Scratch that itch to learn: a comparative study

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***Abstract**: Engineers today are required to make critical judgements involving decisions that often 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. To enable students to develop the skills required for professional practice they need opportunities to experience, practise, reflect and improve their ability to work in a collaborative environment. One method used at the University of Technology, Sydney to develop these skills is collaborative activities incorporating immediate feedback. Subject topics are tested through quizzes that are initially undertaken individually and then collaboratively using immediate feedback assessment technique (IF-AT) cards. These activities allow students to first identify and subsequently have gaps in their learning addressed initially by their peers within the one activity. This paper reports on a comparative evaluation of the collaborative use of IF-AT quizzes in four subjects taught by the authors. We found that these methods not only consistently improved student engagement, learning and developed skills required for life-long learning, but also promoted changes in their learning culture by having them take more responsibility for their own learning.*

Introduction

Engineers are often 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 often from peers from different disciplines (Trevelyan 2007). To develop the skills required for professional practice students need opportunities to experience, practise, reflect and improve their ability to work in a collaborative environment.

Furthermore, many students resist having to take responsibility for their own learning rather expecting this to be the responsibility of their teaching academics. In some cases, this resistance is in part due to students' previous educational experience that combined didactic teaching and passive learning. This type of tuition does not afford students the opportunities to both develop and practice exercising their own judgement in-class.

One method used at the University of Technology, Sydney (UTS) to improve students' collaborative learning skills and provide opportunities to develop and practice judgement is collaborative activities that incorporate immediate feedback. In this paper, we examine an activity where subject topics are tested through quizzes that are initially undertaken individually and then collaboratively using immediate feedback assessment techniques (IF-AT) cards. These activities provide an immediate feedback cycle allowing students to first identify and then afterward have gaps in their learning addressed initially by their peers and subsequently by their teaching academic.

This paper reports on a comparative evaluation of the collaborative use of IF-AT quizzes in four different engineering subjects to investigate their effectiveness in promoting collaborative peer learning.

Background

Professionals, in addition to being technically competent, require the skills of collaboration, communication and the ability to work in teams (Lang et al 1999, Scott & Yates 2002, Mills & Treagust 2003). However, there are reported competency gaps between the skills required by employers including communication, critical thinking, leadership, teamwork skills and life-long learning capabilities, and those developed by students during their undergraduate courses (Hargreaves 1997, Meier et al 2000, Jones 2003, Bryan et al 2005, Markes 2006, & Chung et al 2008). 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 ability to critically evaluate and clearly articulate your point of view are requisite skills for successful participation in most professional practice. Despite this, students often receive little training and infrequent opportunities to develop such skills during their academic studies.

Collaborative learning is also attractive from the perspective of the social constructivist model of learning (Jawitz and Case, 2009). The social 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). Hagstrom (2006) argues that "…contexts for new knowledge construction include a blending of people … 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).

While projects, assignments and laboratories are regularly considered as opportunities to incorporate collaborative learning activities it is less common to undertake collaborative examinations and quizzes. Stark (2006) describes conducting an individual exam and then giving the same exam to teams to complete. He 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 (2006) 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".

Quizzes using IF-AT Cards

Immediate feedback assessment technique (IF-AT) cards (Figure 1) developed by Epstein allow students to immediately identify if they have answered multiple-choice questions correctly. These cards require the students to scratch off a covering over the response they think is correct (hence they are referred to in class as 'scratch cards'). If they have selected the correct response a star is revealed (Figure 1). If they selected incorrectly, they consider the remaining options, and try again. In controlled trials the IF-AT method was shown to promote both retention of learned material (Epstein et al 2002, Dihoff et al 2004, Brosvic et al 2005, Brosvic & Epstein 2007) and higher levels of independent learning (Brosvic et al 2005; Persky & Pollack 2008).

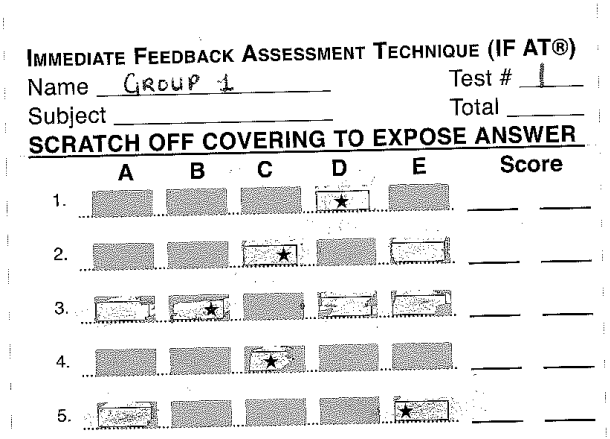

Figure 1: IF-AT card showing a star under the correct answer and multiple attempts to find the answer for Questions 2, 3 & 5.

