Reflections on learning through peer convening

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Structured abstract

BACKGROUND
There is a saying that "you don't really know a subject until you've taught it." There is an element of truth in that which provides the foundation for the use of small group discussions and active learning methods, group projects, peer assessment, and "flipped classrooms". The latter model requires preparation by students before class (e.g. through directed reading and quizzes) then group discussions of concepts in class moderated by the instructor.

Here we address the question, "how far can peer instruction be taken?" For example, are there circumstances in which students could (and should) take on the role of instructor in the classroom? In an effort to explicitly develop self-learning skills, a peer instruction model has been developed and used for several years in a final year engineering unit, "Systems Design and Engineering," in which students take primary responsibility for leading their peers through part of the course material.

PURPOSE
The goal of this work is to report on a different model of peer instruction, i.e. in which students take on the role of instructor in a formal lecture/tutorial setting moderated by the instructor. We assess the success of this approach based on student feedback and reflections of the unit coordinator on student engagement and performance following several years of using this approach to facilitate learning and the development of professional skills and attributes.

METHOD
The unit of study is run as a weekly 3 hour tutorial/discussion session, and based heavily on a prescribed textbook. Students are expected to read the relevant chapters of the text before class each week in order to participate in the discussion, which is assessed. For the first several classes the discussion is moderated by the unit coordinator, who also introduces supplementary material in the form of example problems and key discussion points. For the last several classes individuals and/or small groups of students take over the role of the unit coordinator in presenting the key concepts and moderating the discussion. The role of the unit coordinator during these weeks is to take a back seat, participating in the discussion only when necessary to highlight important points that may have been missed, correct the occasional misinterpretation, and generally keep the discussion on track to complete within the allotted 3 hour block. The performance of the student presenters is graded by a combination of assessments by themselves, their peers in the classroom, and the unit coordinator.

RESULTS
Students often reported that being put in front of a classroom of their peers with the responsibility of leading their peers in discussion (i.e. as distinct from lecturing) was a challenging but usually rewarding experience. The authors felt that in most cases the students took their responsibility to the class seriously, and learnt more deeply about the concepts they were expected to convey to their peers, and also about the process of learning and communication.

CONCLUSIONS
Peer instruction (in the form described in this paper) can be an effective way to assist and motivate development from passive to active learning, and especially to assist the development of self learning skills. It is particularly appropriate to later years of an engineering degree, by which stage students usually have some work experience to draw upon, and by which stage they should be well on the way to becoming lifelong self-learners. Based on student feedback there are some clear advantages to this method of instruction, but also some pitfalls the unit coordinator needs to avoid.

KEYWORDS
peer instruction, self learning, active learning.

Introduction

Active learning, in which social interactions are used to promote or enhance learning has long been recognised as useful teaching method (Greenwood, 1984), with many approaches to promoting class engagement having been investigated and reported upon in various contexts. Situations in which the primary interactions leading to improved learning occur between students (i.e. rather than between the academic and the class) are usually classed as “peer instruction” or “flipped classroom” methods. Such methods have most commonly been developed and used in the context of large classes covering introductory or foundation concepts; their use in senior years and in professional development units of study has been relatively overlooked, though in our experience peer instruction has just as much (if not more) to offer in these contexts.

Here we report our experiences with the use of a modified approach to peer instruction in a relatively small compulsory final year professional development unit “System Design and Engineering”. We have gone beyond peer interaction and introduced what we shall refer to as “peer convening” as a mode of teaching and learning, giving students a degree of responsibility normally assumed by the academic for guiding the class through the learning experience. We describe the benefits and potential pitfalls of our approach.

Outline of paper

After briefly reviewing the literature on peer instruction we highlight the differences in our approach and context, which we believe extends the applicability and outcomes from peer instruction methods, which we therefore define as “peer convening”. An outline of the unit content and details of the unit structure are then provided to illustrate how peer instruction methods have been extended and applied in the context of a senior-level professional development unit of an undergraduate engineering degree. The rationale for our approach is then outlined, followed by reflections on the successes (or otherwise) of our approach by i) a previous student, and subsequently class convenor, and ii) the unit developer and coordinator (i.e. the authors of this paper). The paper concludes with discussion of how our implementation of peer convening may be modified in future in response to recent changes in class size and behaviours.

