Improving graduates' soft skills through laboratory teamwork

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ABSTRACT: Today's engineering graduates are required to demonstrate, besides the technical competency, extended communication and leadership skills. In view of this, the civil engineering degree at La Trobe University has implemented (since the late 1990's) various methodologies to develop the graduates' soft skills.

This paper presents a methodology of enhancing the students' soft skills through the team work during the laboratory classes of one unit of the civil engineering degree. Both the laboratory sessions and the assessment were designed to encourage the team work. Furthermore, the individual contribution to the development of the laboratory test and the report writing is also assessed.

The students' survey over the past three years indicated that the practical sessions and the teamwork helped them to deepen their technical knowledge. Furthermore, they became more aware of their own strengths and weaknesses in working in teams, and improved their communication and interpersonal skills.

1 INTRODUCTION AND BACKGROUND

The rapid transformation of engineering placed new and complex array of requirements on the undergraduates engineering programs in the past 50 years (IEAust 1999). Therefore, the design of engineering courses has become a fine art of interweaving adequate coverage of academic content with the acquisition of necessary professional skills and generic attributes through a student-focused learning environment (IEAust 2004).

The today's graduates are required to be adaptable, self-motivating team players, regardless of their field of expertise. Group/team work has swept through higher education in general as a response, in part, to a rapidly changing society and a demanding employment sector (Thorley & Gregory 1994) and many fields of study are responding with problem-based learning regimes and/or group/team work.

Teaching in civil engineering has a long history in Bendigo. Bendigo School of Mines offered courses in civil engineering (at diploma level) as early as 1873. This tradition was continued by the civil engineering degree offered by the La Trobe University (LTU). The cohort of students at Bendigo campus is drawn from country Victoria. The course offered currently at LTU, Bendigo is typical of the Australian full-time undergraduate civil engineering courses (four years duration). The course is similar to the civil engineering education programs taught in Japan, New Zeeland and Scotland (Fellows 2000, Manoliu 2000, Ohta et al. 2000). The undergraduate civil engineering course comprises thirty-two units/subjects (four in each of the eight semesters) over a wide range of civil engineering disciplines. On completion of the course the graduates are awarded a Bachelor in (Civil) Engineering degree.

The curriculum for the civil engineering course at La Trobe University was changed in 2000 to allow for the new trends and approaches that are currently in practice in engineering education. Although teamwork was recently introduced to the curriculum, the third and fourth year students were expected to be familiar with the teamwork concept, as they were exposed in their first year of study to problem-based learning in a group work environment (Kilpatrick et al. 2006). However, the author's experience showed that, just as students are slow to transfer their academic learning between different units and year levels, so too are they reluctant to transfer their skills.

2 OVERVIEW OF GEOTECHNOLOGY UNITS

Geotechnology is a core discipline in the civil engineering course offered at LTU. Its content is divided into two distinct units, Geotechnology-A and Geotechnology-B, taught at the third year and fourth year levels of study, respectively.

The teaching objectives in the first unit, Geotechnology-A, are as follows:

- to prepare students with an understanding of the characteristics and factors which affect the behaviour of soil/rocks;
- to provide them with the tools to apply these principles in the practice of geotechnical engineering and to identify what soil/rock properties and which tests are needed for typical projects.

The objectives in the second unit, Geotechnology-B, are:

- to deepen the students understanding of soils/rocks mechanical properties;
- to provide them with fundamental knowledge of designing different purpose engineering foundations based on the engineering properties of natural soils/rocks.

Deepening knowledge of the unit material contributes to the development of both interpersonal and professional skills. The teaching in this unit is based on lectures, tutorials and practical classes. Many respected educators agreed that the understanding of most basic concepts is greatly enhanced by the use of demonstration models and practical sessions (Burland 1997, Steenfelt 2000). Therefore, in order to facilitate the understanding of most basic concepts, a significant number of laboratory classes were included in both units. While the teaching in Geotechnology-A is based heavily on the laboratory sessions (30% of the allocated time for the unit), the teaching in the second unit, Geotechnology-B, uses mainly the problem solving approach, with the laboratory component being only 20% of the allocated time for the unit. The aims of the practical sessions in both units are to:

- introduce students to the soils/rocks laboratory tests required to measure their properties;
- involve the students in the development of the tests so they acquire a good understanding of the mechanics of soil/rock behaviour under different conditions of loading;
- allow students to learn how to determine the specific tests associated with a given project or project location and how to perform them;
- provide opportunities to strengthen their generic work skills related to both individual and group activities;
- enable the students to extend their skills in report writing and technical communication.

This paper presents aspects associated only with the teaching in the first unit of this discipline, namely Geotechnology-A.

