

Full Paper

Introduction

The School of Petroleum Engineering at the University of New South Wales has historically seen its small class sizes as one of its key strengths in teaching and learning. This has meant the instructors had been able to devote significant one-on-one or one-on-few time with all their students. Therefore, the conventional teaching approach of delivering a lecture followed by a tutorial has been successfully used. However, recent increases in student numbers mean that these conventional teaching techniques can no longer be efficiently used.

For medium to large classes, conventional learning and teaching techniques are limited in their ability to provide effective teacher-student communication, to facilitate collaborative or peer learning and to encourage active student learning. To overcome these limitations we modified the delivery of course by using 1) tutorial-lecture swapping, 2) peer learning and 3) online assessment and feedback. We applied these techniques in two courses offered by the School during 2015. The goal was to achieve sustainable improvement in the delivery of these courses and enhance our students' learning experience.

The courses selected for this study are Reservoir Engineering B ("Course-1") which is coordinated by the first author of the study and Natural Gas Engineering ("Course-2") which is coordinated by the second author. The first course is a 3rd year course with 150 enrolled students in 2015. The second course is a 4th year course with 80 students enrolled in 2015. Both of these courses had an enrolment of 44 students in 2010.

The purpose of this study is to develop and test Peer Instruction, Tutorial-Lecture Swapping and Improved Assessment/Feedback techniques. These techniques have been discussed in detail in the following section. This study helps to provide significant leadership as the School of Petroleum Engineering shifts from a small to a medium-sized school within the Faculty of Engineering at University of New South Wales. The study also demonstrate how a significant proportion of our undergraduate program (24 UOC) can be shifted from an entirely "sage on the stage" approach to one which is augmented by "guide on the side" activities [1, 2] namely, peer instruction, tutorial-lecture swapping and improved assessment/feedback techniques. We use different methods to get students' feedback. The results show high level of students' satisfaction. However, tutorials and lectures material need to be revised substantially for successful application of these techniques.

Suggested Improvements in this Study

Tutorial-Lecture swapping

Students in these courses are expected to have a sound grasp of the fundamental concepts behind the material covered. Therefore, in order to engage the students in an active process of applying existing knowledge to the new contexts encountered in this course, the tutorials were placed before the lectures. This enables students to collaboratively construct knowledge of the course content in a problem solving context. This means that the students can see the real-world value of the course content from the moment that it is introduced.

We usually run one such session every week except week-1 where introductory material is covered. The duration of these tutorials vary from 30 minutes to more than 2 hours.

The students are guided through the tutorial by three teaching staff (the course lecturer and two tutors). These sessions are structured around the following steps:

1. Students discuss the problem statement with their peers and identify the problem.
2. Teaching staff get feedback from various groups and guide them if their problem identification is off track. Based on the students' response, the lecturer may make provide some instruction to clarify the problem statement.
3. Students will identify possible solutions and then solve the problem. Tutors are circulating around the class to provide guidance as the students work towards a solution to the problem.
4. The lecturer summarises the main conclusions drawn from the tutorial in discussion with students. These conclusions lead into the basic topics for the following lecture.

A key advantage of this approach is that we can ensure that students are able to recognize incorrect approaches to solving the problems. By doing this we avoid students getting stuck as can happen in conventional flipped classroom approaches [5].

Secondly, this approach means that the lecture can be concentrated on the advanced or more complicated parts of the topic under consideration. It also allows more time for Peer Instruction (discussed below). We expect this approach will improve student skills in creative and collaborative problem solving, as well as their skills in self-directed learning.

Peer Instruction (PI)

Peer Instruction is a pedagogical approach where students learn by discussing their ideas, knowledge and experience [3]. In practice, after delivering an important topic/concept, we will give students opportunity to discuss the topic covered. During the discussion period, the lecturer and tutors guide the discussion. Brief summary of the steps followed to run PI sessions are following.

1. First, students will discuss the topic/concept with their peers i.e. their fellow students sitting next to them in class. This step may take from 1 to 5 minutes depending on the complication of the topic.
2. Then, the tutors and lecturers encourage students to discuss their questions with them. This step again takes 1 to 5 minutes.
3. At the end, the lecturer repeats the conclusion(s) or writes the main outcome of the discussion on whiteboard. This step may take 1 minute.