Review of peer instruction methods

“Peer instruction” is usually referred to in the context in which Mazur (1997) first introduced the term in his work on developing a particular active learning method for large introductory physics classes. The aim of Mazur’s approach was to enhance students’ understanding of fundamental concepts, and thereby to improve their problem solving skills, even in large classes. The method required students to take increased responsibility for their learning through pre-reading of material before class, and then collaboratively solving quiz questions in class. In some variants “clickers” were used by students to notify their answers, to which they received almost immediate feedback.

Considerable attention has been paid to Mazur’s approach and the variants thereof. For example, Turpen and co-workers have published a number of studies describing the variants of peer instruction implemented by academics in practice (Turpen & Finkelstein, 2009), and linking this to the range of academics’ understanding of what constitutes effective peer instruction (Turpen, et. al., 2010a), assisted by a classification of peer instruction methods along three dimensions; faculty-student interactions, student-student interactions, and qualitative-quantitative concepts (Turpen & Finkelstein, 2010b).

Some of the main characteristics of peer and research-based instruction strategies listed by Turpen & Finkelsein (2010b) are;

i. Adaption to class progress, alternating lecture material with discussions
ii. Pre-class study expected in preparation for participation in class discussions
iii. Prearranged questions, usually conceptual, used to prompt class discussions
iv. Students must commit to answers, but answers are usually not graded

v. In-class discussions may draw on student ideas and experience
vi. Significant out-of-class assignments

Such strategies are sometimes called “flipped classrooms” because the academic periodically takes a secondary role in the classroom whilst encouraging interaction and information flow between students. It has been noted that the power of peer instruction methods derive from the fact they “leverage the power of social interaction to drive learning” (Schell, 2013).

Studies on extending so called “peer-instruction” methods to other learning situations and other disciplines have also been reported. For example, Dangwal & Kapur (2009), Buraphadeja & Kumnuanta (2011), and Simon & Cutts (2012) have reported the use of peer instruction in learning of computer skills, and it has also been noted as helpful in introductory algebra courses (Crouch & Mazur, 2001). Conversely, there has been relatively limited discussion of how peer instruction methods, as described by Mazur, may be adapted for use in more advanced courses involving more complex problems and/or requiring more sophisticated approaches to problem solving, e.g. in engineering education (Brown & Poor, 2010, Schmidt 2011), in which the development of design skills is important (Wilson 2002).

In some cases researchers have reported difficulties with peer instruction methods, usually due either to student or faculty resistance to these methods (Pollock 2004, Turpen & Finkelstein, 2010b), or difficulties in finding good questions to initiate effective discussions. It has also been suggested that whilst peer instruction and other approaches to active learning assist the development of conceptual understanding and qualitative reasoning, problem solving skills are not improved by these methods (Wilson 2002). Lastly, the place of assessment in peer instruction methods has also been raised by some authors (James, 2006, Perez et. al., 2010) who pointed out that whilst assessment can be a source of motivation for students it can also serve to dampen discussion, or even encourage competition rather than collaboration in learning by emphasising right/wrong dichotomies.

Unit Description

Peer convening versus peer instruction

In the forms of peer instruction described above; i) classes are typically large, ii) the academic remains in control of the class, located at the front of the class or walking amongst students, and iii) discussions are usually centred around technical foundation concepts and questions to which there are definite answers (though not always obvious). Our practice of peer instruction differs in these three respects; i) classes are (ideally) small and are run like a tutorial/discussion groups, ii) the academic relinquishes control of the class to a small group of students (a different group each week) and sits with the other class members, guiding discussion when necessary by asking pertinent questions and/or highlighting any important points missed by the student convenors, iii) the course deals with topics (e.g. the design process) and concepts (e.g. systems) in which there may be no clear right or wrong answers, and hence class discussions are often wide ranging. We therefore use the term “peer convening” to distinguish our approach from that defined by Mazur.

Features of peer convening that are shared with peer instruction methods described by Mazur (1997) are; i) students are expected to prepare for classes by reading one or two set chapters of a prescribed text before each class, and possibly also attempting end-of-chapter problems, ii) students are expected to participate in the class discussions, and there is a small component of the assessment allocated to their participation, iii) management of the class and coverage of concepts is adapted to the students’ needs and interests, and to the performance of the class convenors, iii) discussions and learning aim to build on the students’ own experiences (it is expected that students have completed a substantial period of work experience, preferably in an engineering environment, before taking this unit).

Unit content and structure

Peer convening has been used since inception of the unit “ENGG450 System Design and Engineering”, a final year core professional development unit in the Bachelor of Engineering degree program at Macquarie University. The unit deals with approaches to the design of complex systems and the various tools that assist in such tasks (e.g. requirements analysis, decision making, financial assessment, technical and economic optimisation, etc.) A text by Blanchard and Fabrycky (2008) has been followed closely, with occasional use of supplementary material when needed.

