable and well rounded. The industry feedback extends further than The University of Adelaide, as Mills and Treagust[1] suggest with a well referenced statement:

"Today's engineering graduates need to have strong communication and teamwork skills, but they don't. They need to have a broader perspective of the issues that concern their profession such as social, environmental and economic issues, but they haven't. Finally, they are graduating with good knowledge of fundamental engineering science and computer literacy, but they don't know how to apply that in practice."

A similar consensus is found by Demen et. al.[2] The School of Mechanical Engineering aims to match the skills developed in the Bachelor of Engineering Degrees to those required by industry of graduates. There is thus motivation to implement alternative teaching methods to the more traditional 'textbook based' approach. This paper describes the process of implementing Interactive Learning (IL) techniques to enable students to acquire such attributes.

IL, as referred to in this paper, attempts to remove the full onus of teaching a subject from the lecturer and tutors by moving the focus to the students. The students are expected to develop their own methods of working within their groups, to interactively find a solution rather than just using the methods provided by the course structure. To encourage communication between students, they work in small project teams where each member contributes to the tutorial assignments. As a group, they are then responsible for checking their reasoning and making sure that their answers are successful, in terms of meeting quality assurance procedures.

Section 2 continues to explain the structure of the course used to implement the interactive learning technique. Section 2.1 explains the history of the course and why it was changed while section 2.2 explains what it has changed to and how the IL technique was implemented. Section 3 outlines the potential benefits of the new course structure from the point of view of the lecturer, demonstrators and students. Section 4 highlights the change in distribution of results after the new technique was implemented. Section 5 discusses the experiences of the lecturer, demonstrators and staff and feedback from past and current students. The paper is then concluded in section 6.

2. Course Structure

This section will describe how the course titled Structural Analysis and Design (SA&D), was converted from a subject taught in a traditional style typical in tertiary education to a more interactive and decentralised style of teaching more appropriate to the demands of industry. The content of SA&D is based on five main areas of civil engineering; timber, steel, concrete, aluminium and pavements. The course is compulsory for all third year students in the School of Mechanical Engineering and presented as a one semester 'summary' of civil engineering. This is to provide the students with a broader understanding of engineering.

2.1 Evolution of the Course

The SA&D course was originally taught by the School of Civil and Environmental Engineering, providing instruction in the theory of steel and reinforced concrete structures. In 1996 the current lecturer, L. Doherty, an adjunct with extensive industrial experience, was allocated to teach the course. An opportunity arose to introduce industrial practices into the course after positive industrial feedback for the final year civil engineering design projects at both The University of Adelaide and the University of South Australia. In utilising such practises, the students worked as 'consultants', initially 'bidding' for the job then taking it right through to production of detailed contract documents. Initially the SA&D course was broadened to include a wider range of structures with an emphasis on industrial design techniques. Returning in 2002 after a three year break, Doherty found the class size had increased to over 150 students, inspiring a need for more efficient methods of learning which still reflected industry demands. Consequently, team based tutorial groups requiring the application of quality assurance principles were introduced. To further broaden learning, the tutorials were structured to involve a relevant generic component worth 20% of the overall tutorial assessment. Importantly, this involved the requirement to submit an 'audit trail' detailing the progression and the author of work undertaken for each tutorial.

To encourage the IL learning process and to reflect their importance, half of the assessment marks were allocated to five team-based tutorial assignments throughout the semester, with the other half allocated to an exam. The IL process was encouraged by structuring the five tutorial assignments so they were undertaken by small project teams of six to eight students. Reflecting the application of quality assurance procedures, teams were awarded either no marks, half marks or full marks for their tutorial assignment. With half marks, teams had one opportunity to upgrade it to the 'fit for purpose' quality grade, that is, full marks. There is also a ‘peer assessment weighting’, submitted in the compulsory ‘audit trail’, which forces the team to consider the contribution of each member for each tutorial assignment.