Numbers of such PI sessions in a particular lecture/tutorial vary. Anecdotal evidence in the School indicates that students are reluctant to ask clarifying questions in class because of a fear of looking bad in front of their peers. PI provides an opportunity for students to clarify their own understanding in a context that is less confronting than directly answering questions from the instructor. This approach builds the learning community as students realize they are not alone in misunderstanding or partially comprehending key concepts, as well as providing feedback to the Instructor on the class comprehension. In our experience, for 1 out of 5 PI sessions (approximately), the lecturer have to repeat some part of the topic based on the students' feedback after the PI session. Crouch [4] has shown that incorporating peer discussion into lectures leads to a measurable increase in student understanding.

Improved Assessment/Feedback techniques

In addition to the conventional approaches, we suggest following techniques

1. At the end of every teaching week, students solve an online quiz which will test their knowledge. These quizzes are not part of the final assessment but provide formative feedback to students and guide instructors in their teaching. We use a learning platform Moodle to run the quizzes. Moodle allows us to setup a variety of questions including multiple choice, true/false, short answer and numerical.

2. At the end of every tutorial session, students give informal feedback to their peers. This is not part of the final assessment
3. Online quizzes for both courses under exam conditions. These quizzes contribute to the final assessment.

Format of these quizzes is quite similar to weekly 'test your knowledge' quizzes. For both of the courses, one quiz in week-5 and another in week-9 replaced paper based midterm exam. We use a learning platform Moodle to run the quizzes. Our objective to use online quizzes is to give prompt feedback to students.

Evaluation and results

In order to monitor and measure the effectiveness of our proposed approaches we get feedback from following sources.

Regular meetings between the teaching staff of both courses

We conducted monthly meetings of the teaching team to share experiences/challenges in their relevant courses. These meetings proved very beneficial particularly in the start of the semester. Some of the initial findings are following.

1. Tutorial and lecture material need to be substantially revised for successful application of these techniques. Tutorial questions must be built on the students' prior knowledge.
2. Time allocated for students' discussion in PI sessions (step-1 in PI) is quite critical. Too short discussions may not be enough to debate the topic properly. On the other hand, too long discussions may cause some students to lose interest in the lecture

We observed that implementation of the suggested approaches require considerable staff training. The team involved in the first course has been using these approaches since 2014. Whereas, the second course team found it hard to implement these approaches mainly because of the lack of practice of the suggested approaches. Our discussions also suggest that such approaches may not be very effective for 1st or 2nd year Engineering students, as it would be hard to prepare tutorial questions based on students' prior knowledge.

Feedback from guest academics

We invite academics from other schools to attend one or more of our sessions and give us feedback on PI and Tutorial-Lecture Swapping. The guest academics note the activities and give us written feedback. Most of the feedback comments suggest effectiveness of our approaches which include:

1. *".....students did not ask questions before the PI session but after the PI session good number of questions..."*
2. *"....questions near (the) back (of the room) –good...."*
3. *"....(Tutorial-Lecture Swapping) very interactive...."*

Following are the constructive comments from the guest academics

1. *".....(after a PI session) lecturer clarifies question for whole class – (students) needed to be quietened(became) quiet soon themselves...."*
2. *"....occasional audibility issues at back (of the room)...."*
3. *"....some students working individually...."*

The feedback from the guest academics was quite useful in improving the applications of our approaches. The issues raised about lack of quietness and audibility were controlled for the later stage of the study.

Anonymous student online surveys

We conduct two anonymous surveys using Moodle. First survey is opened after week-5 quiz assessment. This survey closes in week-7. The second survey is run after quiz-2 until week-12. The survey results are shown in Figures 1 to 3. The first author has been using these approaches for last couple of years; this is also reflected from the students' feedback. For the second survey, the Course-2 response rate is too low that is why we do not present its results.

We observe that overall students' response is very encouraging especially for the first course with overall satisfaction towards the suggested PI, Tutorial-Lecture swapping and 'test your knowledge quizzes' approaches of approximately 90% (Figure 1 and Figure 3). Satisfaction in the second course was more variable and generally lower.