Persky & Pollack (2008) report that use of IF-AT cards "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).

Method

Four subjects at different stages of a student's educational journey were chosen to assess the effect of collaborative quizzes on student learning. The subjects chosen were a:

- second year core engineering subject Design Fundamentals taken by all engineering students
- final year Telecommunications Engineering subject Communications Theory
- final year Civil Engineering subject Concrete Design
- postgraduate Telecommunications subject Transmission Systems

Within each subject topics were tested through a series of quizzes (4 to 5). Students completed each quiz individually and then immediately afterwards completed the same quiz collaboratively in groups of four to five students using the immediate feedback assessment techniques (IF-AT) cards. When completing the quiz collaboratively if a group selected the correct response at their first attempt they are allocated full marks for that question. If they selected an incorrect response they continued to select another answer until the correct answer was obtained enabling them to receive partial credit (depending on the subject 60% to 33% second attempt, 40% to 16% third attempt, 0% fourth and fifth attempt). A student's final quiz mark was calculated as 80% from what they scored individually and 20% from their group score.

A survey instrument based on previous IF-AT literature was developed. The survey questions were grouped into three broad categories (only two of which are reported fully due to the page limit) to investigate: the effect of the quizzes on student engagement (Category E), the effect on students' perception of their understanding (Category C) of the subject material and the effect of immediate feedback. . The instrument contained a combination of six point Likert scale (strongly disagree, disagree, slightly disagree, slightly agree, agree, strongly agree) open-ended and free response questions. The survey was paper-based and students completed it in class. To encourage students to provide honest responses without fearing anything they said could influence their subject results, the surveys were collected and collated by a third party with results only being provided to the authors after the posting of final grades.

In addition to the survey instrument, focus groups and observations were used to evaluate the impact of the collaborative quizzes on students.

Results

The percentage of responding cohort who agreed (slightly agree, agree, strongly agree) with the statements in the survey instrument are shown in Table 1. Figure 2 plots these results to enable easy comparison.

Table 1: Percentage of responding cohort who agreed with statements in the survey instrument

Survey Statements	Category	Design Fundamentals (n=31)	Communications Theory (n= 42)	Concrete Design (n= 67)	Transmission Systems (n=81)
The use of the IF-AT cards (the scratch cards) made the group quizzes fun.	E1	97%	93%	73%	96%
Knowing that I would be expected to contribute to the group component of the quizzes increased my motivation to learn the relevant material.	E2	94%	93%	72%	84%
Having to collaborate to decide on answers during the quizzes has improved my understanding of the subject material.	C1	90%	88%	72%	89%
Having to collaborate to decide on answers during the quizzes has improved my ability to think through and resolve problems.	C2	90%	98%	72%	93%
Having to discuss the answers to the quiz with my group members helped me to understand material that I hadn't previously fully understood by myself.	C3	94%	90%	79%	86%

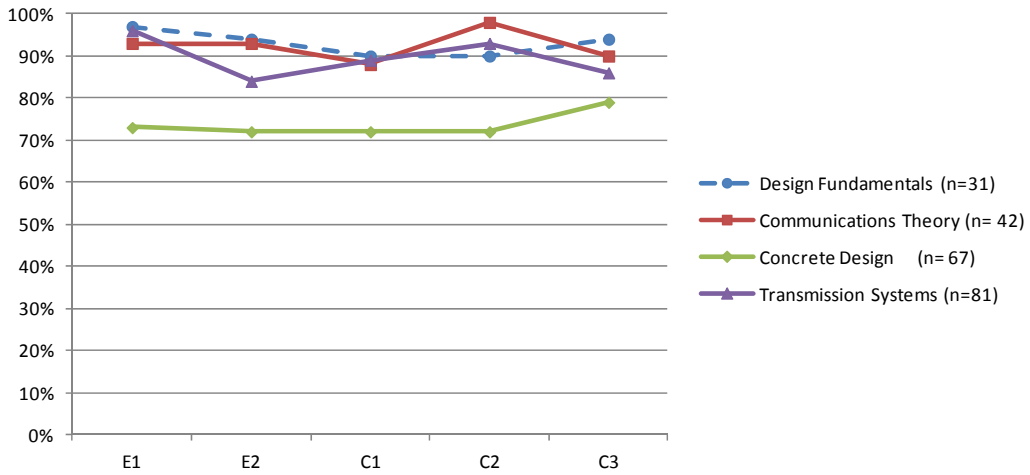

Figure 2: Students who agreed with the statements recorded in Table 1.

Discussion

The results presented in Table 1 and Figure 2 show that the response to the collaborative activities using the IF-AT cards was overwhelmingly positive. We found that in all trials students reported the quizzes promoted high engagement, that the conversations they had with their group peers helped them identify and subsequently address gaps in their knowledge, that the IF-AT cards helped them clarify their understanding, caused them to reflect and increased their motivation to learn. Furthermore, these benefits were evident even when students got the correct answer on their first attempt.

