Team Based Learning as a Method for Improvement in Large Engineering Classes

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BACKGROUND
In 2010, in response to a significant increase in student enrolments, a recommendation to include team learning, and a level of dissatisfaction with course delivery on the part of both students and lecturers, elements of Team Based Learning (TBL) were adopted as a vehicle for course improvement.

PURPOSE
Selected features of TBL were adopted to incorporate learning experiences that would allow students to develop appropriate commercial practice and professional skills, particularly relating to teamwork; to respond to lecturer and student concerns with the method of delivery and assessment; to modify student behaviour with regard to preparation for lectures, so content could be made more interesting; and to address anticipated lecturer work load issues with regard to assignment marking.

METHOD
The lecturers assessed the students on individual differences and assigned them to fixed teams. Prereading was tested individually and in teams at the start of each lecture using the Readiness Assurance Process (RAP) with immediate feedback, and results contributed to the overall assessment. The emphasis on prereading allowed lecture content to cover more interesting and complex areas. Team assignments were introduced and included the demonstration of identified professional behaviours.

RESULTS
Data to evaluate the changes was supplied by student survey, attendance and results, time spent by the lecturers on preparation and marking and a post course review. Survey responses showed that students appreciated the growth in their understanding of professional behaviours. These professional skills and attitudes were developed and exhibited by students in team presentations. Both students and lecturers expressed dissatisfaction with the assessment load. Students were committed to prereading for lectures, and attendance patterns changed. Lecturers' marking workload did not increase to the extent that it would have without the introduction of team assignments. Significant time was spent on developing the changes to the course, but this was accompanied by increased satisfaction with the teaching/learning process.

CONCLUSIONS
The TBL concepts of allocation to fixed teams, RAP and team assignments provided an effective vehicle for increasing student and lecturer satisfaction. Lecturers were able to focus lecture content on areas of greater interest or complexity and on the communication of professional skills and attitudes. Changing the course delivery required significant effort from the lecturers, but the increased assessment load was considered manageable. The change in teaching method provided a vehicle for an ongoing re-examination of the lecturers' approaches and expected outcomes.

KEYWORDS:
Team Based Learning, TBL, Readiness Assurance Process, RAP, professional skills, professional attitudes, cost engineering, team assessment, team presentations.

BACKGROUND

In 2010, a number of factors, including a significant increase in student enrolments, a recommendation to provide opportunities for team learning, and a level of dissatisfaction with course delivery on the part of both students and lecturers, led the authors to adopt some elements of Team Based Learning (TBL), (Michaelsen, 1992) as a vehicle for improvement in their cost engineering unit.

Total enrolments in the cost engineering units had increased from 56 in 2004 to over 100 in 2009, and a further substantial increase was projected for 2010. From the beginning of 2010 the lecturers sought a way to deal effectively with the assessment of the larger cohort, that would also enable them to go beyond 'chalk and talk' to improve student learning outcomes and engagement.

The 2008 Engineering Accreditation review by Engineers Australia specified that students should develop "the ability to function effectively as an individual, in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as effective team member" (Swinburne University of Technology Higher Education Division, 2008). The lecturers, too, were well aware that the ability to work in teams is a critical success factor for cost engineers working as professionals in project teams and so were keen to find ways to introduce team based activities and assignments into the instruction method (Jonassen, Strobel & Lee, 2006).

Feedback from the 2009 survey run by Swinburne University at the end of each unit indicated a level of dissatisfaction with the method of delivery though not the content of the course. Many students preferred to access lectures through podcast and online, supported by the course notes, and expressed a level of dissatisfaction with the teaching method. To the lecturers, these low attendances represented a lost opportunity to communicate professional experience, skills and attitudes.

In partnership with the Australian Cost Engineering Society (ACES, a technical society of Engineers Australia), Swinburne University of Technology includes a unit titled Cost Engineering as a core unit in the third year Civil Engineering Degree. The cost engineering syllabus is also offered as a postgraduate elective called Project Costing. The unit runs in second semester and consists of a two hour lecture which is recorded as a podcast, and a two hour tutorial, every week. Until 2010, assessment was in the form of six individual assignments with an examination for undergraduates and final assignment for postgraduates.

