The Teamwork Impact On Laboratory Sessions And Its Contribution Towards Graduate Attributes

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Abstract – **In today's environment civil engineering graduates are required to acquire extensive softer skills in addition to technical competency. The development of the softer skills has been incorporated in the civil engineering curriculum at La Trobe University since the late 1990's.**
This paper describes the contribution of the teamwork component to the enhancement of the softer skills during the laboratory classes in a third year unit of the civil engineering degree, for which the author is a coordinator. At the end of each laboratory session a written report is required. The assessment was designed to enhance the teamwork and measure the individual contribution to the development of the laboratory tests and the writing of the report.
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.

Index Terms - Assessment, Graduate attributes, Laboratory class, Teamwork, Technical writing.

INTRODUCTION AND BACKGROUND

In the last 50 years, the expectations on undergraduate engineering programs have produced a complex array of requirements due to the rapid transformation of engineering [1]. As a result, worldwide, course design 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 [2].

Graduates today 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 [3] and many fields of study are responding with problem-based learning regimes and/or group/team work.

La Trobe University (LTU) has been in operation since 1967 and has grown rapidly in size to become one of the Australia's leading and highly regarded universities. Today the university is home to more than 26,000 undergraduate and postgraduate students, including approximately 3,000 international students from over 90 countries. Through the five faculties, LTU delivers courses at its eight campuses (six in country Victoria) in a wide range of disciplines.

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. Today, (as was then) the cohort of students 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), being similar to the civil engineering education programs taught in Japan, New Zeeland and Scotland [4, 5, 6]. 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 (about seven years ago) 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 year students are 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 [7]. 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.

OVERVIEW OF GEOTECHNOLOGY-A UNIT

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 by the author 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 behavior of soil as an engineering material.
- To provide them with the tools to apply these principles in the practice of geotechnical engineering and to identify what soil properties and which tests are needed

for typical projects e.g., embankments or footings in sands and clays.

Deepening knowledge of the unit material contributes to the development of both interpersonal and professional skills. The teaching in this unit is based mainly 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 [8, 9]. Therefore, the laboratory component accounts for more than 30% of the allocated time for the unit. The aims of the practical sessions 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 behavior under different conditions of loading.
- Allow students to learn how to determine the specific tests associated with a given project or project site 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.

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.

While the teaching in *Geotechnology-A* is based heavily on the laboratory sessions, the teaching in the second unit, *Geotechnology-B*, uses mainly the problem solving approach. This paper presents aspects associated only with the teaching in the first unit of this discipline, namely *Geotechnology-A*.

CRITICAL REVIEW OF PREVIOUS APPROACH TO TEAMWORK

Working with others enables learning to take place through sharing experiences, existing knowledge and skills. Research has shown that deep learning takes place when the meaning is negotiated in a social context with others [10]. 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 [11]. 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 experiences and backgrounds of team members [11]. 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.

I. Teamwork

Group work is common practice in units such as Surveying, Civil Engineering Materials, Geotechnology-A and Geotechnology-B. This is essentially 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. Nevertheless, group work proved to be beneficial to students learning as discussed earlier.

In this context, the students were randomly placed in groups that would complete a given task (the same for all groups) in which the group work would be performed 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, and 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 [10, 12]. 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.

II. 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 knowledge that is fundamental to a number of areas in Civil Engineering is presented in this unit. The heavy emphasis on the final examination is designed to ensure that students commit these fundamentals to memory in preparation for later units for which this unit is a prerequisite. 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. This ensures that both theoretical and practical competency of the students is assessed. The contribution of these assessment components over the semester adds to:

- Technical reports on the laboratory work 20%, and

- Numerical assessments 10%.

The higher weight is placed on the technical reports to ensure the continuation and enhancement of the soft skills acquired in previous units.

Furthermore, the marking of the technical report assesses the following aspects:

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

One should note that the emphasis is placed on the critical analysis of the results and conclusions. This ensures that the students achieve a high standard of technical competency, in preparation for later units for which *Geotechnology-A* is a prerequisite.

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 of 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.

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.

I. 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 method 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 [10]. 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.

II. 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 [11, 13] 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 % terms). This encourages not only self assessment but also appraisal of the other members' work, so contributing to the learning of new skills [14].

Considering the above aspects, the mark allocation currently used in the assessment of the practical session looks like:

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

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 [12]. Therefore, the use of the newly learnt skills in the report writing is rewarded in later assessments and the mark allocation for the later technical reports has a slightly different distribution:

- Introduction/statement of laboratory aims 5%
- Description of materials/equipment/procedure 10%
- Presentation of the test(s) results 15%
- Discussion/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%

BENEFITS OF REVISED APPROACH TO TEAMWORK

The new method of forming teams ensures that the working groups are balanced 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. Writing reports on the practical demonstrations ensure both continuation and further developments of written communication skills. Nevertheless, the introduction of group report eases the working load on both students and staff, leading to enhanced learning in the unit.

