Collaborative peer learning to change learning culture and develop the skills for lifelong professional practice.

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***Abstract**: Engineers today are often required to make critical judgements involving decisions that extend beyond traditional discipline boundaries requiring ongoing learning, much of which is informal, learnt on the job from peers who are often from different disciplines. To prepare students for professional practice, they need opportunities to experience, practise, reflect and improve their ability to work in a collaborative environment. The University of Technology, Sydney teaches an undergraduate engineering science programme in Hong Kong. The authors have found it initially difficult to get students to participate in collaborative learning activities and in particular those that involved students in using their own judgement or critical analysis. In response, the authors redesigned their course to integrate collaborative peer learning activities into all areas of the curriculum including collaborative problem solving exercises that are subsequently assessed through a series of first individual then collaborative quizzes (using the immediate feedback assessment techniques (IF-AT)) and exams. Initial results from students overwhelmingly showed that the collaborative activities improved their understanding, ability to think through and resolve problems, and the identification and addressing of gaps in their learning. This approach has potential to benefit all engineering students as it prepares students to make the most of the informal collaborative learning opportunities provided in professional practice while simultaneously enhancing their ability to undertake lifelong learning.*

Introduction

Today, engineers are required to make critical judgements involving decisions that extend beyond traditional discipline boundaries. This requires professional engineers to undertake ongoing learning. Much of this learning is informal, learnt on the job from peers from different disciplines (Trevelyan, 2007). To promote students developing the skills required for professional practice they need opportunities to experience, practise, reflect and improve their ability to work in a collaborative way.

Many students resist having to take responsibility for their own learning rather expecting this to be the responsibility of their teaching academics. This resistance is particularly apparent in some cultures where asking challenging questions of an academic is regarded as being disrespectful. Furthermore, undertaking collaborative activities is complicated further when students are not being taught in their primary language. The University of Technology, Sydney teaches an undergraduate engineering science programme in Hong Kong in English. Students have typically undertaken previous engineering studies from a range of disciplines at a local polytechnic. The authors found it initially difficult to get students to participate in collaborative learning activities and in particular those that involved them using their own judgement or critical analysis. To address this issue the authors redesigned their subject to be built around collaborative peer learning activities.

Background

A number of researchers and government-sponsored reports (Hargreaves 1997, Jones 2003, Markes 2006, & Chung et al 2008) discuss a gap between skills typically developed in engineering education and a range of skills required for professional practice such as communication, critical thinking, leadership, teamwork skills and life long learning capabilities. This requires not only considering

what is taught but also how it is taught (Hargreaves, 1997). Workplace learning and professional practice is often collaborative (Littlejohn, Margaryan & Milligan 2009). It follows that students' preparation for entering this environment should include opportunities to practise collaborative learning with their peers. Collaborative learning also provides opportunities to develop interpersonal and critical evaluation skills in addition to professional judgement. The skills to critically evaluate and clearly articulate your point of view are necessary to successfully participate in collaborative professional practice. Despite this, students often receive only cursory training combined with infrequent opportunities to develop such skills.

Collaborative learning is also attractive from the perspective of the constructivist model of learning (Jawitz and Case, 2009). The constructivist view is that learning takes place when students construct their knowledge through individual engagement and social interactions with others (Wu, Beiber and Hiltz, 2008, Purzer, 2009). It is the students doing the learning rather than the teacher doing the teaching that determines whether learning takes place, and so this is a student-centred philosophy. Hagstrom (2006) argues that "…contexts for new knowledge construction include a blending of people … that gives rise to differences in interpretation and provides the occasion for the construction of new knowledge….If educators simply tell students what they need to know, they encourage reliance on memorization of facts. For students to make cognitive changes, the learning experience must begin with each student becoming aware of his or her own present understanding" (Hagstrom, 2006, p28). Dana (2007) reports that compared to traditional competitive or individualistic learning environments, benefits of small group or team based learning include higher student achievement, greater use of higher level reasoning and critical thinking skills, more positive attitudes toward the subject matter and satisfaction with the class, and better interpersonal relationships among students and between students and instructor

While projects, assignments and laboratories are regularly considered as opportunities to incorporate collaborative learning activities it is less common for students to undertake collaborative examinations and quizzes. This may be due to concerns about maintaining the integrity of these kinds of summative assessment. However, if you are going to embrace the principles of learning oriented assessment (designing assessment tasks as opportunities to promote learning) the effectiveness of collaborative quizzes and exams should to be considered. Stark (2006) describes the use of team exams in management education. He first conducts an individual exam and then gives the same exam to teams to complete. After varying the assessment contribution of the team exam from 13-42% of the value of the individual exam he reports that:"…such variations had little effect on team exam scores and on student reactions to team exams. At each point value I have observed that students engage each other in serious discussion of the material to the same end – that of understanding the material better than they did before." Stark further reports students' learning benefits from having to explain concepts to their peers and that "Team exams make post exam feedback more of a student-directed and student-centred activity." Additionally, he finds that team exams add value to post exam feedback activities, as "teams will often answer each others' questions more effectively than the instructor."