As a senior level professional development unit the unit has a strong emphasis on developing generic capabilities such as self-learning ability and communication skills, and professional attributes such as personal responsibility and effective teamwork. Development of the latter generic and professional skills and attributes is regarded as equally important to the unit outcomes as understanding the academic content of the unit and knowing when and how to apply that knowledge. Consequently it was decided that the unit should be structured to encourage students to take responsibility not only for their own learning, but also the learning of their colleagues; this motivated the adoption and adaption of selected aspects of peer instruction methods.

The unit is designed such that classes meet once per week during semester (13 weeks), and run as 3-hour tutorial-discussions. For the first 6 weeks of semester the unit-convenor or class-convenor leads the class discussions, taking the students through concepts contained in one or two chapters of the text each week, and providing examples, often from their own experience, to highlight key concepts and also to encourage students to reflect upon and share their own experiences.

Students are expected to prepare for classes by pre-reading the assigned chapters before class, and are also expected to actively participate in the class discussions. Participation is encouraged by i) keeping class sizes relatively small, and ii) allocating part of the unit assessment (currently 2% per week) to in-class participation. Based on our experience over several years with class sizes ranging from 3 to 20 (mostly male) students, we believe the optimum class-size for this mode of delivery is around 12 students. There are obvious challenges in making such class sizes sustainable, discussed further in subsequent sections. One of the roles of the class-convenor is to ensure that all students have an opportunity to participate.

The unit assessment is usually divided as follows: regular in-class participation (20%), four major assignments (two to be completed in groups) spaced evenly throughout the semester (40%), final exam (40%). The large assignments are intended to take the place of additional class time, and to focus on the practice and development of generic and professional skills together with the application of the concepts being covered.

The tutorial/discussion format lead by the unit convenor during the first half of the unit is intended to serve two purposes; i) to initiate and encourage the peer instruction process by getting students comfortable with reflecting on and talking about their perspectives of the unit content in light of their own experiences and in the company of their classmates, and ii) to provide a model that students may follow, if they wish, during the second half of the semester when they are required to take on the role of class convenor themselves.

During the second half of semester the classroom is “flipped”; the third assignment is for small groups of up to four students to convene a 3 hour class on assigned chapters from the text. Resources (e.g. solutions to selected problems) are provided to support the students, if requested. Students often comment that this is the most challenging but also the most rewarding section of the unit.

Expected prior knowledge and learning outcomes

As a professional development unit it is generally expected and is certainly advantageous if students have completed a period of work experience, even if not in engineering, to reflect

upon and offer during class discussion. Every workplace is different, so there is usually no shortage of examples and experiences the students have to draw upon to illustrate the concepts discussed, whether in the context of product and system design and development, testing and quality assurance models, product and system maintenance and support models, system optimisation in different scenarios (e.g. consumer versus industrial products), etc.

It is also expected that students have by this stage developed a level of maturity, and an understanding of their future role in society as an engineer. Whilst the primary focus of the unit is on the design and optimisation of technical systems, the process of reflection encourages students to extend systems thinking to other systems, for example to organisations in which they have been, and to develop a perspective of their place and role within those systems.

The learning outcomes for the unit may broadly be classed into two categories; i) acquisition of knowledge and understanding and capabilities relating to system design, and ii) development of generic and professional skills and capabilities, with a strong emphasis on the development of self-learning ability. Development of the latter skills and capabilities are regarded as at least as important as the understanding of unit-specific knowledge. In terms of Engineers Australia Stage 1 Competencies, the expected learning outcomes are;

1.0 Knowledge and skills base:

1.2 Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.
1.5 Knowledge of contextual factors impacting the engineering discipline.
1.6 Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the engineering discipline.

2.0 Engineering application ability:

2.1 Application of established engineering methods to complex engineering problem solving.
2.2 Fluent application of engineering techniques, tools and resources.
2.3 Application of systematic engineering synthesis and design processes
2.4 Application of systematic approaches to the conduct and management of engineering projects.

3.0 Professional and personal attributes:

3.2 Effective oral and written communication in professional and lay domains.
3.3 Creative, innovative and pro-active demeanour.
3.4 Professional use and management of information.
3.5 Orderly management of self, and professional conduct.
3.6 Effective team membership and team leadership.