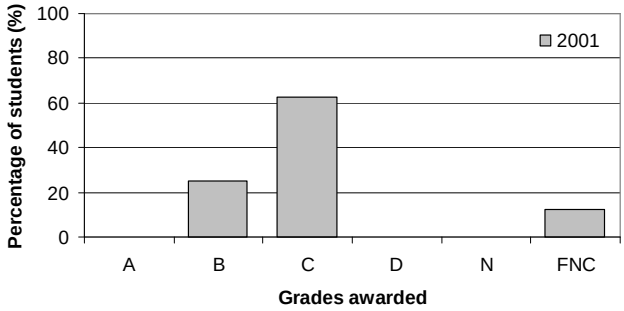
The revised assessment scheme encourages team work during the practical sessions and technical report writing. Rewarding the individual's contribution to the teamwork ensures that every member of the team contributes to the completion of the task given, enhancing their skills to work as team members. 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 [13]. 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 [14].

RESULTS AND DISCUSSION

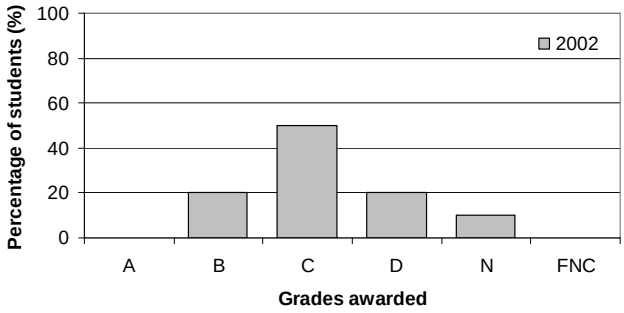
The new strategy for teamwork in the unit was implemented in 2004. The results to date demonstrate a considerable improvement in students' performance in the unit and their skills intended to be fostered within teams and students. This is demonstrated by comments from students taken from Quality Assurance (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. The evolution with time of the marks for the laboratory component in the unit is presented in Figures 1 to 6. Please note that A, B, C and D are passing grades, whereas N is a failure grade. The first three figures (Figs. 1 to 3) show a continuous deterioration of the marks between 2001 and 2003 with each cohort of students undertaking the unit. It is



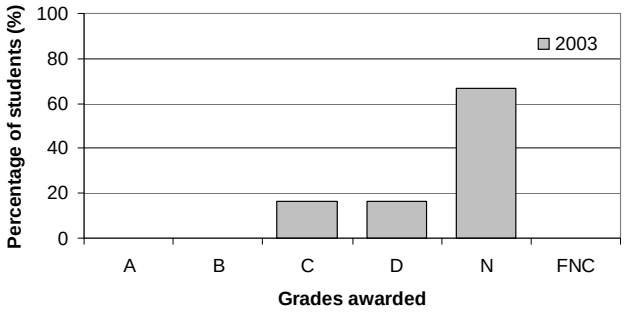
Note: FNC = failure to complete the unit

FIGURE 1
GRADES ATTAINED FOR THE LABORATORY SESSION IN 2001.



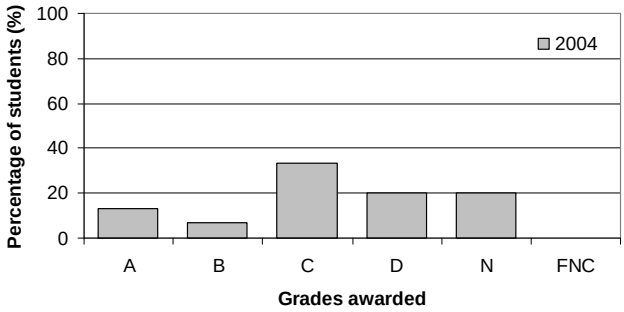
Note: FNC = failure to complete the unit

FIGURE 2
GRADES ATTAINED FOR THE LABORATORY SESSION IN 2002.



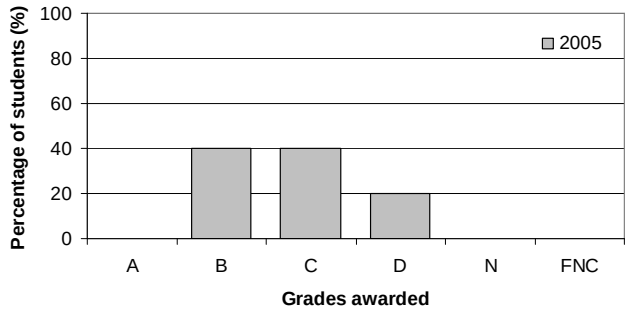
Note: FNC = failure to complete the unit

FIGURE 3
GRADES ATTAINED FOR THE LABORATORY SESSION IN 2003.



