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Using active learning strategies to shift student attitudes and behaviours about learning and teaching in a research intensive educational context

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Abstract

Background: Active learning strategies were used to shift student attitudes and behaviours about learning and teaching in a research intensive Faculty of Pharmacy and Pharmaceutical Sciences at a large Australian University. Principles and active learning strategies were developed and tested in discrete content sections during the pilot phase, and then implemented for all students in first and second year units the following two years.

Method: The impact of the approach on student perceptions of active learning, attendance in face-to-face classes and performance in exams were evaluated.

Results: The majority of students perceived that active learning improved their understanding of content, developed skills in critical thinking and communication, and corrected misconceptions. Nevertheless, 53% of students felt they "*learnt better*" in traditional lectures than with active learning during the pilot phase. After strategies to improve student understanding of the generic skill benefit of active learning were implemented, this proportion fell to 34% in year one of implementation and 15% in year two. Students who reported that they "*learnt better in traditional lectures*" valued clear content presentation, whilst students who disagreed with this statement valued communication and critical thinking skills development and problem solving. Student attendance was 73% higher in active learning units than untransformed units during the implementation phase.

Conclusion: The use of a coordinated and strategic approach to implement active learning led to positive changes in student attitudes to their learning and associated behaviours.

Keywords: *active learning, student perception, pharmacy education, attendance, engagement*

Introduction

Graduates of Pharmacy or Pharmaceutical Sciences programmes around the world require a large number of complex skills and attitudes in order to master their challenging roles. Graduates must be able to use a body of basic science, social science and clinical knowledge to find solutions to complex scientific and clinical problems. Whilst the predominant mode of instruction in Pharmacy schools has been the lecture, and whilst students sometimes prefer content delivery approaches (Hanna *et al*., 2014), lectures do not help students develop these essential skills (Bligh, 2000) or perform better on assessments compared to more active approaches (Freeman *et al*., 2014). Lectures fail a basic test of good teaching practice: alignment of learning outcomes, teaching and learning activities and assessments. In our context, lecture attendance has been falling for some years. A combination of education theory, empirical evidence from the literature and our own experience suggested a paradigm shift towards a more active learning paradigm. However, students see many advantages to passive, traditional classes (Hanna *et al*., 2014), which prompted us to develop strategies to ensure that students would cope with and indeed embrace active learning as it was implemented in our Faculty from 2012 onwards.

Active Learning Strategies

Active learning is a broad term for teaching approaches that enable students to actively pursue learning outcomes, and in which students gain deeper understanding of the content by '*building mental models of whatever is being learned, consciously and deliberately testing those models to determine whether they work, and then repairing those that seem to be faulty*' (Michael & Modell, 2003: p.160). A number of analyses have shown

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active learning to produce superior outcomes to traditional teaching methods via a number of measures (Hake 1998; Freeman *et al*., 2014). The development of the critical thinking, communication and interpersonal skills required to solve complex clinical or scientific problems takes time, iteration and correction. Active learning, using scenarios progressively closer to real life situations encountered by graduates, helps to develop those skills and attitudes.

Previous reports of active learning strategies describe a mix of positive and negative student perceptions of active learning (Fox-Cardamone & Rue, 2003; Felder 2007; Welsh, 2012). Most reports indicate that students enjoy active learning exercises, and demonstrate greater engagement in classes involving active learning than in more traditional didactic lectures (Fox-Cardamone & Rue, 2003; Armbruster *et al*., 2009; Deslauriers *et al.,* 2011). Despite this, Fox-Cardamone and Rue reported that around 80% of students surveyed expressed a preference for traditional lecture-style teaching (Fox-Cardamone & Rue, 2003). Harold Modell, a pioneer of active learning in physiology, identified the problem as a combination of prior conditioning to passive learning environments and the '*uncomfortable and, perhaps, even intimidating*' prospect of participating in active learning (Modell, 1996: p.70). Welsh (2012) reported that positive comments about active learning were more likely to come from later year students and female students. These insights are of interest given that our implementation strategy began with an initial stage involving all first year units of study, progressing through to the remaining year levels over the period 2014-2016.

Our aim in introducing an active learning approach was to teach in a manner that reflected an understanding of how students learn: providing some content prior to classes to aid integration of new information into existing conceptual frameworks, and using active learning exercises to develop, test and refine domain knowledge and generic skills. Our goal was to evaluate students' perceptions of this new pedagogical approach we employed in terms of the perceived impact on their knowledge and skills, and on their attendance in face-to-face classes. We also looked at data on their exam performance before and after introduction of a systematic active learning approach.