Rationale for peer convening

The primary reason underlying the development and application of peer convening in this unit of study was the desire to develop strong self-learning skills before undertaking the major final year project, and subsequently professional practice. We primarily wanted students to develop increased independence in learning, and also to test their learning and communication skills by demonstrating they could convey their own learning to others. We aimed to achieve this by increasing the responsibility of students for not only their own learning, but also for the learning of others through formal and informal interactions in a class sufficiently small that it would be difficult to avoid one's responsibilities. At the most basic level, we wanted students to be able to pick up a book (or other source of information), develop an understanding of the content and its context, through a process of reflection relate that information to their own knowledge and experiences, and lastly to face the challenge of communicating their learning in a way their colleagues could relate to and understand.

The advantages of this approach, if successful, are that the students end up with increased confidence in their own learning abilities, and also in their ability to communicate, i.e. skills

which are invaluable in any profession. The bonus is that they the students learn at least some part of the course material in great depth, i.e. in order to be able to present it to others in the class. Students have never openly voiced complaints regarding this task, such as they are "doing the Lecturer's job"; such potential complaints are pre-empted by making it clear that the task is intended to develop the students' self-learning and communication skills, which are highly valued by employers. The main risk is that students, for one or more of a variety of reasons, do not take their responsibilities seriously, which can have a negative impact on the whole class. The expectation was that the power of social interaction would motivate students and minimise the risks.

A student's response to peer convening

The following reflections are by the second author, who completed the unit of study in one of its early offerings in a small class of four students. (Note: It was not possible to provide specific feedback from other students due to a prohibition on the publication of the content of student course evaluations).

Being a member of a discussion group with three other students provided quite a few opportunities for putting forward points of view and focusing on aspects in more detail based on student experiences. Such a small group was risky as those students who were not as comfortable with the material, or their spoken English, were not as inclined to participate beyond what they felt was required. I believe this changed as the shyer / less forthcoming students felt comfortable with the environment and the format of the course. The small class eventually provided a rich environment for discussion and also set the standard for what was expected when the class would be flipped in the second half of the course to get the students to convene the discussions. These were not open ended discussions and they were not a “single path” journey either. I felt the format provided enough flexibility in the mode of discussion to cater to the topics at the time while providing an overall picture of the structure from the chapters.

One of the barriers to the instructor-led discussions that I observed was that the prescribed readings were not initially completed by all the students. I attributed this to students expecting to turn up to the first lecture of a course and be given an outline of how things will work in the course. It did prove to be a bit of a problem for those students to adequately contribute to the ideas and discussions of that session. However, expectations were clearly set and the student engagement improved in subsequent weeks. The initial weeks of the unit were presented in a "read and discuss" mode.

In the second half of the course, it came time to flip the classroom and for the other students and I to convene discussions. We had been given plenty of weeks for preparation to consider techniques to use, the mode of delivery to use, and the resources and tools that would be needed to aid in leading the discussion. It was the first time that a flipped classroom was experienced by myself or the other students. As a student in other units, I had given individual presentations, group presentations, participated in group meetings, been a project manager and had some lectures (50+ students) where the lecturer was trying to get feedback / interaction with students. The flipped classroom, however, was a completely different format to anything I had experienced before.

Being thrust into this scenario of leading an extended discussion forced us to use critical analysis, decision making and problem solving skills to construct and guide a lesson plan. Furthermore, the self learning was rigorously executed for the week that the students were leading the discussion. The reason for this was that we had to teach / lead an intelligible discussion on the predefined topics with questions possibly coming at any point in time from anyone in the class.

How much was gained from the other students leading the discussions depended on how much the designated student convener prepared for the topic. There were mixed feelings with this as it depended on the calibre and diligence of preparation of the student leading the

discussion for that week. Students with weak oral skills, or poor preparation were not as effective at leading the discussions; in these situations the instructor would sometimes step in and ensure key points were covered. When each week was led by only 1 student, their strengths and weaknesses were fully exposed which had a greater impact on the overall impression on the class for that week.

Unit convenor's response to peer convening

The following reflections are by the first author, the unit developer and convenor.

In general I have observed that the response to peer convening (e.g. as reflected in student unit evaluation feedback) has been very positive. A common response is that the unit was a challenging but nevertheless a positive and largely enjoyable experience, and that the peer convening exercise gave students a new and heightened appreciation of the work done by their instructors in classes with more conventional modes of delivery and engagement.

