Monitoring mining engineering undergraduate perceptions of contribution to group project work

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Abstract: *A combination of self and peer assessment is a powerful and rich teaching and learning management tool that can be used to monitor and evaluate group performance in project work. An on-line system (SPARK^{PLUS} – Self and Peer Assessment Resource Kit) has been developed to simplify this process for the academic. This system generates factors for both the peer assessment weighting to be applied for individual contribution and the student's perception of their contribution compared to their peers by using key assessment criteria and a rigorous algorithm that is applied to the student evaluations of themselves and their peers. This paper describes and evaluates the introduction of SPARK^{PLUS} to assess the performance of Mining Engineering Undergraduates in Year 3 at The University of Queensland in the first semester of 2008 in two of their core undergraduate courses that required group project work to be completed for assessment. The results obtained from this initial trial show the potential for improving student behaviour in group work through a structured approach to monitoring and feedback of their performance. It was found that male students with GPAs ≤ 5 tend to overestimate their contribution to group work more frequently than their peers whereas the opposite applies for male students with GPAs > 5.*

Introduction

Project based learning has increased in recent years. It is considered a desirable mode of educating students as it is seen by employers to equip students with valuable professional skills that they will be required to implement in the workplace. In addition, Engineers Australia requires students to develop graduate attributes that in some instances are arguably best developed through project based learning (Willey and Gardner, 2008a). Among other things this teaching method provides students with the opportunity to experience working in a team environment and to improve their professional skills including oral and written communication skills.

One of the drawbacks often levelled at project based learning however, is that it is difficult to evaluate an individual's contribution to a group project. To overcome this perceived shortcoming, methods of self and peer assessment have been developed, which provide students with the means to evaluate the contributions of both themselves and their peers to the group project. Willey and Gardner (2008b) and van den Bogaard and Saunders-Smits (2007) provide recent examples of the use of these systems.

Effectively there are three types of self and peer evaluation in group project work (van den Bogaard and Saunders-Smits, 2007). The first type is a Simple Ranking where students are asked to rank each team member with respect to each other. This results in a list with the "best" student at the top of the list and the "poorest" performing student at the bottom of the list. The second type is Proportioned Ranking where the group is given a set of assets to divide, similar to a fictional amount of money, which they can then choose to divide among the group members. The third type is Criteria Rating where students provide ratings for their peers and themselves based on quantitative descriptions of desired and undesired behaviour that are linked to learning objectives of the group project. This results in a description of how others perceive a student has met the desired outcomes of the group work and how they themselves perceived their own performance (van den Bogaard and Saunders-Smits, 2007). In this system, students are not necessarily ranked amongst each other, but rather it provides a contrast between the student's perceived performance and the group's perception of that individual's performance. This is a very important distinction.

This paper presents the process and experience developed in choosing a self and peer evaluation system that suited the needs of project based learning in Mining Engineering undergraduate courses. Results are presented from Year 3 students at The University of Queensland in their first exposure to the use of the Self and Peer Assessment Resource Kit (SPARK) developed by researchers from the University of Technology, Sydney and Sydney University (Freeman and McKenzie, 2002; Willey and Freeman, 2006a; Willey and Gardner, 2008a,b). In addition, suggestions are made for improvements that will be incorporated into future implementations of SPARK.

Choosing an appropriate self and peer evaluation system for mining engineering undergraduate group project work

In 2008, Mining Education Australia (MEA), which at that stage was a joint venture between the University of New South Wales (UNSW), the University of Queensland (UQ) and Curtin University of Technology through their Western Australia School of Mines (WASM) campus, decided to standardise on a systematic approach to self and peer evaluation of group project work. This was driven by the teaching philosophy that when team skills are part of the learning objectives of a degree program it is important that students have an opportunity to develop and learn these skills and that academic staff members have the opportunity to monitor and coach this process.

