Large-class peer-marked assignments for improving second-year student performance in Electrical and Computer Engineering

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Abstract: *Peer-marked assignments (PMAs) have been used successfully to improve student engagement in small tutorial groups in a first-year engineering course at the University of Auckland. This paper reports on an investigation to determine whether PMAs could also be used in the second year of the programme, when small tutorial groups are no longer available. Research methodology included holding fortnightly PMA sessions in classes of 150+ students in the core course ELECTENG 202, Circuits and Systems. Peer marking was carried out under the guidance of a lecturer, and with the help of teaching assistants. Sessions lasted about half a lecture period (25 minutes) each. Students received a 1% mark for doing an assignment, and marking another's. They were required to interact with the tutorial material both from the perspective of one solving the problem, and also from the perspective of a marker. 92.2% of students participated in the peer-marked sessions. The research was evaluated formally by surveys of students involved, and by an assessment of examination performance. The great majority of students indicated that they found PMAs very helpful, and the course was given a very high 'satisfaction' score. Another second-year course will trial large-class PMAs shortly.*

Introduction

ELECTENG 202 *Circuits and Systems* is a core course in the second year of the Bachelor of Engineering degree programme at the University of Auckland. It builds on introductory circuit theory given in first year, and covers DC and AC circuits, transient analysis, Laplace transforms, and single and three-phase AC power calculations. It effectively introduces students to the *language* of electrical engineering. In the past it has been seen as a difficult, 'gatekeeper', course. Over the years the lecturers have worked hard, and with some success, to make the course palatable to students. Material is presented in the context of the lecturer's own experience as a professional engineer, and in relation to research currently being carried out in the department. Problems are worked through in detail in

the lecture class, and the students are given access to online tutorial questions through our *OASIS* system (Smaill, C. (2005)). Unlike our first-year course however, there is no provision for small-class tutorials.

Class size in ELECTENG 202 is about 150, and with few exceptions students come from our first-year programme which is common to all engineering disciplines. In common with many programmes worldwide, we have noted in recent years an increase in the spread of abilities across the class. The top students are very good indeed, but test and exam marks spread across a wide range and the 'tail' students struggle to achieve a pass. It can be difficult for the course to meet Faculty expectations on pass rates and proportions of A and B grades.

A number of initiatives have been taken in recent years to address this problem, including the use of remedial tutorials and peer mentoring (Rowe, G.B., Smaill, C., Godfrey, E., Carter, L.J., Guillemin, B.J., Andrews, M., and Abdulla, W., (2009)). With the aim of further lifting overall student achievement in the course, and following a successful trial in Year 1, the decision was made to implement *peer marking* in lectures. The lecturers were aware of a considerable body of research supporting the efficacy of peer marking. Some of this research is outlined in the following section.

Peer marking – the evidence for its success

The motivating power of assessment has been well-established by research. One study found that by year four only 5% of student time was spent on learning unrelated to assessment (Innis, 1996). Other studies have shown that the assessment system is the main influence on how students structure their learning, determining both their effort and their focus (Brown & Knight, 1994; Price, Carroll, O'Donovan, & Rust, 2011; Ramsden, 2003). While both students and lecturers often regard summative assessment as all-important, compelling evidence suggests it is *formative* assessment that provides the most effective way to improve student learning, with one landmark study asserting: "formative assessment is an essential component of classroom work... We know of no other way of raising standards for which such a strong prima facie case can be made" (Black & Wiliam, 1998b). And again: "significant learning gains lie within our grasp. The research reported here shows conclusively that formative assessment does improve learning. The gains in achievement appear to be quite considerable... amongst the largest ever reported for educational interventions" (Black & Wiliam, 1998a).