Aside from the two fifty-minute lectures there was one fifty-minute tutorial per week. With the increased class size and only two to three minutes to converse with each team the tutorial became impractical resolving into a ‘talk and chalk’ session. This small amount of time was not enough to truly portray the importance of matters such as why interactive team-based learning and quality assurance are essential for industry application. Consequently, a number of postgraduate students were utilised to better implement the IL measures described.

The examination for both 2002 and 2003 followed the format of earlier years of open-book, and two hours in duration. In the anticipation of successful application of quality assurance to tutorial assignments, most students would have 50% of their final marks before undertaking the examination. Thus, to ensure students saw the examination as an encouragement for sound study and learning, the tutorial marks were multiplied by twice the examination mark achieved if the examination mark was less than 50%. Thus in order to pass, a student who achieved full tutorial marks was required to obtain a minimum of 33.3%, and a minimum of 50% to obtain a distinction. This established a necessary standard for the examination. Whilst successful in an overall sense, it was a frightening challenge when the students first saw the exam paper. Also, it became evident that the overall effort of preparing, undertaking and marking such an examination was out of proportion to the value achieved and an alternative became desirable. These results are discussed in section 4.

To address these deficiencies a new approach utilizing The University of Adelaide’s online learning environment called ‘MyUni’[3], which is produced by Blackboard Inc.[4] was used to create a multiple choice, open-book internet-based exam for 2004. Under standard examination conditions, the students sit at a computer terminal working their way through simple answer questions designed to test the fundamental knowledge of the five main areas of the course. In an endeavour to introduce the students to this form of examination as well as to encourage appropriate learning, the exam questions were designed by the students themselves. This took the place of the ‘generic’ component of the tutorials and attracted an overall mark of 10%. Each student was to submit a question for each tutorial, totalling a possible 750 questions for the exam to be based upon. The demonstrators selected from these as a basis to form the 1½ hour exam. To avoid the temptation for students to cheat, the questions were randomised in order for each computer. The typical format for a question involves presentation of a simple diagram, with a short question, and eight possible answers. It was hoped this would have the effect of calming the nerves of students that typically ‘freeze’ under the pressure of an exam, as well as automatically determining the students marks and providing a grade shortly after completion. Conveniently, this saves a lot of labour for marking exams in future years. The results of this exam are also discussed in section 4, and comparisons are made to the exam from 2003.

2.2 Current Course Structure

The lectures are designed to explain the design manual and to ‘fill the gaps’. Mostly these are presented as digital overheads using the QikLink[5] system. This has the flexibility to enable significant lecturer interaction. Additionally, relevant items such as examples of reinforcing bars and various types of concrete anchors are circulated during the lecture to gain a real appreciation of items being discussed.

The year 2005 is the second in which demonstrators (postgraduate students of the School of Mechanical Engineering and authors of this paper) were assigned to particular teams. This allows each demonstrator, with three tutorial teams, a reasonable 15 minutes to casually discuss the importance of IL techniques, and how they are related to skills demanded in industry of graduate engineers. The importance of this is discussed in Gunn[6], summarised by a final thought statement:

"It is important that we carefully explain to students the value and use of these early courses to their later courses and careers. It is then the responsibility of every instructor to foster discussion on the varied uses of all that is taught."

The demonstrators act as general engineers with no expertise in the area of SA&D, thus requiring students to clearly and fully explain their questions. The demonstrators encourage the students to find their own solutions from within the team and do not simply provide answers. If the students require confirmation or explanation after discussion within the team and with the demonstrator, the team leader is required to take questions to the weekly 'team leader' tutorial session with the lecturer. This session is an opportunity for team leaders to discuss concerns with the lecturer in a smaller forum around a large table with all team leaders, such that the concerns are clarified with all teams. This then gives a responsibility to each team leader to take the information back to their teams and make it clear to them. The roles of 'team leader', and 'quality assurance manager' are rotated within each team for every tutorial assignment. It was decided for 2005 to only allow re-submissions to be upgraded to a mark of 90% to help prevent students from 'testing the waters' to determine the minimum acceptable quality of work.