Simple Ranking systems do not give any direction to improvement of student performance in group work and it was felt that such systems would not capture or encourage true teamwork in mining projects. Proportioned Ranking systems do allow for student improvement and have an advantage that progress can be expressed quantitatively, but it is more difficult to give feedback on multiple learning objectives (van den Bogaard and Saunders-Smits, 2007). This type of system had been in use prior to the formation of MEA, but the students soon learned how to divide the assets up between them so that some "took the hit" (low ranking), while others benefited (high ranking) as an agreed arrangement, but making sure that all in the group passed overall. This system was therefore not capturing freeloaders as most students were reluctant to mark their peers down and also individual weighting multipliers of a maximum of 1.2 and a minimum of 0.8 were being applied. There was also no real indication to the lecturer of how each student felt they were performing in group work.

To overcome these shortcomings it was decided to commit to implement the use of SPARK in 2008 and then subsequently SPARK^PLUS with guidance from staff at the University of Technology, Sydney (UTS) to assist with monitoring of student performance in group project work. This system was selected as it provided a sound basis for self and peer assessment that students could easily use and it also provided MEA academic staff members with a tool that enabled individual marks to be allocated based on students ratings judged against set criteria. In addition, the results obtained from SPARK could be used by students as feedback to improve their learning outcomes from the group work experience.

Project based learning in Year 3 at UQ

The two undergraduate Mining Engineering core courses that were analysed in this investigation of self and peer assessment were Resource Estimation (MINE3120) and Socio-Environmental Aspects of Mining (MINE3127). A total of 51 students completed the assignment work in both courses, with 27.5% of the cohort being female. This is quite a high percentage of female students for engineering, but mining has always attracted a higher proportion than other engineering disciplines at UQ. The cohort covered a range of Grade Point Averages (GPAs – based on a 7 point scale at UQ) from 3 to 7, with 47.1% having a GPA ≤5 and 52.9% having a GPA > 5.

In Resource Estimation the students were required to work in groups of four to evaluate a thermal coal exploration lease extension of an existing mine in the Bowen Basin of Queensland. The project was worth 25% of the course assessment. The overall aim of the project was for students to experience the step by step process of coal resource estimation using a software tool on a real case study. Data was supplied from 23 cored boreholes, which consisted of borehole coordinates, cored intervals sampled from the seam of interest and coal quality analyses for each interval. This project required significant analytical technical skills to be employed by the students. The desired outcomes of the project were for students to learn:

- To work together in the roles of a multi-disciplinary team (the project contains elements of resource geology, statistical data analysis, mining engineering, cost estimation, marketing) to provide the appropriate technical inputs for completing the project,
- About the structure of exploration data files,
- To create, validate and composite a borehole database,
- To create contour plots of coal quality by using a simple surface modelling package,
- To carry out resource estimation and reporting of a coal deposit according to the Joint Ore Reserves Committee (JORC) Code,
- The process of converting coal resources to a reserve status and the associated cost, and
- To present the results in a formal technical report.

Two group projects were evaluated using SPARK in the Socio-Environmental Aspects of Mining course. These were a Mine and Environmental Management Plan (MEMP) and a Field Trip Report worth 25% and 15% of the course assessment respectively. For the MEMP groups of four people had to choose an operating coal mine, metalliferous mine or quarry within Australia or overseas and prepare a concise mine and environmental management plan for the operation focusing on the key sustainability issues and how they are or will be addressed. The groups were also required to include in the plan (if possible) a section on past environmental or community incidents, their impacts, how the incidents were managed and an explanation of how the incidents could have been prevented or managed more effectively.

The Field Trip Report was linked with a site visit to Consolidated Rutile's mineral sands operation on North Stradbroke Island, which was designed to provide the context of how a mine operates in such close proximity to a local community and popular tourist destination on Brisbane's doorstep. The students were required to work in groups of four to prepare an Environmental Management Overview Strategy (EMOS) for a proposed Mining Lease (ML) to extract foundry sand and glass sand on North Stradbroke Island within a defined Exploration Permit for Minerals (EPM). The location of the ML was in the vicinity of Dunwich Township on the island and bordered a natural and cultural heritage site (Brown Lake).