Formative assessment can radically lift student achievement. However, it does entail increased instructor workload. This workload can be minimised if the marking is carried out by students rather than instructors. While it is commonly believed that, ideally, marking is best done by the instructor, there is significant evidence and sound justification for the benefits peer marking brings to learning. One study (Gibbs, 1999) describes a compulsory second-year engineering course in which students submitted answers to weekly problem sheets. These were marked by the lecturers and handed back. The average exam mark was 55%. Numbers increased and the lecturers no longer had time to mark the problems. The average exam mark went down to 45%. In an effort to restore standards, peer assessment was implemented. Six times during the course, students met and handed in their problem sheets. These were then redistributed randomly with a mark scheme. Students then marked the work they were given and the papers were returned immediately. Marks were not recorded and teachers were not involved at all in this process. Students were required to complete about three quarters of the problem sheets, otherwise they could not complete the course. Everything else about the course remained the same. Amazingly, the average exam mark went up to 75%.

Reviews of the peer-assessment literature (Dochy, Segers, & Sluijsmans, 1999; Topping, 1998) show that this kind of outcome is not unusual. The first conclusion to be drawn is unsurprising; that the problem sheets, when marked, motivated students to actually solve problems and distribute their effort more effectively rather than concentrate it in the period just prior to the final examination. The second conclusion is more surprising; that there was a clear benefit from having students rather than instructors carry out the marking process. In fact there is convincing evidence for the efficacy of peer marking in both engineering (Gibbs, 1999; Mafi, 1989; van Hattum-Janssen & Pimenta, 2006) and other areas (Berg, Admiraal, & Pilot, 2006; Race, 2001; Vickerman, 2009). As well as in a variety of subject areas, peer marking has also been implemented successfully in a variety of settings ranging

from small groups (Smaill, Rowe, & Carter, 2011) to cyberspace (Luxton-Reilly, 2009). The current study focuses on a large-group implementation.

Perhaps having one's work marked by peers is more daunting than having it marked by some relatively-unknown tutor. However, it is improbable that this in itself would have produced the large achievement gains attributed to peer marking in the above and other examples. Some further reasons are now advanced. The act of examining a mark schedule and following it gives a fuller perspective than simply doing the problems can give. In marking the problems of other students, the student markers would have noticed other ways to do the problems correctly, errors which they made themselves, and errors which they were alerted to avoid. They would also see the care some students took and others did not. They would get a good idea of the standard of work and the effort required to achieve at various levels. In time, the process of marking enables students to learn and internalise the appropriate standards. Once the standards are internalised, students are equipped to be able to monitor the quality of their own work. In other words, practising peer assessment improves self assessment (Weimer, 2002). The students become more responsible and reflective (Dochy, et al., 1999).

Dealing with the large-class format

We were confident, based on our Year-1 experience, that peer-marked assignments (PMAs) would be helpful to learning. The question was, would it be possible to transfer the process from tutorial-size classes of less than 40 to full-size classes of 150+ students? There was always the possibility that the logistics of getting the scripts from the owners to the markers, and back again, would take an unmanageably long time. To assist in moving scripts around, four teaching assistants (TAs) were employed for each PMA session. A senior TA also had the job of assessing the scripts after marking, and allocating 'real' marks.

At the start of semester, the new process was explained to the class. It was immensely helpful that this cohort had already experienced PMAs in their previous year, albeit in small-class format. In previous years of this course, 8% of the total course mark had been provided by a number (usually 4) of online assessments, using our *OASIS* system. For this year, it was decided that fortnightly *OASIS* assignments would be retained, but that their weighting would be reduced to 4%, and that 4% would be allocated to four fortnightly PMAs, alternating with *OASIS*. So the 'carrot' for each PMA was small: only 1% of the course mark. However, it was enough to ensure that the great majority of students participated. During PMA sessions, the lecture-room was noticeably fuller than normal.

About one week before each PMA session, the assignment questions were made available to the class, via our online learning management system *Cecil*. Questions were based on current lecture material, and typically were drawn from past tests and examinations. Students were asked to write out their answers on their own paper, and bring this to the PMA session. They were urged to be on time for the session, since marking would start soon after the beginning of the lecture period, and to qualify for the 1%, they had to show that they had both completed the assignment, and marked someone else's script.