Methods

Definition of active learning and active learning principles

We initially defined active learning classes simply as classes in which all students tackled two or more tasks that were designed to help students achieve specific learning outcomes, which accounted for more than 10% of the class time. Our reasoning for this definition was to start the transition for staff and students using the most basic definition of active learning as a shift away from a passive approach. We developed more detailed principles of active learning, as an umbrella under which individual teaching staff could use their own creativity to develop teaching methods that matched specific learning outcomes.

Principles of the active learning approach**:**

1. *Some content will be provided online prior to classes:*
   a. In order to focus on core concepts and skills development, and in order for class discussions to move beyond terminology definitions and simple concepts during lectures, some content will be refined and presented to students up-front (pre-class). In earlier years of study this content will largely be provided by lecturers, and as the course progresses a greater use of student inquiry will occur.

   b. The number of classes in each unit will be reduced to allow students time to prepare. This will vary, but it is anticipated that one class in every three or four will be set aside for preparation. Thus, a unit that included 36 didactic lectures will now move to 24 - 27 lectures.

2. *Units will routinely involve student participation in active learning activities during class - these activities will involve all students in the class.*

   Of note, active learning activities are defined in our context as behaviours or tasks involving all students that:

   - progress towards scenarios that become progressively more complex and more similar to real-life graduate tasks,
   - assist students in developing generic communication, critical thinking, inquiry and cultural competency skills required to find solutions to complex clinical and scientific problems
   - require thinking that is directed toward attainment of learning outcomes, developing skills or attitudes
   - provide some outcome for the student – an answer to a question, a concept map, a technique or process for problem solving

   Examples of well characterised and evaluated active learning activities include:

   a. Integrating new information within existing conceptual frameworks
      - tests of pre-class homework material via 'clickers'
      - questions embedded within pre-class video recordings

   b. Solving problems in class will require students to articulate what they understand of new material, and using peer discussion and instructor feedback students will refine their ideas and conceptual models

- 'clicker' questions reviewing a content block
- solving mathematical or conceptual problems using a method demonstrated earlier by the instructor
- 'clicker' questions asking students to predict outcomes of a novel scenario following a content block, with associated peer discussion
- scenario analysis involving all students producing written solutions or predictions based on a novel scenario
- group work on semester-long tasks

c. Explicit development, testing and refining of students' personal conceptual models and metacognition

- concept mapping in class, in which students analyse the causative relationships involved in a phenomenon such as blood pressure control
- testing and refining concept maps by using them to answer questions about novel scenarios and then returning to refine the concept map

Pilot and implementation phases

The approach to the implementation of an active learning intervention firstly involved orientation of staff in a common vision and principles for active learning in pharmacy teaching. These principles stated that face-to-face (FTF) classes would involve preparation by students for class and in-class activities involving all students directed towards achievement of learning outcomes. In the pilot phase in 2012, nine staff members used a variety of active learning strategies including clickers (an audience response system consisting of devices supplied to each student with which responses to questions posed can be answered) with peer discussion, concept mapping, prediction of outcomes for novel scenarios using principles, and various forms of group work. These pilot active learning classes were confined to short lecture series on single topics within a unit of study, and were spread across the three years of the Bachelor of Pharmaceutical Sciences and the four years of the Bachelor of Pharmacy.

In most cases instructors began their classes with an explanation of the aims and expectations of this novel teaching approach. At the completion of the pilot, an evaluation of student perceptions of active learning was conducted. The findings of that evaluation were used to refine the approach used in the implementation phase across all first year units the following year. The decision to start the implementation phase with first year units was based on the premise that first year students represent, if not a blank pedagogical canvas, then a group prepared to embrace a new set of expectations and group norms about learning and teaching in the Faculty.

Strategies for student engagement

In order to assist students with the sometimes confronting change to active learning (Felder, 2007), a number of strategies were developed and implemented:

Pilot phase

- pilot active learning staff explained their active learning approach to students.
- Evaluation of student attitudes and behaviours was conducted, and feedback provided to students on survey outcomes.

Implementation phase

- Active learning implementation was discussed at each Student Liaison Committee meeting (involving leaders of all student bodies within the campus) as a standing agenda item. This allowed for issues such as allocation of clicker marks to be raised by students, but also allowed the pedagogy of the approach to be discussed on numerous occasions.
- 'Closing the loop' on activities: providing instructor validation of students responses to active learning problems to the entire cohort.
- Allocation of marks for participation and correctness on in-class assessments was introduced Evaluation of student attitudes and behaviours, and feedback to students on survey outcomes was conducted.

One element of the approach for the implementation phase was the provision of 'clickers' (audience response devices) to all first year students, based on our observations of the use of clickers at the Carl Wieman Science Education Initiative group at the University of British Columbia. In 2013, we developed a range of activities using clickers, from assessing whether students had completed pre-class learning ("done their homework"), to scenario-based questions asking students to predict the outcome of a novel problem based on newly introduced concepts, and to questions designed to start a conversation among students about a new topic, which were designed to help students integrate new information into existing conceptual frameworks.