The authors/lecturers have substantially retired after long and varied careers in cost engineering, a profession which embraces all the skills and knowledge to control cost, time and commercial risk on major engineered projects. Laurence Pole began teaching the Cost Engineering unit in 2004. As student numbers grew Laurence was joined in 2008 by Nolan Bear an ACES member, occasional lecturer and past ACES National Chair.

In March 2010, the lecturers attended a presentation at Swinburne University given by Professor Larry Michaelsen entitled *Team Based Learning (TBL): An In-Class Strategy for Going Beyond Covering Content.* Team Based Learning (TBL) was billed as "an instructional strategy that is based on procedures for developing high performing learning teams that can dramatically enhance the quality of student learning in almost any course" (Lobo, 2010).

To the lecturers, the process of assessing prereading and the use of "permanent and purposefully heterogeneous work groups" (Michaelsen, 1992) outlined by Michaelsen appeared to address their problems on a number of different levels and they agreed that they would modify their course delivery to see if these elements of TBL, along with the incorporation of team assignments could be an effective tool for improvement.

The authors began their course preparation for 2010 with extensive searching of the literature and found copious documents about TBL. Articles by Froese (2002) and Sweet (2010) were particularly useful for designing the practical details such as selecting teams, and organisation of the teams in a lecture theatre.

After consultation with the course convenor, a decision was made in mid-2010 to proceed with a customised application of TBL to the cost engineering teaching method.

RATIONALE

This paper argues that using some of the elements of TBL created an environment that enabled the lecturers to:

- Provide learning experiences that would develop the professionalism of students in terms of the skills to produce reliable analysis and communication.
- Create a structure that facilitated the development of students' skills to function in a multi-disciplinary and culturally diverse team.
- Ensure students covered the basics of course content by requiring them to undertake prereading for lectures.
- Improve the depth of material delivered in lectures so they were more stimulating and complex, rather than only covering the basic content.
- Communicate their core professional attitudes and beliefs more effectively.
- Address workload issues by reducing marking time through the use of multiple choice tests and team assessment.

We describe the ways in which we implemented the changes to the course, and then present the evidence we gathered to review the innovation.

METHOD

The Team Based Learning (TBL) methodology being adopted was introduced to students in August 2010 in the first lecture and tutorials, and their willing support for this significant change was sought. It was emphasised that this was a new initiative that had potential benefits in preparing them as valued professionals in commercial organisations.

1. Allocation to Teams

In that first lecture, the students were asked to complete a two page multiple choice learning styles and experience survey (Team-Based Learning Collaborative, 2010) to be used solely to allocate them into teams with a mixture of skills and learning styles. This was explained as being required to reflect professional practice where they would not normally be able to select their team members and would need the capability to work with a variety of other people with diverse operating styles and skills. When allocated, each team of 5-7 members was scrutinised for a mix of industry experience and Excel analytical skills (as reported in the survey) and adjusted to give a varied mix in each team. Teams were then fixed for the duration of the unit.

2. Readiness Assurance Process

The TBL method used a lecture based 2 step 'Readiness Assurance Process' (RAP) test to ensure prereading for the lecture had been completed. This consisted of a multiple choice individual test of 15 to 20 questions (IRAT) which assessed completion of the prereading identified for that lecture, followed by the same test being completed as a team (TRAT). The IRAT was completed under exam conditions for the first part of the lecture. Students who came late were not allowed to enter the lecture theatre until after the IRAT answer sheets had been collected and were scored zero for that RAP test.

After collection of the IRAT tests, the teams were then issued with the TRAT, one test sheet per team, consisting of a proprietary scratch answer card with panels which when scratched revealed a star if the answer was correct (Epstein Educational Enterprises). The teams conferred on the answer and tried to scratch the correct panel and reveal a star first time, but if no star was revealed they made a second attempt and so on till they revealed a star.

The scratch cards came with an internet program for assigning questions to a variety of cards with stars under different panels so as to prevent students memorizing a pattern for answers.

In practice, the students spent five to ten minutes on each test of 15 to 20 questions, so the overall RAP time spent in lectures, was about 30 to 40 minutes out of two hours, depending on the number of test questions. Once the TRAT's were collected for recording and verification of team marks, and any questions were addressed, the lecture proper proceeded.