SPARK criteria and rating scheme

As each of the three projects that were assessed had different objectives the SPARK criteria used was slightly different in each case, although the rating scale that was used remained the same (Table 1). Table 2 contains the SPARK criteria used for the Resource Estimation Project. The criteria used in the other two projects were abridged versions of Table 2 in response to student feedback that ten criteria were too many to respond to. In this version of SPARK the ratings were recorded using discrete buttons (rather than the sliders that are available in the current version of SPARK^{PLUS}), and each criterion had equal weighting.

Table 1: Rating scale used for each SPARK criteria

4	Excelled in their contribution for your team
3	Above average contribution for your team
2	Average contribution for your team
1	Below average contribution for your team
0	Little or no contribution

Table 2: SPARK criteria used for Resource Estimation project

Category	Criteria	Self	Peer 1	Peer 2	Peer 3
Category 1 Overall Contribution	How an individual member's contribution compared to other group members				
Category 2 Efficient Functioning of Group	Providing constructive feedback to team members and reliable, met required deadlines, attended group meetings				
Category 2 Efficient Functioning of Group	Helping the group to function as a team				
Category 2 Efficient Functioning of Group	Level of enthusiasm and participation				
Category 3 Project Work	Preparation of correct data compositing with appropriate level of accuracy				
Category 3 Project Work	Production of relevant contour plots with appropriate labelling				
Category 3 Project Work	Contribution to calculations for an accurate resource estimation				
Category 3 Project Work	Contribution to production of valid and justified drilling program for resource upgrade				
Category 4 Report	Report production including editing, grammar, spell checking, production of diagrams, figures and tables				
Category 4 Report	Contribution to preparing summary, conclusions and recommendations in the report				

SPA and SAPA calculations

Unlike other self and peer assessment packages, SPARK[PLUS] has the capacity to produce three assessment factors. The use of two of these factors was integrated into the group work presented in this paper. The first factor known as the SPA or Self and Peer Assessment factor is a weighting factor determined from both the self and peer rating of a student's contribution compared to the average rating of their team. It is typically used to change a team mark for an assessment task into an individual mark using the following equation:

$$\text{SPA Factor} = \sqrt{\frac{\text{Total ratings for individual team member}}{\text{Average of total ratings for all team members}}} \qquad (1)$$

Individual mark = team mark x Individual's SPA (2)

The second factor calculated is the SAPA or Self Assessment to Peer Assessment factor. This is the ratio of a student's own rating of themselves compared to the average rating of their contribution by their peers. It is calculated using the following equation:

$$\text{SAPA Factor} = \sqrt{\frac{\text{Self ratings for individual team member}}{\text{Average of ratings for individual by peer team members}}} \qquad (3)$$

The SAPA factor has strong feedback value for development of critical reflection and evaluation skills comparing a student's self assessment to the assessment of their contribution and/or submission by their team peers. For example, a SAPA factor greater than 1 means a student has rated their own performance higher than the average rating they received from their peers and vice versa.

At the completion of each project, students are provided with their SPA and SAPA results. A radar diagram is available within SPARK to help students reflect on their performance both within the group and for individual criteria used in the assessment. This is supplied to each student by the lecturer in charge of the project.

Analysis of SAPA Results

The SAPA results from the three projects have been analysed to study the performance of the students in terms of over-rating and under-rating themselves. Over-rating is defined as a SAPA score of ≥ 1.20 and under-rating is defined as a SAPA score of ≤ 0.80. In the case of over-rating, often these are students who are attempting to gain an unfair advantage by inflating their ratings of themselves compared to the ratings of their peers. It is important to recognise these students, particularly if they are repeat offenders so that they can be alerted to their unacceptable behaviour and also SPARK has a feature that allows them to be excluded from the SPA calculations so that their ratings do not distort the results of their peers. In the case of under-rating students, they are clearly not giving themselves due credit for their efforts as seen by their peers. Again repeat offenders are alerted to this behaviour and excluded from the SPA calculations so that their ratings of themselves do not disadvantage their final mark for the project.