3 CRITICAL REVIEW OF PREVIOUS APPROACH TO TEAMWORK

Working with others, sharing experiences, existing knowledge and skills make possible the learning process to take place. Research has shown that deep learning takes place when the meaning is negotiated in a social context with others (Frank & Barzilai 2004). It also helps learners develop a sense of responsibility for their own learning.

Engaging the students in teamwork on a regular basis allows them to take part in discussions, which encourage critical thought and reflection. The understanding of ideas and concepts would be continuously challenged in such teaching environment (Powell 2004). Furthermore, through reflective discussions, the team actively would validate information and would come to a deeper understanding of various topics.

Teamwork also teaches to value cooperation above competition, and encourages greater respect for the varied experience and background of team members (Powell 2004). It helps development of important skills to manage oneself and the people around besides enhancing the effective communication skills. Furthermore, teamwork can boost oneself esteem as a student because each individual would feel that had a part to play in the success of the team.

3.1 *Teamwork*

Group work is common practice in units such as Surveying, Civil Engineering Materials, Geotechnology-A and Geotechnology-B. This is chiefly due to the complexity of the practical sessions performed that would require more than one student to carry out a given task. However, there are other aspects that impose the teamwork approach. One of the factors is the time constraints, especially when the number of students enrolled in a unit is large. The other one is the limited laboratory facilities, common for smaller departments teaching the civil engineering programs, located outside the bigger cities.

In this context, the students were randomly placed in groups that would complete a given task (the same for all groups) in which the task would be completed simultaneously by all groups. Alternatively, each group would be required to perform a different task in a given practical session. In this case the tasks would be performed in sequential order one after another.

In any of these situations it was possible that a group may contain more than the necessary number of students to perform a given task. This would cause some of the students to take the role of the performers/doers being actively involved in the test's development, and thus improving their practical skills. Others may take the role of the observers, not willing to contribute at all or contributing very little to the development of the practical task, hence, not reaching one of the objectives of the practical session to gain hands-on skills.

At times, the arbitrary distribution of students into groups caused imbalances between groups from the point of view of the academic level, with a detrimental effect on the learning process (Frank & Barzilai 2004, Gibbings & Brodie 2006). Frequently, those groups showing a lower level of academic and practical skills would require a longer time to complete a set task, thus delaying the completion of the entire laboratory session.

3.2 *Assessment in the Unit*

The assessment in the Geotechnology-A unit relies heavily on the final examination, which contributes 70% of the final mark in the unit. The remaining 30% is made up by the marks for both numerical assessments and technical reports on the laboratory work.

The students are required to submit both the numerical assessments and the technical repots as individual work. The contribution of these assessments over the semester is as follows:

- technical reports on the laboratory work 20%, and
- numerical assessments 10%.

Furthermore, the marking of the technical report assesses various aspects of students learning/understanding in the unit as presented in Table 1.

Table 1. Technical report mark's composition.

Report section	Weight
Introduction/statement of laboratory aims	5%
Description of materials/equipment/procedure	15%
Presentation of the test(s) results	25%
Discussion/critical analysis of the results	35%
Conclusion(s)	20%

Despite the fact that this assessment system adopted a variety of methods to assess the learning in the unit, it had the following shortcomings, with negative effects on the students learning:

- excessive work load for both students and lecturer;
- it only assessed the individual's progress;
- the teamwork was not assessed;
- the individual's contribution to the development to the practical was not assessed.

A major weakness of the earlier approach was that it did not provide appropriate incentive, through assessment, for the types of behavior that were considered desirable such as collaborative learning and mentoring.

4 REVISED APPROACH TO TEAMWORK

In 2004 the teaching and the assessment scheme in the unit was revised and updated in order to eliminate the shortcomings mentioned earlier. The new approach was developed to encourage the teamwork and mentoring during both the practical classes and technical report writing. Information on the method of group forming, the responsibilities of teams, a summary table of the assessments, including due dates, technical report marking distribution and submission method, has been included in the Geotechnology-A unit layout and handed to the students in the first class in the semester. The same information is posted on the university intranet for easy access.

4.1 *Team Selection*

It was obvious that the random separation of students in groups had a negative effect on the group behavior as well as on the development of the practical classes. Therefore, a means to balance the groups was searched for.

In order to achieve better balanced teams, the recognition of prior academic achievements was considered as a reasonable criterion. This would encourage peer assisted learning (mentoring within teams), which would also motivate the teams work (Frank & Barzilai 2004). Furthermore, it was clear that in order to encourage further development of the communication and interpersonal skills, the groups have to change from one practical session to another. Although this approach may require more attention from the unit coordinator over the semester, the outcomes are worth the additional work.