Despite this high general acceptance, some students show dissatisfaction towards online quizzes- 20% for Course-1 and 39% for Course-2. However, a majority of the students – 80% for Course-1 and 61% for Course-2 – prefer the online quizzes approach. The students seem to appreciate the quicker feedback provided by this assessment method. This finding supports our expectation that online quiz assessments would benefit students by providing rapid feedback. The key complaint against online quizzes is that the online interface does not allow students to demonstrate the (partial) extent of their knowledge. We attempted to solve this concern by providing students with work books. Markers could refer to these work books and award part marks, when finalizing the grades calculated by the quiz system.

Another difference between the two courses is the level of experience of the two authors. As discussed the first author is more experienced in applying the suggested techniques, whereas the second author was developing and applying the Tutorial-Lecture swapping and 'Test Your Knowledge' quizzes for the first time. Switching to these techniques requires a significant investment of time in reconfiguring existing material or creating new material. Instructors in this position will benefit from additional support in quiz development and also exemplars of swapped tutorials.

Further, the content in Course-1 builds directly on material covered in the previous semester, whereas Course-2 contains substantial portions of entirely new material. Hence the requests (Figure 2) from some students for more detailed course notes prior to class. This is even though the students had been given readings from the textbook in the previous week. This indicates that an instructor may wish to apply the technique in some parts of the course when students have a strong grasp of the basic principles and in others run a tutorial which follows and consolidates the lecture.

Finally, Course-1 has approximately twice the number of students as Course-2. It may be that our suggested approaches are more suitable for large group teaching.

Feedback: 95 out of 150

Label	Question	Responses					Plot
Q1	Have you found peer instruction (with your neighbour) approach helpful?	Yes 86 91%	–	Neutral 4 4%	–	No 5 5%	
Q2	Peer instruction has made it easier for me to understand complicated concept delivered by my lecturer	Strong Agree 21 22%	Agree 53 56%	Neither 15 16%	Disagree 5 5%	Strong Disagree 1 1%	
Q3	Have you found the new tutorial (swapping) approach helpful?	Yes 83 87%	–	N 4 4%	–	No 8 9%	
Q4	The new tutorial (swapping) approach, has made my learning more interactive	Strong Agree 33 35%	Agree 47 49%	Neither 14 15%	Disagree 1 1%	Strong Disagree – –	
Q5	Do you prefer Moodle-based quiz over paper-based midterm exam?	Yes 60 63%	–	N 16 17%	–	No 19 20%	
Q6	I like that using an online quiz instead of a paper exam means quicker feedback	Strong Agree 49 52%	Agree 25 26%	Neither 11 12%	Disagree 4 4%	Strong Disagree 6 6%	
Q7	The 'Weekly self-assessment' questionnaires helped me get feedback on my learning progress	Strong Agree 79 83%	Agree 16 17%	– –	– –	– –	
Q8	(optional) What is one way we could improve your learning in this course? * Hire more tutors. Publish past papers for the course and let us keep the past papers. * your teaching approach is just perfect... * Even though discussions are good they take time. * Actually, the course has already a fantastic method of teaching * increase the difficulty of the 'test your knowledge' quizzes * Move the friday lecture to Wednesday * I prefer paper based exam over moodle-based quiz, i believe the paper based quiz can indicate more understanding on topic						

Figure 1: Anonymous survey results – course-1, conducted in week-5 to 7 (response rate = 63%)

Feedback: 18 out of 80

Label	Question	Responses					Plot
Q1	Have you found peer instruction (with your neighbour) approach helpful?	Yes 10 56%	–	Neutral 4 22%	–	No 4 22%	
Q2	Peer instruction has made it easier for me to understand complicated concept delivered by my lecturer	Strong Agree –	Agree 7 39%	Neither 8 44%	Disagree 3 17%	Strong Disagree –	
Q3	Have you found the new tutorial (swapping) approach helpful?	Yes 12 67%	–	N 3 17%	–	No 3 17%	
Q4	The new tutorial (swapping) approach, has made my learning more interactive	Strong Agree 1 6%	Agree 13 72%	Neither 1 6%	Disagree 3 17%	Strong Disagree –	
Q5	Do you prefer Moodle-based quiz over paper-based midterm exam?	Yes 6 33%	–	N 5 28%	–	No 7 39%	
Q6	I like that using an online quiz instead of a paper exam means quicker feedback	Strong Agree 7 39%	Agree 6 33%	Neither 2 11%	Disagree 3 17%	Strong Disagree –	
Q7	The 'Weekly self-assessment' questionnaires helped me get feedback on my learning progress	Strong Agree 3 17%	Agree 12 67%	Neither 3 17%	Disagree –	Strong Disagree –	
Q8	<p>(optional) What is one way we could improve your learning in this course?</p> <ul style="list-style-type: none"> * The weekly self-assessment questionnaires are very useful! * Keep up the good work! * Giving course notes in more detailed way prior to class. * I liked utilizing the videos in the lectures, more of those videos is good to understand hard concepts * changes in percentage distributions!!! * Written quizzes * I hope you could give us the complete solution of the tutorial instead of only charts with answer. Beside, we can only find the quiz answer online, but never sees how you calculate the problem. 						

