Cooperative learning in an engineering context

by Clive Knobbs

In 2009, in my first semester as a lecturer, I was dismayed when one third of the class failed my subject, Underground Mining Methods and Fundamentals of Management and Leadership (PMY 410). This set in motion a process of finding and implementing a turnaround strategy involving cooperative learning, which not only addressed the technical (content) part of the course, but also facilitated the integration of soft skills (process) into engineering education.

When such a large number of students failed, it was tempting to lay the blame on the students, but the old adage states that "if the student hasn't learnt, the teacher hasn't taught". I realised that my aim of imparting an appreciation of the behavioural aspects of the real world and teaching some "people or soft skills" had not succeeded.

Adhering to Einstein's admonition that "insanity is doing the same things over and over and expecting to see different results", I went back to basics and asked a few fundamental questions. Was the course teaching the right material for mining engineers? What aspects of the course were superfluous? How could I teach more effectively, or, more aptly, how could I help the students to learn? What else did they need to know to handle the complexities and challenges of the real world, particularly the people issues?

Objectives

Clearly, the most important objective for the course was the need to improve the pass rate to something close to 85%, a figure 5% higher than the figure of 80% that the dean had set as a target for the Faculty of Engineering, Built Environment and Information Technology. Naturally, the technical and professional standard of the course could not be compromised (if anything, there was room for improvement).

The Fundamentals of Management and Leadership part of PMY 410 had constituted only about 20–30% of the course, but it was theoretical. The new course would concentrate more on emotional intelligence (EQ), subtly enveloping and permeating the technical content. Basic theoretical knowledge of behavioural concepts would be conveyed to students and rudimentary practical skills would be developed, concentrating on those elements that constitute the foundations of effective people management and leadership.

The EQ knowledge and soft skills that had to be included were intrapersonal skills (self-awareness, self-regard, assertiveness and independence), interpersonal skills (empathy, relationships and communication), adaptability (reality testing, conflict-handling and problem-solving) and stress management (tolerance and impulse control). An understanding of group dynamics, particularly in small teams, was also important. The aim was to mimic, as closely as possible, the personal and people issues that graduates would be faced with in the real world and to enable them to understand the situation in order to cope appropriately and adequately. No quantitative objectives were set in this area for obvious reasons. People and their behaviour are highly complex and defy accurate quantification. I also knew what would constitute a "meaningful" change in these multifarious things.

The action plan

I read prolifically (books, papers from luminaries, articles in authoritative publications and the like) – everything I could lay my hands on. I consulted with the cognoscenti at the University of Pretoria who gave unstinting assistance in redesigning the course and the way it was to be presented. In addition, the course that I am attending at the INSEAD Business School in France (Executive Master's degree in Clinical Organisational Psychology) contains many modules that have been invaluable in assisting me to formulate the programme for incorporating some behavioural knowledge and skills into the PMY 410 course. Subjects such as "know thyself" (Plato's dictum), group dynamics, management and leadership, conflict-handling, change management, group coaching,

Soft skills are integrated into engineering education.

and one-on-one coaching for underperformers are among the many topics covered in the INSEAD course.

Armed with this "academic" knowledge, augmented by advice from my mentors, I opted for a cooperative learning approach to teaching. The approach also comes in other names, but essentially it involves the use of small teams to enable effective learning. The discussion and debate in these teams are central to the learning process; not just for technical content, but also for developing soft skills.

For technical content, the international CDIO (conceive, design, implement and operate) model was used. Heavy emphasis was placed on the first three dimensions, as the students would encounter the operate dimension in their mine design course in the second semester. In essence, the goal was to enable students to construct mini-designs of mines by the end of the course. With the content decided, I had to consider the details of the modus operandi for teaching through cooperative learning.

Reading material relating to course content was sent to individuals through ClickUP, the University's online teaching platform. This material consisted of published papers, presentations by experts, lecture notes and references to chapters in a prescribed textbook. Students were expected to prepare themselves for the small-team discussions, where specific questions and points for consideration were posed on the subject matter. Unresolved or unsatisfactorily resolved issues from the small groups, involving understanding or interpretation, were passed on to the full class for later discussion and resolution. Short presentations were made by randomly selected teams.

The big spin-off from this small-group activity of tackling technical issues was the conversation that was taking place inside the group and subsequently in the full class discussions. These discussions were promoting interaction, communication, problem-solving, confidence and a whole array of soft EQ skills.

As part of the soft EQ knowledge and skills and to help construct the small teams that were pivotal for cooperative learning, psychometric tests were employed extensively throughout the semester. Tests were administered that measured brain dominance, habits, learning styles, and character, personality

and behavioural styles. All students wrote a reflection paper at the beginning and in the middle of the course, describing their feelings about cooperative learning. But what was really happening during the course – the hard facts?

Throughout the course, progress was measured. More frequent individual assessments were introduced. Regular short weekly tests were written and three longish assignments were completed in addition to the two standard semester tests. Heavier weighting was given to these semester tests and assignments, which together accounted for 50% of the final mark.

Results

The evaluation of the efficacy of cooperative learning on students' prowess in the hard technical core of the course was measured directly by their final marks. Of the 28 students in the class, 23 passed the course: a pass rate of 80%. Of the five failures, four could rewrite their examinations and one failed outright. On the face of it, the objective was realised. It is impossible to say that cooperative learning was solely responsible for the improved results, but it was an important factor. The students' perceptions might shed some light on the real value of cooperative learning.

Responses to the custom-designed questionnaire administered before the final examination showed that the majority of students found the cooperative learning approach to be helpful or extremely helpful in imparting knowledge and understanding, and in teaching design skills. On the question of enjoyment, the majority of students responded positively; a handful of students disagreed.

What about the effect of cooperative learning on the soft EQ issues? Judging by the responses to the questionnaire, it would appear that the "peripheral" behavioural issues were affected positively. On the main questions of confidence, communication, self-worth, problem-solving, teamwork and interpersonal relationships, understanding of themselves and others, about 80% of the students said that their knowledge and skills had been enhanced or extremely enhanced. This would appear to vindicate the assertion that cooperative learning can have a positive influence on soft EQ issues.

The cooperative learning approach is not new, but to my knowledge it has not been extensively applied in the field of mining engineering. The majority of students have accepted cooperative learning and it has probably contributed to an improved pass rate.

The use of psychometric tests and questionnaires at undergraduate level to help individuals know themselves, understand others and gain an appreciation of behavioural issues in the workplace is innovative. Placing such emphasis on teaching and developing soft skills, and integrating these aspects into the core technical part of the course are certainly new for the Department of Mining Engineering.

Future plans

The class of 2011 could consist of 60 students, double the number of 2010. This poses some logistical problems that would need attention. Refinements to the approach are already being considered. Other workplace skills like written English, project management and ethics can also be integrated into the course. The department is considering the possibility of introducing students to cooperative learning earlier in the degree, perhaps in one of the third-year courses.

A brilliant engineer with no knowledge of himself or herself and the behavioural issues that permeate the workplace is one-dimensional and at a distinct disadvantage relative to his or her counterpart who has acquired even a modicum of EQ knowledge and skills. The introduction of soft EQ knowledge and skills into PMY 410 will enable students to "hit the ground running" in the real world.

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