Immediate feedback assessment technique (IF-AT) cards (figure 1) developed by Epstein (http://www.epsteineducation.com/home) and promoted in team based learning techniques by Michaelsen (Michaelsen, Knight & Fink 2004) allow students to immediately identify if they have answered multiple-choice questions correctly. If an answer is incorrect, groups consider the remaining options and try again. This process continues until the correct answer is achieved. Several researchers have shown that the immediate feedback provided by the IF-AT cards improved learning (Epstein et al 2002, Dihoff et al. 2004, Brosvic et al 2005, Brosvic & Epstein 2007), student satisfaction (Epstein & Brosvic 2002, Persky & Pollack 2008) and promoted higher levels of independent learning (Brosvic et al 2005; Persky & Pollack 2008). Furthermore, Persky & Pollack (2008) report that use of the IF-AT "allows a student to assess his or her own mastery of the material, indicates to the student areas of potential misconception, and allows the student to think about and rework problems. Each of these elements potentially increases deep learning."(p.5)

In this paper we report on the integrated use of collaborative peer learning activities in offshore classes not taught in students' first language to assist students to make the most of informal collaborative learning opportunities characterised by professional practice. The activities were designed to allow

students to test their understanding through a number of interactive collaborative problem solving exercises that were subsequently assessed through a series of first individual then collaborative quizzes (using immediate feedback assessment techniques (IFAT) (see Figure 1)) and exams.

Method

The reported trial was conducted in the course Design Fundamentals. In Hong Kong this course runs for a 14 week semester throughout which students complete a team-based design project (worth 50% of final grade). In addition, students attend 22 hours of lectures delivered in a block mode format (over four consecutive days). Students are expected to pre-read material before lectures, allowing class time to focus on higher learning outcomes. After each topic is reviewed students test their understanding through interactive collaborative tutorial problem solving. Groups then report to each other discussing each other's solutions and approach. The coordinating academic also used these activities to identify students who have a thorough understanding of the topic material. These students are appointed as peer mentors to other groups and are encouraged to explain the topic material to their peers in their first language. The coordinating academic then asked students who they believed to be one of the poorer members of each group to explain their understanding of the problem to the class in English. This approach has the advantage that students can have issues addressed and discussed in their native language that may have been difficult due to comprehension problems when explained in English. By having students report back in English the coordinating academic is able to assess their understanding of the course material and clarify any outstanding issues.

Subsequently topics are tested through a series of three quizzes, (each worth 5% of a student's final grade) which are initially undertaken individually and then collaboratively, using IFAT cards. This method enables groups to receive partial credit for questions that required more than one attempt. For example if the group answers the question correctly in two attempts out of five they have demonstrated enough knowledge to enable them to narrow the options. In this course groups were awarded 3 marks if the question was answered correctly on the first attempt, 1 mark if the question was answered correctly on the second attempt and 0.5 marks if they took three attempts to get the correct answer. In the review following each exercise the group that required the most attempts to correctly answer each question is identified. These groups explain their solution/understanding of that question to the class.

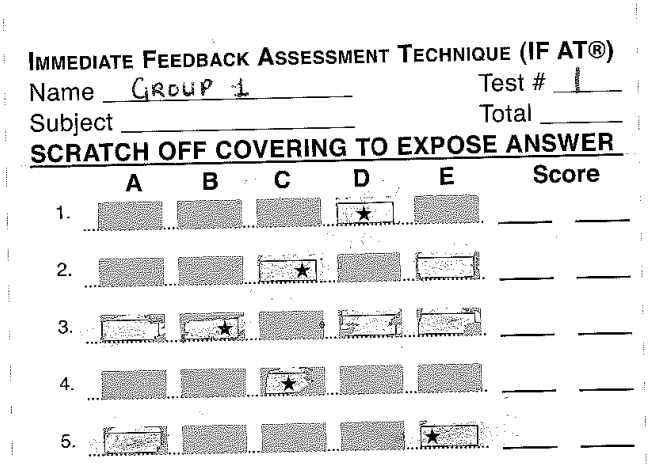

Figure 1: Example of IF-AT scratch card. Note questions 1 and 4 were answered correctly on the first attempt while multiple attempts are required for Questions 2, 3 & 5.

Evaluation of collaborative teaching activities

A student's mark is calculated as 80% from their individual quiz mark and 20% from their collaborative quiz mark. Hence, the collaborative component of each quiz is only worth one mark (20% of 5 marks). Despite this, the collaborative sessions were quite animated with groups actively discussing and sharing their knowledge to answer the questions and increase their learning.