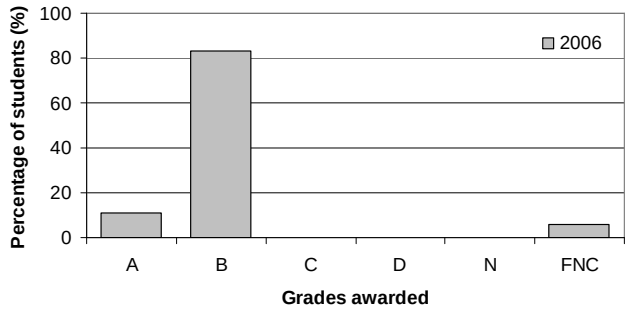
Note: FNC = failure to complete the unit

FIGURE 4
GRADES ATTAINED FOR THE LABORATORY SESSION IN 2004.



Note: FNC = failure to complete the unit

FIGURE 5
GRADES ATTAINED FOR THE LABORATORY SESSION IN 2006.



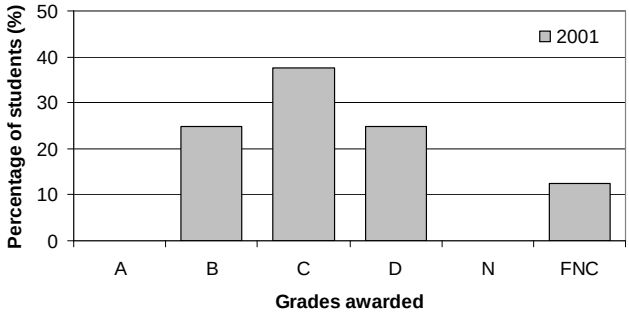
Note: FNC = failure to complete the unit

FIGURE 6
GRADES ATTAINED FOR THE LABORATORY SESSION IN 2006.

also clear that the 2003 group of students (Fig. 3) had significant problems in managing the work load for the laboratory component. This resulted in very low marks in the assessment, with more than 60% of the students getting a failure grade for the laboratory component. It is obvious from Figures 4 to 6, presenting the evolution of marks for the laboratory component, after the implementation of the revised teamwork, that the change continuously eased difficulties that some students had. A considerable improvement was also observed in the final grades attained by the students prior to and after the change. Figures 7 to 9 present the overall performance of students in this unit prior to the change. Please note that 2004 is the year when the new procedure was introduced. It is obvious from Figures 10 to 12 that the overall performance of the students improved steadily after the change. This supports the assertion that the revised teamwork and assessment scheme has improved student learning.

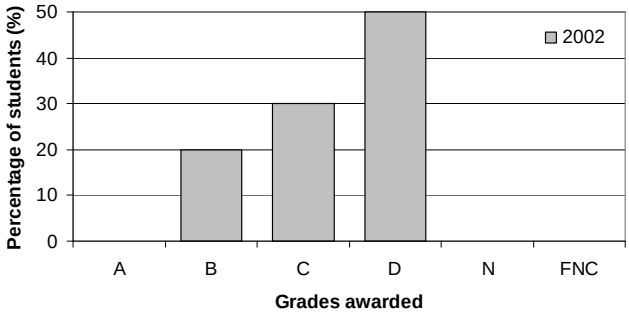
In addition, the students' survey prior to and after the change showed that they welcomed the new assessment scheme. The students response to the statement "The amount and type of assessment is appropriate for this unit" is presented in Figures 13 and 14, using a scale 1 to 5 where 1 is for *Strongly 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



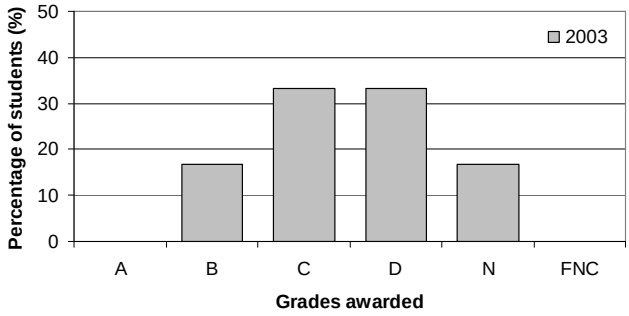
Note: FNC = failure to complete the unit

FIGURE 7
FINAL GRADES ATTAINED FOR THE UNIT IN 2001.