Various techniques had been used in Year 1 small classes to transfer scripts between students. To make things quick and simple in the large-class format, we generally asked students to swap with someone in the row in front or behind. TAs helped where needed to move scripts across aisles. Despite the possibilities for confusion, each time the process was achieved within a couple of minutes. Next, the students marked the script in front of them, under the direction of the lecturer, who showed the marking master on the screen. Students were shown how to deduct marks for minor errors such as missing units. In some cases students asked for extra guidance, and were given this.

After marking was complete, the markers were asked to ensure that they had written "Marked by…" with their name and ID on the script. Next, the scripts were returned to their owners for a brief but necessary check, with the TAs again helping. Finally, the scripts were all collected and taken away by the senior TA, whose job it was to ensure that each student had met the criteria for scoring the mark. This TA later provided a spreadsheet of names and marks to the course coordinator. The peer-marking process was generally completed within 25 minutes, or half of one lecture period.

In general, the process went more smoothly than expected. We think this was due to the use of TAs to help with moving scripts around, but also because the class already knew roughly what to do, having been through something similar in the previous year. Some students expressed concern that the script distribution could have been more tightly controlled, since it was thought that some students just swapped with their friends; however, we felt that this was not a major concern since the mark given for the script was not related to the 1% mark awarded. This was only given when it was clear that a student had both made a reasonable attempt at the assignment, and marked someone else's. This check was made independently of the student marking.

Results

The success of this experiment was evaluated in a number of different ways: student participation, survey results, and examination performance. Three different surveys were used: an informal show-of-hands, a survey dealing specifically with PMAs, and the standard online course survey, in which some students commented on PMAs.

Although each PMA was only worth 1%, student participation was high, with an average of 92.2% receiving the participation mark across the four assignments. In two informal show-of-hands surveys taken in class, there appeared to be unanimous support for PMAs. After the last PMA, students were asked to fill in a survey. 79 out of a possible 158 responses were received. Question 1 asked: "To what extent do you consider that peer-marking supports your learning?" Answers were "Not at all" **0%**, "A little bit" **6%**, "Fairly well" **38%**, and "Very well" **56%**.

Results from Question 2 are shown in Table 1. Figures given are percentages.

Table 1: Survey responses

Question 2

Please indicate how much you agree with the following statements, using the following scale:

SA = strongly agree / **A** = agree / **N** = neither agree nor disagree / **D** = disagree /

SD = strongly disagree / **DK** = don't know / **R** = refused

	SA	A	N	D	SD	DK	R
Peer-marking is done too often	**0**	**8**	**34**	**48**	**7**	**0**	**3**
Marking the papers made me think more deeply about the course material	**14**	**58**	**22**	**4**	**0**	**1**	**1**
I am now more aware of difficulties encountered by staff in the marking process	**18**	**52**	**28**	**0**	**1**	**1**	**0**
Peer-marking made me think more deeply about how a solution is communicated	**25**	**58**	**15**	**0**	**0**	**1**	**0**
The amount of time given in tutorials for marking is about right	**22**	**55**	**16**	**4**	**3**	**0**	**0**

Question 3 of the survey asked for students' comments about PMAs. Here is a selection of the responses, in their own words:

- *PMA's were a great way to keep me on top of current material. The questions ensured that I practi[s]e test-style problems, while the marking enhance[d] my understanding.*
- *In my opinion, peer marking tutorials are useful learning tools for students. A student is informed about the marking procedure and how an answer is evaluated, which is really handy.*
- *It motivated me to look through the course material more thoroughly, and because it isn't worth too much, there is no pressure, just a rel[ax]ing learning process.*
- *If possible, more PMAs should be good. It is a constant reminder to keep up to date with course material. Also, they are good practice for tests.*
- *PMA is a good way to learn to write out full solutions to your questions.*
- *Good but marking is a bit slow sometimes.*
- *The PMA questions tended to be too easy or too short. The 1% for participation also took away much of the motivation to do that properly!*
- *Very beneficial for learning. It's always good to have problems with worked solutions, especially given the chance to attempt first.*