There are 'generic' components of the tutorials for 2005 involved developing strategies for 'career success', utilising an online forum. This continued over the five tutorials involving an anonymous introduction response, three anonymous responses, and finally a group response formed by discussions within the team. This is to assist them in their future success with their careers, or life in general. The second, third, and fourth anonymous responses encouraged discussion with people such as family members.

3. Potential Benefits

This section will outline the potential benefits of the new course structure, from the point of view of the lecturer, demonstrators, and students. The more 'relaxed' assessment system of tutorials discourages the students from being concerned with obtaining precise results that are emphasised in other subjects and instead focuses on a 'fit-for-purpose' result achieved through teamwork. The interactive team-based learning approach is more like reality, in that engineers rarely solve problems alone. Group communication skills have a good opportunity to develop, as they will be important for achievement of a successful quality assessment. The goal is that this will collectively help students acquire the desirable skills and adaptability to enter the engineering industry.

It was noticed that, in general, the students learnt better when discussing the principals of the course amongst themselves. It is thought by the authors that this could be because they are not only less embarrassed, if at all, to ask questions, but because they can communicate on the same level of understanding, and have a good knowledge of their fellow students current background knowledge. Also, it is believed by the authors that the demonstrators' responsibility to the small team would be more personalised, and hence better respected.

They are also more likely to ask questions that they may otherwise not ask in a lecture type arrangement for fear of embarrassment by their peers. Importantly, team members were encouraged to understand differing personal characteristics, and to encourage team members with a less forceful nature.

The benefits of interactive learning are not limited to the students. Interactive learning could also be considered as a cost-saving mechanism in any given situation in that it potentially increases the amount of learning per unit of teaching time.

4. Exam Results Comparison

This section will discuss and highlight the change to the distribution of marks after the interactive learning technique was implemented. A clear difference can be seen in the distribution of student marks before (Figures 1a and 1b next page) and after the introduction of the decentralised learning approach (Figure 1c next page).