"The collaboration elements of the quizzes assisted me in my learning throughout the semester." (Comms Theory student)

"The heavy use of group/teamwork was very effective in consolidating everyone's knowledge, and kept us on the ball."(Design Fundamentals student)

Encouragingly, students across all four subjects reported that the collaborative quizzes helped them to understand material that they had not previously fully understood on their own.

"*Having an individual quiz followed by a group quiz forced discussion of the questions which was often productive in terms of learning*" *(Concrete Design student)*

Our observations in all the subjects noted the high levels of student engagement in the collaborative quizzes as evidenced by the high noise levels in class as students animatedly discussed their answer to the questions. This is reflected in the student's agreeing that using the IF-AT cards made the group quizzes fun (73% Concrete Design, >90% in the other courses).

We found that the collaborative quizzes not only improved student engagement and learning, but helped change their learning culture by having them take more responsibility for their own learning, improved their ability to provide critical evaluation and exposed them to the benefits of collaborative peer learning.

"Mentor groups allowed me to have others to ask when I was stuck both in and out of class. .... I learnt more." (Comms Theory student)

"Improved my way of thinking." (Comms Theory student)

Students' also overwhelmingly approved of the fact that their learning did not stop when they got an incorrect answer.

"IF-AT very helpful - normally a wrong answer is a wrong answer, but this way we learnt more and thought more" (Design Fundamentals student – note underlining provided by student)

While the collaborative IF-AT activities were successful in all subjects the authors noted and the students reported, not surprisingly, that the physical environment had an impact on their ability to

collaborate. Design Fundamentals and Communications Theory were held in rooms with flat floors and movable tables and chairs. In contrast, both Concrete Design and Transmission Systems being larger classes were held in traditional tiered lecture theatres. In Concrete Design (73%) and Transmission Systems (65%) of students agreed that "*the physical environment of the lecture theatre made it difficult to participate adequately in the group quizzes*". Students found it easier to collaborate when the physical environment allowed them to sit comfortably facing each other around the shared workspace. The authors also observed that students seemed to be more animated and engaged in the flat desk environment. As more instructors move toward using collaborative activities, demand for rooms that allow flexible seating arrangements is likely to increase.

Future Research

It is unclear why the results for Concrete Design were not as positive as the other three subjects whose cohorts consistently reported 90% agreement with the statements in the survey instrument as opposed to approximately 75% agreement in Concrete Design. The authors intend to investigate this further however, the fact that this was the Concrete Design lecturer's first experience in using the IF-AT cards probably contributed somewhat to these differences. Furthermore, the culture of the Civil Engineering students in Concrete Design was observed to be quite different compared to students in the other subjects (Design Fundamentals being a core subject has a multidisciplinary cohort, while Transmission Systems and Communications Theory are Telecommunication Engineering subjects).

Firstly, in Concrete Design a number of students expressed their resentment at being expected to actively participate in class, a complaint not evident in the other subjects. Secondly, because many Concrete Design students were not prepared to stay after the collaborative quiz to discuss their answers, the implementation of the quiz process differed from the other subjects. In Concrete Design the lecturer provided worked solutions to the quiz questions a week after the quiz. In the other subjects, a collaborative discussion led by the lecturer occurred immediately after the quiz was complete and no worked solutions were provided. This delay and the fact that worked solutions were available may have contributed to reduced engagement with the quiz process contributing to the lower positive response rate in Concrete Design.

Interestingly, unlike the other subjects, the quizzes in Design Fundamentals were formative (having no assessment marks associated with them) yet the students still enthusiastically participated. This may have been in part due to the small cohort (31 students) involved. In a future study, we intend to investigate if participation in larger classes is significantly affected if the quizzes are formative. In other studies, the authors have found that with the correct scaffolding formative activities have the potential to improve learning outcomes by freeing students from the burden of strategically collecting marks, allowing them to focus on learning. Furthermore, the authors found that students often approach summative tasks, with some justification, strategically to achieve the best mark at the expense of learning (eg they may choose to divide up work, or move on without having their knowledge gaps addressed to save time) (Willey & Gardner, 2011).

Conclusion

We found that in all four subjects students reported the collaborative quizzes promoted high engagement, that the conversations they had with their group peers helped them identify and subsequently address gaps in their knowledge, that the IF-AT cards helped them clarify their understanding, caused them to reflect and increased their motivation to learn. We also recommend that to get the most out of collaborative activities students should be able to work in an environment where they can face each other around a shared workspace. While further investigations are needed to determine the impact of formative versus summative implementations, the activities were successful in improving student learning and engagement. In addition, by simulating the way professionals learn in industry such collaborative activities help students develop the skills required for continuous learning in the workplace.

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