These activities are designed to enable students to identify their learning gaps and have them immediately addressed initially by their peers and subsequently during an end of activity review session by the lecturer to clarify any unresolved issues.

At the end of the block mode session all course material is examined through a final examination process with three distinct parts. The first is an individual formal exam (worth 40% of final grade), the second is when the examination is taken again collaboratively within groups (worth 10% of final grade) and the third is a formal exam review conducted by the instructing academic.

A combination of surveys, free response questions, observations, a group interview and video analysis were used to evaluate these collaborative activities.

Results and Discussion

The survey instrument contained a series of multiple-choice and free response questions. The multiple-choice questions used a four-point Likert scale from strongly agree to strongly disagree. While this paper mainly focuses on discussing the results obtained from this survey instrument, further insight is provided by referring to the observational and group interview data. The class cohort consisted of 26 students all of whom volunteered to participate in the study (both survey and group interview) in accordance with the conditions required for ethics approval (to remain anonymous etc).

Table 1: Results from post-subject survey instrument. Questions that used a 4 point Likert scale have had strongly agree and agree responses and strongly disagree and disagree responses combined. The percentage of any unanswered responses are not shown but can be calculated by subtracting the provided results from 100%.

Survey statements	Agree SA/A	Disgree D/SD
I was "engaged" most of the time in classes in this subject	96%	0%
I was usually actively involved in classes in this subject.	96%	0%
The use of the IF-AT cards (the scratch cards) made the group quizzes fun	100%	0%
When we had some doubt about our chosen answer, but we still got the question correct the first time, the immediate feedback provided by the IF-AT cards (the scratch cards) contributed to our learning as it clarified our understanding of the relevant material	100%	0%
When our chosen answer was incorrect, the immediate feedback provided by the IF-AT cards (the scratch cards) caused us to reflect and re-evaluate our thinking in choosing another answer	100%	0%
Knowing that I would be expected to contribute to the group component of the quizzes increased my motivation to learn the relevant material	100%	0%
Having to collaborate to decide on answers during the quizzes and the exam has improved my ability to think through and resolve problems	100%	0%
Having to discuss the answers to the quiz and exam questions with my group members helped me to understand material that I hadn't previously fully understood by myself	100%	0%

The conversations I had with my group when discussing the answer to questions helped me identify and subsequently address any gaps in my knowledge of the subject material	96%	4%
Compare your experience of the subject this semester with your prior experience in other subjects. Indicate how much the approach to learning in this subject, including the use of the collaborative quizzes and final exam, improved your understanding of the subject material.	Min Reported 25% Max Reported 120% Average Reported 72 %	

The results from the post subject survey relevant to this article are shown in Table 1 and Figure 2. The 'Strongly Agree' and 'Agree' responses were combined to give an aggregate result (SA/A), as were the 'Strongly Disagree' and 'Disagree' responses (D/SD). The percentage of any unanswered responses are generally not shown but can be calculated by subtracting the provided results from 100%.

The results reported in Table 1 show that students were overwhelmingly positive in their opinion that the collaborative learning activities made a significant contribution to their learning. Students reported high engagement with the class (96%) and that the conversations they had with their group peers helped them identify and subsequently address gaps in their knowledge relating to the subject material (96%). Furthermore, the entire cohort agreed that the IF-AT cards helped them clarify understanding, caused them to reflect and increased their motivation to learn. Similarly, the entire cohort agreed that the combination of the collaborative quizzes and examination improved their ability to think and resolve problems and helped them to understand material that they had not previously fully understood on their own.

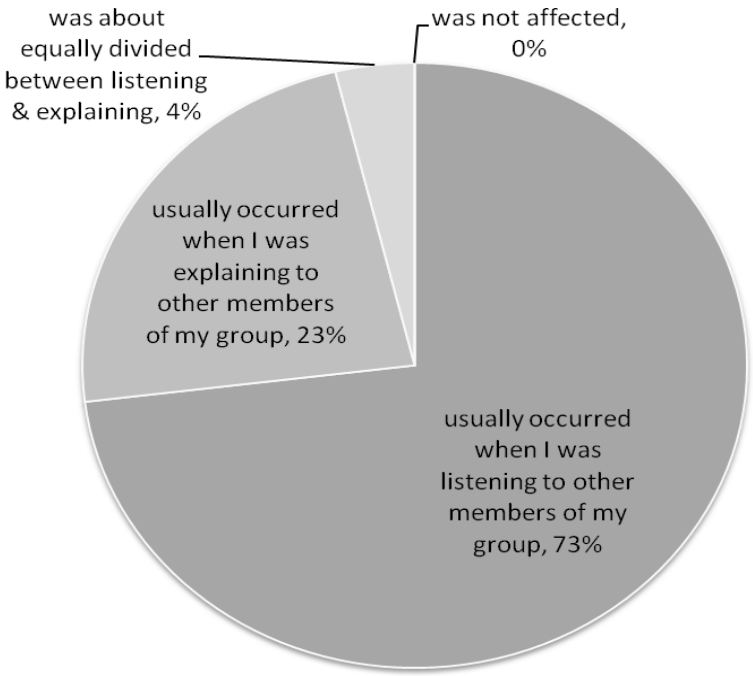

Figure 2: Results from post-subject survey instrument to the question "In discussing the quiz or exam questions with my group members, my learning:"