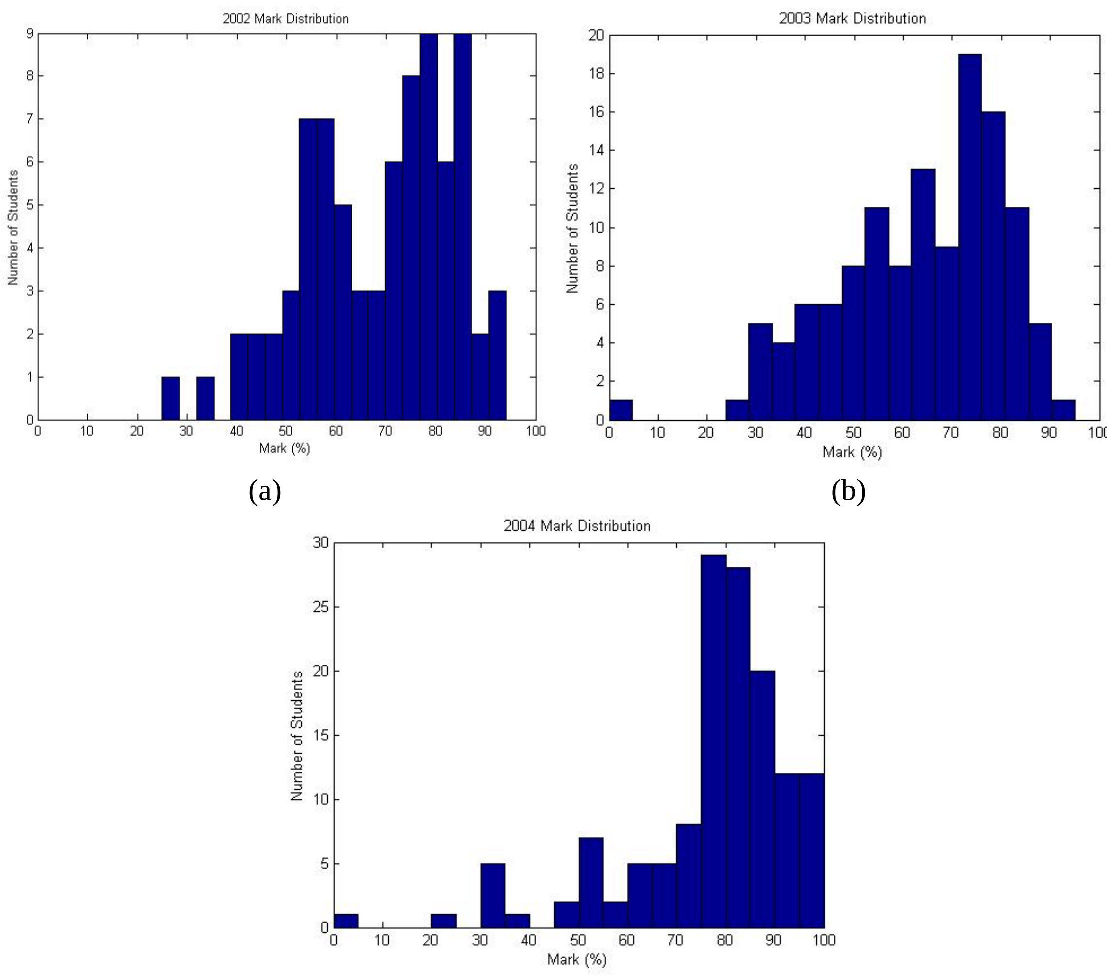

Figure 1: Student marks before (a,b) and after (c) the introduction of decentralised learning.

Figure 2, highlights the average student mark as a function of time in years. Both the average mark and the number of students achieving marks above 75% rose dramatically. The authors suggest that this can be directly attributed to the introduction of 'Quality Assurance' (i.e. quality of learning) measures by the teams as encouraged by the course demonstrators. Such an approach led to the students teaching each other, addressing gaps in their knowledge and thus being better prepared for an exam.

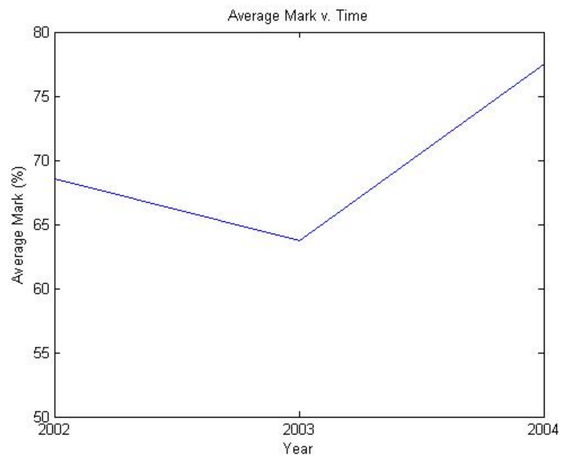

Figure 2: Average student mark as a function of time in years.

Figure 1(c) shows a spread of students still achieving poor marks. It is suggested that this may be attributed to the nature of the course in which students could do little work throughout the semester yet achieve good marks for their group assignments. However, the results of Figures 1 and 2 should be interpreted with caution, as the structure of the final exam was changed after 2003, as described earlier.

5. Experiences and Feedback

This section will discuss experiences of the authors, followed by feedback from past and current students. It is found by the authors of this paper that when groups do not meet the full quality mark it is typically because team collaboration is lacking. This is often reflected in the 'peer assessment weighting'. Most errors should be picked up by the teams quality assurance measures where students cross-check each other's work. Once this is pointed out to the students, the quality of the work quickly improves.