Figure 2: Anonymous survey results – course-2, conducted in week-5 to 7 (response rate = 23%)

Feedback: 57 out of 150

Label	Question	Responses					Plot
Q1	Have you found peer instruction (with your neighbour) approach helpful?	Yes 54 95%	–	Neutral 1 2%	–	No 2 4%	
Q2	Peer instruction has made it easier for me to understand complicated concept delivered by my lecturer	Strong Agree 20 35%	Agree 24 42%	Neither 13 23%	Disagree – –	Strong Disagree – –	
Q3	Have you found the new tutorial (swapping) approach helpful?	Yes 51 89%	–	N 2 4%	–	No 4 7%	
Q4	The new tutorial (swapping) approach, has made my learning more interactive	Strong Agree 29 51%	Agree 21 37%	Neither 5 9%	Disagree 1 2%	Strong Disagree 1 2%	
Q5	Do you prefer Moodle-based quiz over paper-based midterm exam?	Yes 34 60%	–	N 12 21%	–	No 11 19%	
Q6	I like that using an online quiz instead of a paper exam means quicker feedback	Strong Agree 20 35%	Agree 19 33%	Neither 9 16%	Disagree 3 5%	Strong Disagree 6 11%	
Q7	The 'Weekly self-assessment' questionnaires helped me get feedback on my learning progress	Strong Agree 38 67%	Agree 19 33%	Neither – –	Disagree – –	Strong Disagree – –	
Q8	<p>(optional) What is one way we could improve your learning in this course?</p> <ul style="list-style-type: none"> * My experience in this course was extraordinary. * Just continue your learning techniques, * Supplementary reading material * Slower pace perhaps? I'm a bit of a slow learner hehe thank you * Reduce the weight of the final exam * In online quiz2, it would be better if u asked us from the begining to show our work or to transfere the tabe to the answer sheet *is the 2nd best lecturer in my life 						

Figure 3: Anonymous survey results – course-1, conducted in week-9 to 12 (response rate = 38%)

Other students' feedback resources

We encourage students to provide us feedback through face to face meetings with the course coordinators, face to face meeting with the head of the school and via emails. Students really appreciated our teaching approach. We are summarizing only the constructive comments from these meetings/emails.

1. A student suggested that PI approach is very useful but sometime it can become uninteresting. Therefore we should do shorter discussions
2. Another student suggested increasing the discussion time during PI sessions.
3. Some students suggested that conventional tutorial may also be run in the courses

We also monitor the number of students attempting weekly 'test your knowledge quizzes'. On average, 67% of the students attempted the quizzes in course-1. While 40% attempted these quizzes in course-2.

Conclusions

In this paper we have presented our experience of employing Tutorial-Lecture swapping, Peer Instruction and Improved Assessment/Feedback techniques to enhance students' learning experience.

- Students' feedback show their high satisfaction level towards these approaches
- Minority of the students show dissatisfaction towards online quiz assessments part of the Improved Assessment/ Feedback techniques. However, they agreed that online quizzes provide quicker feedback
- Peer Instruction approach promotes students to interact with their peers and ask more questions from the lecturer
- A shift from conventional teaching to Tutorial-Lecture swapping requires redesigning the tutorial questions in a way that tutorial question are based on the students' prior knowledge. Therefore, our suggested approaches probably suit: advanced level courses (3rd and 4th year Engineering courses) and large group teaching.
- Results also suggest that the student perception of these approaches improves as the instructor becomes more experienced in using them.
- New instructors shifting to these techniques would benefit from a variety of examples in developing the new style of tutorial and additional support in shifting existing question banks online.

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