In the standard online course survey, carried out after completion of the course, the course scored very highly compared to previous years and to other courses in the Faculty. It was given an overall rating of 8.1 out of a possible 10, giving it the second highest score in the department. The Faculty average figure was 6.76. Some student comments are given here:

• *The foundation tutorials and peer assessments were very helpful*

• *Good notes with worked examples - Lecturers explained material well - Staff were approachable - A lot of problems to practice on - Peer Marked Assessment was helpful - Oasis problems were good practice*

• *This is the best course ever. Everything is so well organized and made easy for the students, especially the AC part. I really like how the lecturer took his time explaining everything and all the resources were provided on time. Thank you so much for making everything simple. Also the exam briefing was very helpful and peer marking too.*

• *Waleed's questions "Right right???? WRONG!" It made us pay attention. Also the breaks at half time were really great. PMAs were also great.*

• *Peer marking and oasis are very helpful. Also good coursebooks.*

• *This course is amazing, but it would be good if a bit more time is spent on second order circuits*

• *Perfect!*

Despite the very enthusiastic reception of the course by the class, examination results were relatively disappointing, with a raw overall failure rate of 17%. This was adjusted by scaling the two worst-answered questions to bring the rate to 10.76%. It is perhaps worthy of note that the worst-answered question covered Laplace transforms, which had not been covered in a PMA. Another 'difficult' topic, second-order circuits, was covered in a PMA and the lecturer's view is that students coped much better this year than in earlier years. The average mark for the course this year 2011 was 67.5%, compared to 60.9% in 2010 and 69.5% in 2009.

Discussion

Our most important result is that it is clearly possible to run PMAs in the large-class format. It was essential to have TA support, and very helpful to have a cohort of students who had experienced PMAs before in the tutorial setting. The results show clearly that students were very positive indeed about the value of PMAs in their studies, and would probably welcome more. Most of them could appreciate the value of their seeing the problems from the perspective of the marker. We will consider increasing the frequency of PMAs in future courses, and ensuring that they cover topics that are known to be difficult. We think it is significant that students struggled with Laplace transforms (where no PMA was offered), yet did well in second-order circuits (which was covered by a PMA). On this one year's results, it was not clear that PMAs had made a significant difference to the overall performance of the class: marks were better than the previous year's, but not as good as those in the year before.

Confounding factors include possible variation in cohort ability from year to year, and the effect of other initiatives such as peer-mentoring which was being carried out in the remedial tutorials associated with this course; however these tutorials were made available only to the weakest 58 students (out of 158). Student surveys mentioned a number of other things of which they approved, including *OASIS*, course notes and lecturer performance; however, we think that these things, while subject to small improvements from year to year, were fairly constant over the three-year period considered, and that the PMAs were the only new initiative to affect the whole class this year.

We have been sufficiently impressed with large-class PMAs to try them on the same cohort in another course in the second semester, and we hope to be able to report on these shortly.

Conclusions

Fortnightly PMA sessions have been held in classes of 150+ students in the core course ELECTENG 202, *Circuits and Systems*. Peer marking was carried out under the guidance of a lecturer, and with the help of teaching assistants. Students received a small number of marks for doing an assignment, and marking another's. They were required to interact with the tutorial material both from the perspective of one solving the problem, and also from the perspective of a marker. The great majority (92.2%) of students participated in the peer-marked sessions. The research was evaluated formally by surveys of students involved, and by an assessment of examination performance. Most students indicated that they found PMAs very helpful, and the course was given a very high 'satisfaction' rating. Examination results were comparable to those in previous years. Another second-year course will trial large-class PMAs shortly.

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