Groups were randomly selected at the start of the course resulting in most groups consisting of students with different levels of ability. We theorised that this would provide high achieving students

the opportunity to identify their learning gaps through teaching others and poorer students the opportunity to increase their understanding through explanations provided by their peers. However, most high achieving students reported that they did not always take on the teaching role and that they learnt a lot from their peer's contributions. This feedback from the group interview was supported by the results of the survey instrument (recorded in Figure 2). These results show that most students reported their learning usually occurred (73%) through listening to peers' explanations. Furthermore, on average, students reported that compared to their experience in previous subjects the collaborative approach to the subject improved their understanding of the subject material by 72% (Table 1).

While the survey instrument used in this study was designed to determine the success of the collaborative peer learning activities, the authors recognise its shortcomings as a research instrument. You must always be careful when relying on self reporting (asking respondents to interpret their own experiences) as the results are subject to the state of the respondent at the time of completing the survey. For example, the survey was conducted at the end of the block mode when students may have been feeling euphoric from several days of intense collaborative activity. It is possible, that if the survey had been conducted a week later the results may have been somewhat different. In addition, confidence in these results would be strengthened if the questions had been designed to be low-inference, and hence reduce the risk that some respondents may have answered the questions in the way they think the instructor wanted them to.

Even excepting this potential bias, the results unequivocally show that the collaborative learning activities made learning in the class fun, resulted in high engagement and made a significant contribution to students' learning and development of lifelong learning skills such as critical evaluation and reflection.

This method has proved so effective (students learning from each other) that the teaching academic typically has to now only answer or clarify the more complex questions. This approach supports the authors' aim of using minimum assessment to motivate maximum learning. In this case, the allocation of a maximum of 13 collaborative marks (one for each of the three quizzes and 10 for the final exam) motivates a significant amount of learning. What's more, students have fun, enjoying the process reporting in their free response comments that the best things in regard to their learning in the subject were the:

- "interactive learning and immediate feedback system"
- "discussing with group regarding exam questions"
- "make me thinking more about the design subject" (sic)
- "interesting .. group discussion"
- "Scratch card made quiz fun, and makes us able to discuss" (sic)
- "more understanding by collaborative quizzes"
- "the scratch cards is fun with group" (sic)
- "I learnt more from the quizzes and group discuss"
- "I can discuss and find out answer with my group member"
- "The IF-AT card let my group more input in class" (sic)

The authors' observations and feedback received from students in the group interview indicate that the collaborative methods were particularly useful in helping students not being instructed in their first language to comprehend, understand and reflect on the material being taught. Students also reported that they found it easier and less embarrassing to ask a question of their peers rather than the lecturer whom they regarded as an expert. In addition, the lecturer reported that having peer mentors explaining difficult concepts was extremely successful, as previously they had had difficulty explaining nuances and subtleties in the subject material to students with poorer English skills in a way that they could appreciate and comprehend.

Furthermore, in agreement with Stark (2006), the authors have found that the immediate post-quiz and exam feedback provided by the review sessions had real benefits for the instructor as it indicated the validity of the questions. That is, whether they were authentic, achieved the desired assessment objective and were clear and not contradictory. Again, like Stark (2006), the authors found that the

questions that groups had the most trouble with in the collaborative activities often indicated questions of poor quality, which contributed to students' difficulty in answering them.

The authors fully expect that the collaborative approach reported in this paper would provide significant benefits to all engineering students (not just those being instructed in another language) as it prepares students to make the most of the informal collaborative learning opportunities provided in professional practice while simultaneously enhancing their ability to undertake lifelong learning.

Conclusion

The Design Fundamentals course was reconfigured around a series of collaborative peer learning activities, including group quizzes and a group examination. The results of an evaluation of the effect of these activities show that students reported high engagement with the class, that the conversations they had with their group peers helped them identify and subsequently address gaps in their knowledge relating to the course material, that the IF-AT cards helped them clarify understanding, caused them to reflect, increased their motivation to learn and made learning fun. The entire cohort agreed that the combination of the collaborative quizzes and examination improved their ability to think and resolve problems and helped them to understand material that they had not previously fully understood on their own. The authors fully expect that the collaborative approach reported in this paper would provide significant benefits to all engineering students in preparing them to make the most of the informal collaborative learning opportunities characteristic of professional practice.

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