Of the 153 SPARK submissions made for the three projects, there were 21 cases of over-rating (13.7%) compared with 6 cases of under-rating (3.9%). An examination of the make up of students involved in these cases (Figures 1 and 2) shows some interesting trends. Male students constituted 81% of the over-rating cases, with those having a GPA ≤ 5 being the main offenders (Figure 1). To some extent this is consistent with Hofstedes cultural dimension results for Australia that show a high masculinity index. In contrast, male students with a GPA > 5 constitute the majority of the under-rating cases. This is more related to these students not wishing to be seen as "big-noting" themselves.

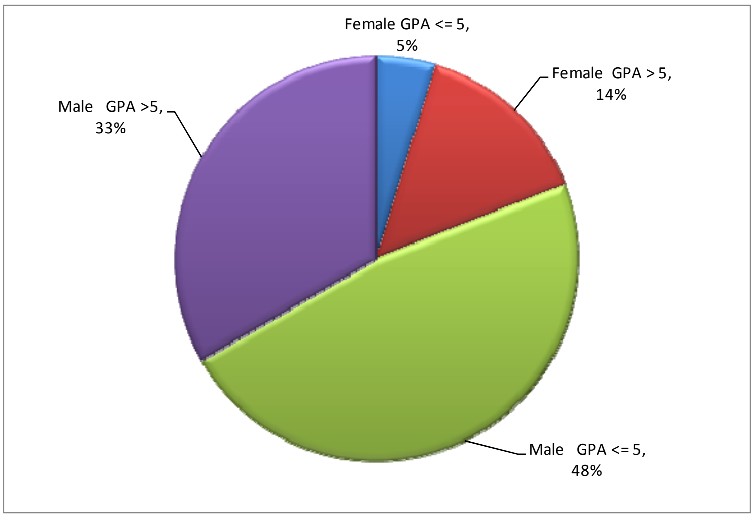

Figure 1: Breakdown of over-rating SAPA results

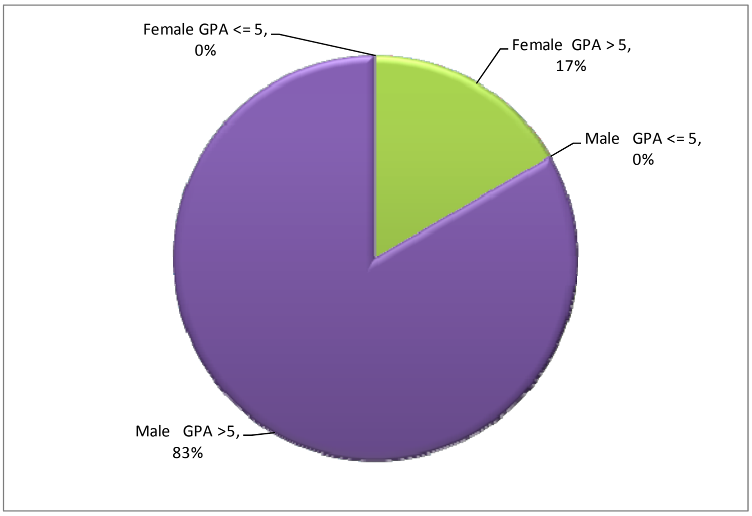

Figure 2: Breakdown of under-rating SAPA results

Future MEA Adoption of SPARK^{PLUS} Capabilities

Change to using a slider rating scale

The initial use of the simple rating scale in Table 1 gives equal weighting to each number used and using the integer values allows students the opportunity to easily submit equal values agreed on beforehand, although this was actively discouraged. Also the integer system does not allow the students to consider that they might be somewhere on a spectrum for each category being assessed. To overcome this shortcoming in the future, MEA intends to use two other features of SPARK^{PLUS}. First using a slider rating scale reduces the risk of students colluding and submitting agreed values. Essentially, the only way they can submit exactly the same slider scale rating is to be sitting next to each other at a computer terminal and clicking the slider at the same time. Such efforts of collusion are easily spotted in the automated results generated by SPARK^{PLUS}, and students can then be asked to resubmit their ratings independently. Secondly, the latest version of SPARK^{PLUS} allows reporting of the average rating submitted by an individual for themselves and their peers on each criterion. If honest assessments are provided the average rating provided on each criterion should be approximately average. For example if students collude and agreed to rate each other high or above-average this will be clearly visible in the results. This is just another feature of SPARK^{PLUS} that has been introduced to encourage honest assessments.

Use of Knee Method calculation to generate SPA factors

The most significant feedback obtained from the students was that the existing factors generated by the version of SPARK used in this implementation were not catching the 'freeloaders'. The lowest SPA ratings for each project were: 0.86 for the Resource Estimation project; 0.70 for the Mine and Environmental Plan project; and 0.81 for the Field Trip Report. Hence using the lowest value as an example, the report mark would need to have been less than 71% for a student to receive less than a pass mark for the project. Even if the report was a bare pass at 50%, the student would still receive 35% for their individual mark. This was mainly due to the fact that if the student did some of the work then their contribution rating was assessed as 1 according to Table 1.