4.2 *Assessment*

The assessment scheme involves both individual and team assessment, and includes a mix of summative and formative assessments. The assessments are used as an incentive to discourage undesirable activity and to encourage desirable behavior, such as mentoring within the teams. The assessment scheme was revised to place more emphasis on the development of individual's skills and ensure an increased level of competence.

The overall contribution of the various assessment forms did not change. The revised approach applies only to the mark allocation for the practical sessions.

It has been recognized by many (Powell 2004, Acar 2004) that good performance has to be both encouraged and rewarded. Therefore, in order to motivate the individual participation in the development of the practical session, this should be assessed and reflected in the technical report mark. Furthermore, to encourage mentoring within a team, the teamwork should extend from the development of the practical sessions to the preparation and writing of the technical report. In this way the mark will reflect entirely the team performance.

Nevertheless, the individual contribution to the report writing needs to be motivated and rewarded by allocating a mark to it. To ensure that each member of the group contributed to the preparation and writing of the technical report, the team was required to submit a written statement, signed by each member of the team, indicating the individual contribution to the report writing (in %). This encourages not only self assessment but also appraisal of the other members' work, so contributing to the learning of new skills (Heron 1999).

Considering the above aspects, the marking system used in the assessment of the practical session was revised to include the individual's contribution to both test development and technical report writing and its composition is presented in Table 2.

The writing of the technical report it is a repetitive task, applying the same principles to different laboratory classes. This encourages advancement of already attained skills in addition to learning new skills (Gibbings & Brodie 2006). Therefore, the use of the newly learnt skills in the report writing in later assessments is rewarded and the mark allocation for the later technical reports has a slightly different distribution as given in Table 3.

Table 2. The revised weighting of the technical reports' mark.

Report section	Weight
Introduction/statement of laboratory aims	5%
Description of materials/equipment/procedure	10%
Presentation of the test(s) results	20%
Discussion/critical analysis of the results	25%
Conclusion(s)	20%
Individual contribution to the practical session	10%
Individual contribution to the report writing	10%

Table 3. The revised weighting of the technical report mark.

Report section	Weight
Introduction/statement of laboratory aims	5%
Description of materials/equipment/procedure	10%
Presentation of the test(s) results	15%
Discussion/critical analysis of the results	20%
Conclusion(s)	15%
Report writing skills	15%
Individual contribution to the practical session	10%
Individual contribution to the report writing	10%

5 REVISED APPROACH TO TEAMWORK

The new method of forming teams ensures balanced working teams in terms of both academic and practical skills. This fosters mentoring within the team, better teamwork and competition between teams (especially when working on the same task). Moreover, intra-team communication and interpersonal skills are further developed while working as a team during the practical sessions and report writing. Exchanging information between groups, mainly when groups perform different tasks during the same practical session and all students are asked to report on the collected data, further contributes to efficient (mainly oral) communication and to some extent enhances the leadership skills learned in previous units. Nevertheless, the introduction of group report eases the working load on both students and staff, leading to enhanced learning in the unit.

The revised assessment scheme encourages team work during the practical sessions and technical report writing. Rewarding the individual's contribution to the teamwork ensures that every member of the team contributes to the completion of the task given, enhancing their skills to work as team members. The use of learnt skills is encouraged by the new marking system. This also contributes to further development of the written communication skills. Responsible attitudes and interpersonal skills are promoted and enhanced by the adopted marking system.

Overall, the revised scheme places the emphasis on advancement of skills and learning new skills, rather than just achieving a minimum standard (Heron 1999). This ensures improved learning in the unit and further development of the students' soft skills such as, communication skills, teamwork, interpersonal skills and to some extent leadership skills (Shuman et al. 2005).

6 RESULTS AND DISCUSSION

The new strategy for teamwork in the unit was implemented in 2004. The results to date demonstrate a considerable improvement in students' performance in the unit and their skills intended to be fostered within teams and students. This is demonstrated by comments from students taken from Quality Assurance (QA) surveys of the unit and students' comments and the author's observation when teaching them in a different unit.