Anecdotal evidence received from some graduates has been that the unit was “one of the most useful” they completed, due to the relevance of the content to professional practice, and the development of professional skills. Something that was not commented upon by students, but was noticed by the unit convenor, was a general strengthening in the students' respect for each other and the respective perspectives and experiences they brought to the class.

Whilst the power of social interaction can be a powerful force to enhance learning, I observed that a number of factors can reduce the students' sense of responsibility to their classmates, with a corresponding negative impact on learning through peer convening, including;

i) lack of time (e.g. due to pressures of life and/or other units of study),
ii) lack of experience upon which to draw (e.g. lack of work experience),
iii) lack of motivation, lack of maturity, lack of professional identification,
iv) lack of, or underdeveloped, communication skills,
v) large class size.

Of the above factors, observation and comparison of class dynamics and performance from year to year indicated that class size was the dominant factor determining the success of peer convening. Whilst most students were able to overcome their fear of a socialised classroom and make presentations with varying levels of competence, I believe that the average quality of presentations was lower in large groups and classes, probably due to a "safety in numbers" effect, and (I suggest) a reduced sense of responsibility of students to their peers in larger classes.

One surprising behaviour I observed consistently and independently of class size was the tendency for many students to award maximum marks for any presentation by another student, independent of the quality of the presentation (Note: student presentations to the class were evaluated by themselves, other students, and the unit coordinator, with all three marks combined to give an average grade). The latter behaviour was true even when the student marks were not submitted anonymously.

Trends and future challenges

The class size in early offerings of the unit was generally small (e.g. as few as 3 students) but in recent years numbers have grown (up to 20 students), which is forcing a re-evaluation of class management strategies, driven by changes in student behaviour that are, we believe, at least partly linked to increases in class size.

Specifically, we have observed that as the class size has increased the level of preparation by students for classes has reduced, which in turn has reduced the ability of students to participate in class, and which in turn results in reduced learning outcomes of both individuals and the class. This is perhaps not surprising; as class size increases not only is the likelihood that a particular student will be called upon to contribute in class, there is

(apparently) an increasing likelihood that someone else will be able to contribute if any particular student cannot. Strategies such as small group discussions (i.e. returning to the original format of peer instruction) may be a necessary compromise, but would change the level of student responsibility, and would therefore substantially change the nature of the unit and its outcomes.

Additionally the class-convenors have recently detected a disturbing trend, i.e. that the amount of preparation students put into their class-convening assignment has reduced as the size of their group and class increased. This can have a deleterious effect on individual and class learning outcomes which are not easily compensated by the class convenor from their largely passive position in the classroom during student-convened classes. Furthermore it has been observed that when one student sets a poor example to the class, many subsequent students will readily follow. It appears that each student's sense of personal responsibility for learning, by themselves and/or the class, varies inversely with class size.

There is some evidence that the latter trends are not only driven by class size, but by university policy concerning the proportion of through semester assessment, which must be no less than 50%. Consequently students are required to work more consistently during semester, and – for whatever reasons - have been struggling to find the time to do meet all their commitments. It is not uncommon to find students starting work on major assignments a day or two before they are due, i.e. the increasing amount of through-semester work is having some negative impacts on learning, despite the good pedagogical reasons behind these developments. In any case, outcomes from peer instruction and peer convening methods, whilst positive in general, are not independent of overall student workloads, and there is clearly a need to structure program and unit content and workload expectations along with unit content.

Conclusions

Peer instruction, and in particular its extension to peer convening, has been observed to be effective for developing generic and professional skills and attributes in students. There are also indications that it enhances student learning of the academic content, though the degree of enhancement may vary considerably with student background and the effort they put into preparation. Based on our observations and experience we believe that when used in small classes peer convening enhances the students' sense of responsibility for learning, both individually and collectively.

Based on trends observed in student behaviours with increasing class sizes we believe that, unlike peer instruction, peer convening would not translate effectively to large classes where the power of peer expectations and the sense of personal responsibility to one's classmates is diluted. We are therefore endeavouring to maintain the small-class format by appointing class-convenors (i.e. postgraduates who have either completed the unit themselves, or who have suitable professional experience outside of academia) to moderate peer convening.

Areas for further investigation include the development of strategies to i) deal with larger than ideal class sizes, ii) overcome cultural and other barriers which sometimes inhibit student participation, and iii) increase the effectiveness of assessment as an incentive for preparation and participation and hence learning in the context of peer instruction and peer convening.

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Acknowledgements

We acknowledge the insightful and constructive comments provided by the reviewers.

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