The whole Readiness Assurance Process is designed to ensure an understanding of the basic content area before the lecture begins (Michaelsen & Sweet, 2008). The process of repeating the test as a team gives the students immediate feedback on their own performance, and creates a forum for the articulation and clarification of key ideas (Stark, 2006). It also serves as an opportunity for team interaction and development, an aspect the students clearly enjoyed.

3. Enriched lecture content

The lecturers found the RAP tests established a common level of understanding in the lecture theatre. They were then able to enrich the lectures with specific examples and present concepts of greater complexity than had been possible when all the course content needed to be covered in lectures. Occasionally, guest speakers also provided variety and depth to the lecture program.

Team problem solving within a lecture environment was one of the elements of TBL that was not trialled in this study. The level of innovation being attempted was already significant, and the lecturers did not feel well enough equipped to manage this demanding process for a large class nor were they convinced that it is appropriate for their subject matter.

4. Team Assignments

A series of team assignments were introduced based around a case study prepared by the lecturers. The teams were the same as those used for the classroom RAP and benefited from the relationships and understandings developed in that process. The case study used for assignments was crafted to encourage team work, review of fellow team member's results, and group problem solving. Teams worked on the assignments in their own time to

produce a formal written team report, and delivered a presentation to the stakeholders (represented by the lecturers and the other teams) in their tutorial.

All team members received the same mark but failure to attend the relevant tutorials and especially the presentation resulted in an individual being given a zero team mark, unless they could prove special circumstances and demonstrate a substantial contribution to the team output, confirmed by the other members of the team.

Review of Outcomes

To evaluate whether the changes were effective in achieving the objectives, at the end of the semester the lecturers carried out a student survey, considered the data on students' attendance and results, reviewed their workload and gathered their reflections in a formal post-course review meeting.

Student survey

A customised student survey was created in 2010 to give feedback on the implementation of TBL. It was completed in the lecture theatre ahead of the last RAP, thus assuring a more than 90% response rate. The survey was strictly anonymous and included a series of Likert scale (5 point) questions plus two questions requesting written responses.

Figure 1 shows the results of the TBL Student survey used to provide feedback in 2010. In their responses to the RAP process, the students show they were less aware that the TRAT contributed to their learning than that the IRAT did. Michaelsen & Sweet (2008) acknowledge the phenomenon of students not recognizing how much they have actually learnt through the RAP, because it is unfamiliar to them as a learning process. The lecturers, however, were well aware that a level of learning had taken place, as indicated in Figure 2, and were able to provide a richer lecture experience on that basis. The lecturers have also frequently observed the effect cited by Michaelsen & Sweet (2008) where team formation benefits from a process that gives instant feedback and by this means moderates the behaviour of the dominator in a team.

The most positive responses identified a perception by students that TBL and the course knowledge would contribute to their career prospects.
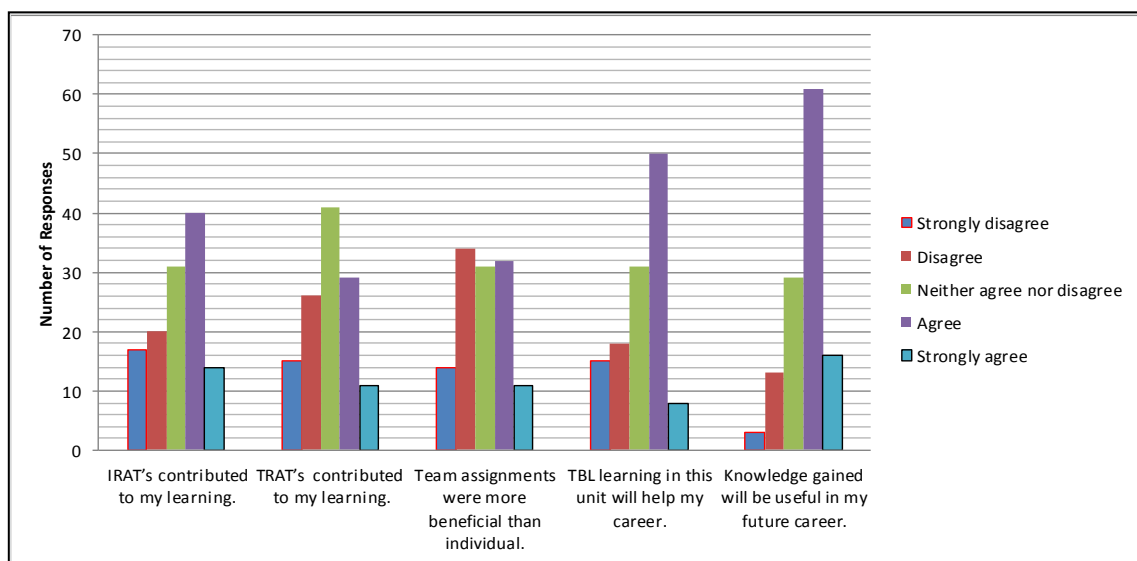