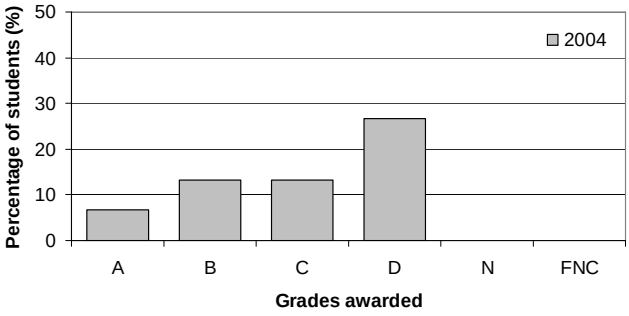
Note: FNC = failure to complete the unit

FIGURE 8
FINAL GRADES ATTAINED FOR THE UNIT IN 2002.



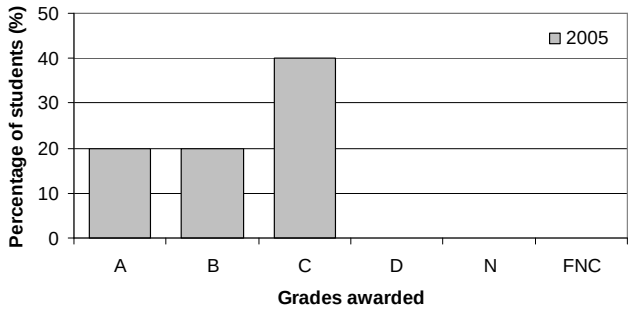
Note: FNC = failure to complete the unit

FIGURE 9
FINAL GRADES ATTAINED FOR THE UNIT IN 2003.



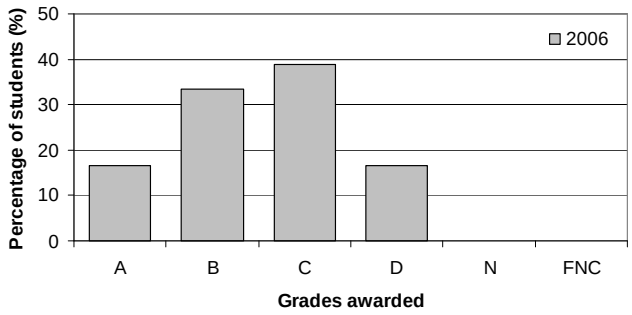
Note: FNC = failure to complete the unit

FIGURE 10
FINAL GRADES ATTAINED FOR THE UNIT IN 2004.



Note: FNC = failure to complete the unit

FIGURE 11
FINAL GRADES ATTAINED FOR THE UNIT IN 2005.



Note: FNC = failure to complete the unit

FIGURE 12
FINAL GRADES ATTAINED FOR THE UNIT IN 2006.

Geotechnology-A enhanced the students' competence and communication skills, which resulted in 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 [1, 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.

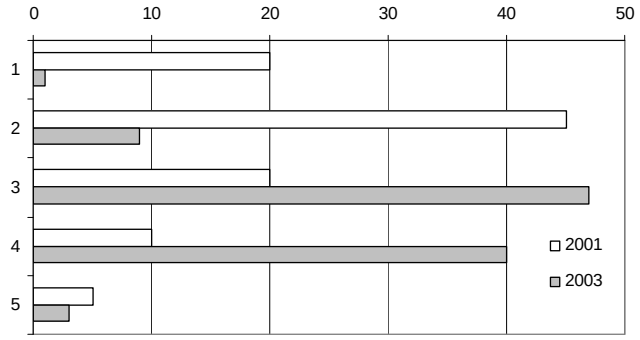


FIGURE 13
QA SURVEY – STUDENTS' RESPONSE FOR THE STATEMENT "THE AMOUNT AND TYPE OF ASSESSMENT IS APPROPRIATE FOR THIS UNIT" PRIOR TO THE CHANGE.

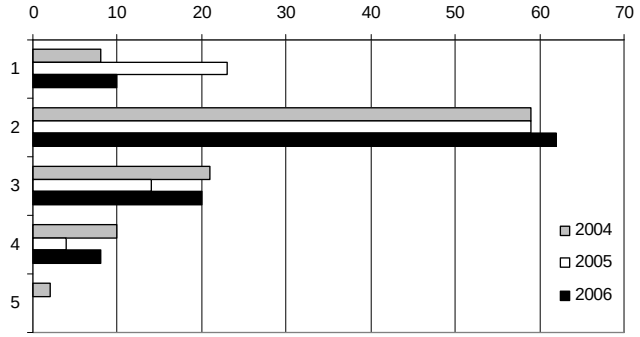


FIGURE 14
QA SURVEY – STUDENTS' RESPONSE FOR THE STATEMENT "THE AMOUNT AND TYPE OF ASSESSMENT IS APPROPRIATE FOR THIS UNIT" AFTER THE CHANGE.

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