The change to using the slider rating scale partly addresses this shortcoming. In addition, $SPARK^{PLUS}$ also allows non-linear scaling to be implemented. An example of this is to divide the slider into five categories representing an overall range of 0 to 100. The no contribution rating could be 0 to 5, below average 5+ to 20, average 20+ to 40, above average 40+ to 70 and excellent 70+ to 100. This would have the effect of providing less reward for those students not contributing their fair share to the team effort.

A more powerful modification has been made to the method of calculating the SPA factor that more closely reflects a student's contribution to the team effort. This is known as the knee method. The formula used in this method combines the best features of the original and linear calculation methods:

Knee SPA = $(\text{Equation } 1)^2$ if ≤ 1 (Linear) or Equation 1 if > 1 (Original)

The knee formula helps promote teamwork and fair division of the assessment task between team members. For example the knee formula does not reward students who might be tempted to do most of the work (a student who did twice as much work as their peers would only get an SPA factor of 1.26) while providing incentive for those who are tempted to underperform (a student who did half as much work as their peers would get an SPA factor of 0.57).

Conclusions

Mining Engineering courses at Year 3 and 4 levels are taught as a common national curriculum within Mining Education Australia Universities. Several of these courses use project based learning for student assessment. To help manage the student learning in group projects and apportion an individual mark for each student's effort it has been necessary to identify and adopt an appropriate self and peer assessment evaluation tool. This has been successfully accomplished through the implementation of an on-line evaluation package (SPARK), which has also simplified the process of self and peer assessment for both students and staff.

Self and peer assessment ratings are generated by students evaluating themselves and their peers against a set of criteria developed for each project. The initial trial of SPARK used a simple discrete (integer) rating scale, which did not provide the students with sufficient flexibility to rate each other. This will be modified in future usage with a slider rating scale.

Two factors were determined from the self and peer assessment ratings submitted by the students. A Self and Peer Assessment (SPA) factor was used to determine the student's individual mark and a Self Assessment to Peer Assessment (SAPA) factor was used to establish how each student felt they contributed to the group project compared to the rating given by their peers. The calculation method for the SPA factor will be modified in the next iteration of $SPARK^{PLUS}$ to help promote teamwork and reward student effort more fairly.

The SAPA factors were also used to identify students who were over-rating or under-rating themselves. It was found that the majority of over-rating students were males with GPAs ≤ 5, whereas the majority of under-rating students were males with GPAs > 5. These students have been counselled to encourage them to be more honest about their efforts in group project work.

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