Figure 1: Student survey results 2010

The class had a significant proportion of students for whom English is a second language, so it was not unexpected that only about 30 of the 120 students who completed the survey in 2010 provided written reflections on the course. From those who did write comments, the following themes emerged.

In response to the question "The best aspects of this unit were:", 10 out of 30 comments were about team work, team assignments and presentations, suggesting that team assignments were valued by students. This was consistent with verbal comments that had been made to the lecturers through the unit.

In response to the question "The Team Based Learning used in this unit could be improved by:" 10 out of 33 comments were about the high workload for assignments and inadequate time to complete them, suggesting that the students considered the workload was excessive. This was confirmed by the lecturers' impression and comparison with the course convenor, of workloads in other units.

Student results

Overall student results in 2010 were comparable with 2009 and the pass rate was similar. Final exam results showed the cohorts were of comparable ability, but the lower end of students performed better on course work in 2010 than in the previous year, indicating that they had benefited from the inclusion of RAPs and team assignments.

The individual and team RAT results (Figure 2) show a consistent attendance of about 90% of the students, with no falling off during the semester, and indicate that most of the students were completing the required prereading.
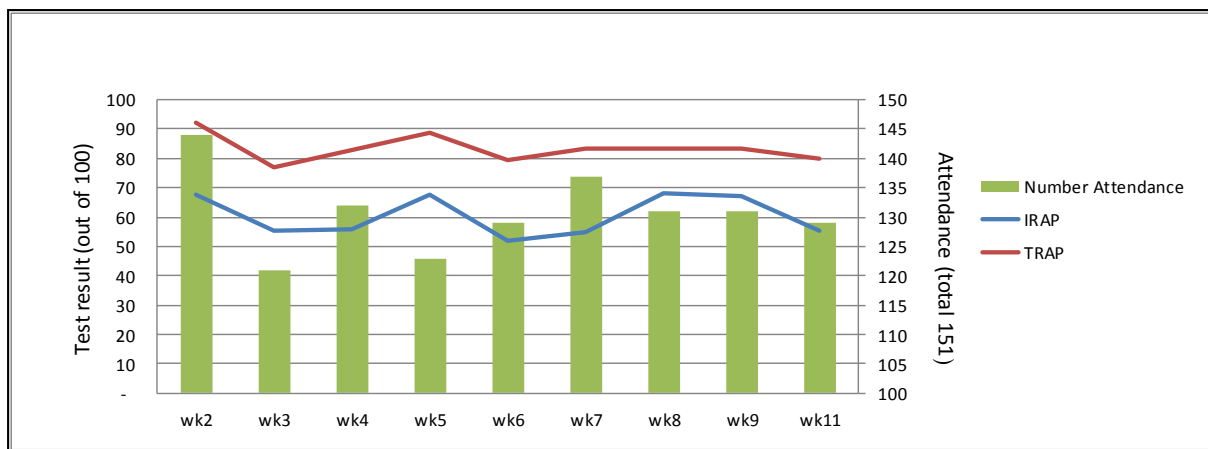

Figure 2: Student IRAT and TRAT results & attendance for 2010

Attendance at lectures

Student attendance at lectures improved to reflect the change in assessment requirements (Figure 2). It was however noticeable in the undergraduate unit, that a significant number (20 to 30%) chose to exit the lecture immediately after the TRAT.

Enquiries to other academics indicate that this type of behaviour is quite prevalent, with many students choosing not to attend lectures that were available in an alternative format. As student unit results did not differ markedly between 2009 and 2010, we surmise that the TBL prereading requirement and RAP test methodology, together with the team based

assignment keep these non-attendees up to date with learning the course material, and ensure they have exposure to the process of teamwork.