One of the aims of the new teamwork scheme was to improve the teamwork, and so enhance the learning in the unit. Figure 1 presents a comparison of the mark for the laboratory work component in the unit. The comparison is done over a six years period (3 years before the change and 3 year after the change). Please note that A, B, C and D are passing grades, whereas N is a failure grade. It is clear that the 2003 group of students had significant problems in managing the work load for the labora tory component, leading to lower marks in the assessment. The implementation of the revised teamwork scheme continuously eased difficulties that

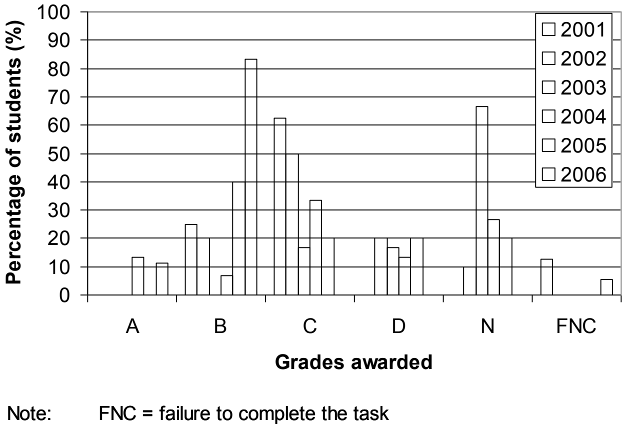

Figure 1. Laboratory session marks between 2001 and 2006.

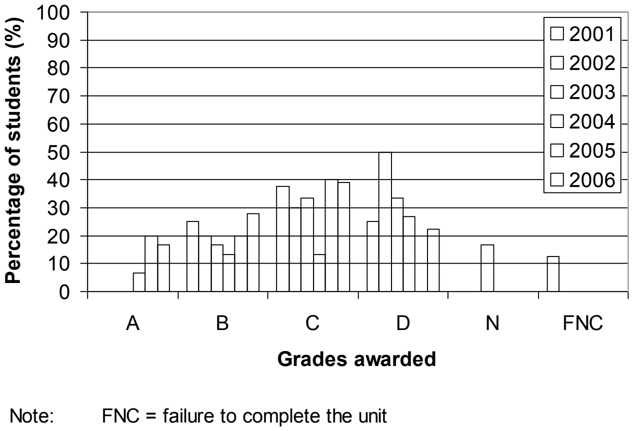

Figure 2. Final grades between 2001 and 2006.

some students had. A considerable improvement was also observed in the final grades of the two student cohorts (prior to change and after change). This is displayed in Figure 2, considering the same time frame, which supports the assertion that the revised teamwork and assessment scheme has improved student learning.

In addition, the students' survey prior to and after the change showed that they welcomed the new assessment scheme. The students response to the statement "The amount and type of assessment is appropriate for this unit" is presented in Figure 3, using a scale 1 to 5 where 1 is for Strongly agree and 5 if for Strongly disagree. Furthermore, the students became more aware of their own strengths and weaknesses in working in teams. This aspect was reflected in students' comments on the QA.

The author is also involved with the teaching of the second unit of the Geotechnology discipline, thus making it easy to observe the progress of a cohort of students over the years. The change to the assessment scheme implemented in Geotechnology-A enhanced the students' competence and communication skills, which caused better performance in Geotechnology-B.

Although the results so far show significant improvement in the students learning in the unit, there are few aspects that need to be improved and they form the basis of further investigation. One point that needs to be further improved is the assessment of individual contribution to the report writing to discourage reliance on the few, as is the case with the current assessment scheme. Furthermore, the enhanced student performance observed may be contributed to by the introduction in the curriculum of a Project Learning Stream, which addresses (besides other objectives) teaching and development of students soft skills (IEAust 1999, Kilpatrick et al. 2006).

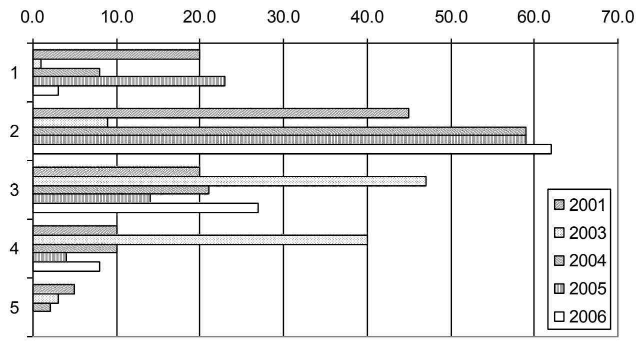

Figure 3. QA survey – Students' response to the statement "The amount and type of assessment is appropriate for this unit".

7 CONCLUSIONS

The revised approach to teamwork and the assessment of learning in the Geotechnology-A unit encourages teamwork and provides a mechanism for assessing the individual's contribution to the teamwork. It also enhances the communication between the teams and intra-teams, promoting interpersonal skills development. The teamwork contributes to a higher level of learning through peer's mentoring within a group. In addition, the new system encourages and rewards the implementation of the acquired skills (especially the communication skills). Overall, it was shown that the current teamwork and assessment strategy in the Geotechnology-A unit resulted in deeper and higher quality learning.

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