T. Bammann, an author of this paper and a student of SA&D in 2003, believes his experiences as a past student with the IL technique, helped him to appreciate the necessity of quality communication and organisation, both critical to the success of a team. He noticed the techniques his SA&D team used in 2003 became particularly helpful in his final year engineering design project. Feedback from other past students now working within the industry also indicates a benefit from working as a team in the university environment where the students can gain experience in clear communication, delegating tasks, relying on others and checking the quality of the final submission.

Feedback from past students has also highlighted the realistic organisation of the course notes which were prepared in the form of a 'design manual'. As in industry, students have to look through pages of possibly useful information, either in table form or as theory and equations, frequently in a subject area that is new to them and decide for themselves the appropriate solution. Many times in assignments students are not given all the specifications required to solve the problem and they are forced to make a judgement on a suitable value for the missing parameters. This scenario is very common in the engineering industry, although it is in the opinion of the authors that the students are initially unsure of themselves and unwilling to make decisions. However, with a little encouragement from the demonstrators and the realisation that there are many occasions for which there is no precise solution, it is in the opinion of the authors that the students gain some degree of confidence in their ability to make a sound judgement from the available information. While they may still ask a demonstrator how to select the necessary parameter, a quick enquiry reveals that they have already made a suitable choice and are simply looking for reassurance.

As the weeks progress, the students gain confidence in their ability to make sound judgements and learn independently. They also gain confidence in their team and the skills of their fellow students. By making the students consult their team before approaching their demonstrator and then getting them to explain the problem to the demonstrator step by step in front of the team, the students find that they can usually solve the problem themselves. Teams gradually rely less and less on the demonstrators and start discussing and solving problems within the team with more confidence. It has been observed that as each tutorial assignment is submitted, more innovative solutions are obtained, more thorough quality check systems are implemented and hence more reliable solutions are produced.

6. Conclusion

It is in the opinion of the authors and informal feedback from students, that improvements in learning and skill development as applicable to practising engineers has been demonstrated to result from the introduction of Interactive Learning, and the provision of sufficient postgraduate course supervisors to make such tutorial sessions viable. Feedback discussed in this article from students, demonstrators and the lecturer has indicated that Interactive Learning has a valid place within the School of Mechanical Engineering as it furthers the aim of producing students with skills better matched to the demands of the engineering industry.

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Biographical Notes

TOM completed his B.E. (Mechatronic) with First Class Honours in 2004. He is now researching thermoacoustic refrigeration within the School of Mechanical Engineering, at The University of Adelaide with a Divisional PhD scholarship. He hopes to significantly reduce the cost of manufacturing a thermoacoustic refrigerator, and believes strongly that such devices will help lead to a more sustainable environment.

SUSAN has a B.E. (Mechanical) with First Class Honours, and a Bachelor of Science (Physics), and is now with the School of Mechanical Engineering at The University of Adelaide. She has a Divisional PhD scholarship, and an AINSE postgraduate research award. Her research interests are in materials: residual stresses produced in welding high strength steel pressure vessels.

ROHIN was awarded the degree of B.E. (Mechatronic) from The University of Adelaide in 2003. Graduating with First Class Honours, he was also awarded a university medal for academic excellence. He is currently researching the application of advanced nonlinear control theory for aerospace systems at The University of Adelaide, under an Australian Postgraduate Award.

LINDSAY lectures the Structural Analysis and Design course with the School of Mechanical Engineering at The University of Adelaide. He also works for Arup Water, a global network of specialists addressing the demands for water, and a sustainable environment. Previous work includes water supply and sewerage structures, large dams and hydroelectric projects and indigenous housing developments.

REBECCA has a B.E. (Mechanical) with the School of Mechanical Engineering at The University of Adelaide, and has continued her studies with the School as a postgraduate student doing her PhD.