Post course review

A post course review of processes and outcomes was held, with the two course lecturers being joined by Swinburne Engineering Education Research Coordinator and a former educator. The latter two functioned as critical reviewers, making valuable contributions to the analysis of data and evaluation of the innovation.

The post course review made the following observations in relation to the changes made:

- Assessing prereading proved to be a significant driver of student learning.
- The RAP process supported the lecturers' desire to be able to bring depth and nuance from their industry experience to the lectures.
- Fixed teams, team tests and team assignments were valued by both students and lecturers, as an environment for developing students' professional capability to function in teams.
- Team presentations were valuable for demonstrating professional team behaviours. Students were able to be assessed on their ability to respond to challenging questions with honesty and transparency, and to deliver reliable and correct information that was well presented and focussed on the critical issues (Jonassen, Strobel & Lee, 2006).

The following issues for consideration were also identified:

- The number of assignments should be reduced as the student workload of three individual and three team assignments, together with the RAP tests, over a twelve week course, was considerably more than was expected in other units.
- Skills oriented sections of the course should be sequenced earlier in the course so students had sufficient time to develop and apply these essential skills in assessment tasks.
- The balance of assessment weighting should be altered, to allow greater recognition for skills learning, by reducing the value of the TRATs.

Lecturer workload

The change in effort spent and billed by the lecturers on preparing and marking assignments was such that a 50% increase in student numbers in 2010 was accompanied by only a 26% increase in billable hours and a decline in the effort per student. Even though there was an additional effort needed to develop and assess the RAP tests, the introduction of team assignments led to an effective reduction in marking time.

There was, however, a considerable but unmeasured effort expended in researching and developing the changes to the unit.

CONCLUSIONS

While any introduction of team assessment would have provided an improvement to the course, (Swinburne University of Technology Higher Education Division, 2008), the particular components of TBL that were adopted provided a useful vehicle for increasing student and lecturer satisfaction with the course delivery and content.

Allocation to permanent teams based on skills and experience produced a simulated workplace team environment that lead to greater understanding of how to function effectively in a multidisciplinary and culturally diverse team. The team assignments and presentations facilitated the development of professional attitudes and skills.

The application of the Readiness Assurance Process (RAP) established a level of prior knowledge which allowed the lecturers to focus lecture content on areas of greater interest or complexity and on the communication of professional skills and attitudes.
The flexibility to explore the interesting, challenging and high value aspects of the course content within the lecture format is an ongoing success and challenge. Students have responded enthusiastically to enrichment activities and the lecturers continue to search for ways to improve this aspect of the course. A recurrent theme in the later surveys has been an appreciation for the value of 'practical lectures', 'real job' examples, 'project oriented cost engineering concepts' and guest speakers, all of which demonstrate the value perceived by students of reorienting the focus of lecture content.

Effort spent on course development time increased, but time spent on marking has reduced.
Given that significant development work is required to adapt TBL to current teaching methods, a risk/reward evaluation is a necessary precursor to making such a change. Time spent on marking has reduced but changing student numbers and developments in the number and style of assessment make it difficult to quantify these changes exactly. The strong perception of the lecturers is that their workload increased significantly in 2010 due to the effort required for course development.

The number of assessments used in 2010 created an excessive workload for students and workload was a recurrent theme in the 2010 student survey.
In 2010 the RAP tests were added and 3 of the 6 assignments required in 2009 were converted to team assignments. Following findings from the post course review and discussions with the course convenor, the number of assignments was reduced in 2011.

The change in teaching method provided a vehicle for an ongoing re-examination of the lecturers' approaches and expected outcomes.
Apart from the use of TBL to improve the course, the lecturers have adopted other innovations that have added value. For example, they now develop interconnected, case study based, assignments to teach and demonstrate cost engineering skills. As well, in response to the course review process, they restructured the sequence of lecture content to place skill acquisition topics early so students were given more course time in which apply essential skills in assessment tasks.

Other factors contributing to the success of the innovation.

The significant and all-encompassing change in teaching method embarked on in 2010 was successful due to the sessional lecturers' particular circumstances. The lecturers were able to form a support group of themselves and their partners, who brought considerable teaching and business skills and experience to the team. The teaching was part time over three week days, thus allowing useful development time in the other two days. The units are given in the second semester, and the first semester in 2010 allowed the lecturers the lead time to gather ideas and develop strategies for coping with the forecast increase in numbers.

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