Evaluation of the active learning approach

The pilot evaluation involved gathering data on three components:

a) Student perceptions of the impact of active learning on their learning;

Pilot phase: An anonymous survey of student cohorts involved in the active learning pilot was conducted at the end of 2012 (n= 222; 144 Pharmacy students and 78 Pharmaceutical Science students). The survey addressed student perceptions of the active learning approach they had experienced in comparison to their 'traditional' lecture experience. 'Active learning' was defined in the

pilot phase as the '*tackling of one or more clearly defined tasks by all students, whilst 'traditional'; or 'typical' lectures were defined as classes in which the lecturer spoke for more than 95% of class time'*. The survey was conducted in the final week of the semester to evaluate student perceptions of the active learning experienced within the pilot. Students were directed to *'Use three words or phrases to describe your reaction to the active learning component of these lectures'*. In total there were 1,114 words used, which were categorised into positive, qualified and negative. Students were also asked to *'use three words or phrases to describe your typical experience of traditional lectures in your course'*. These were categorised and quantified in the same manner.

A series of questions about student perceptions of active learning as compared to didactic teaching were also asked. Additionally, unsolicited comments were extracted via a search for 'active learning' and related keywords in the database of student comments for the University student survey of all units (Student Evaluation of Teaching and Units: SETU).

Implementation phase: A second anonymous student survey of first year students involved in the active learning implementation phase was conducted during classes at the end of 2013 (n= 119 responses; 42 Pharmaceutical Science students and 77 Pharmacy students), and after semester one 2014. These students had not participated in the pilot phase. Students were asked the same questions regarding their perceptions of active learning as compared to didactic teaching. In order to explore some issues further, students were also asked some follow-up questions *via* the Keepad® audience response system (n= 189 responses; 77 Pharmaceutical Science students and 112 Pharmacy students).

b) Impacts of active learning strategies on attendance of F2F classes, and performance in assessments

In the first two years of active learning implementation, semester one 2013 and 2014, head counts were taken for lectures in all units of study in weeks seven and ten; from three to six head counts were conducted for each unit of study.

c) Student performance in assessments pre and post introduction of active learning.

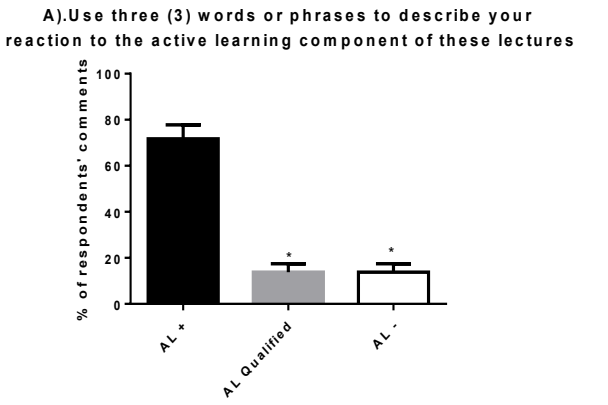
Examination results were collated for all topics assessed within the active learning pilot. Mean scores for 2012 pilot active learning topics were compared to the mean scores for the same topics in 2011 and 2010, which were all taught by the same instructors. Examination results were also collated for all first year units during the implementation phase. Mean scores for 2013 active learning topics were compared to the mean scores for the same topics in 2011 and 2010, which were all taught by the same instructors. Mean unit exam marks for 2012 were not included in the analysis for the implementation phase because some first year units in 2012 were involved in the pilot phase. Concerns as to the lack of engagement of a small proportion of students in active learning prompted us to correlate attendance and performance marks from clickers with final unit grades.

Results

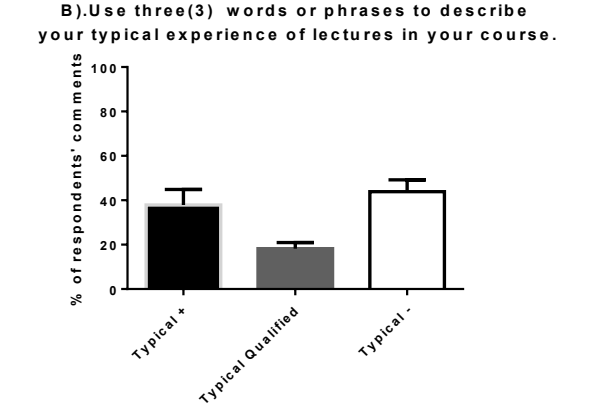
Student perceptions of the impact of active learning

Most students found active learning enjoyable and interesting, as can be seen by the words used to describe active learning (see Table 1, Figure 1). The comments show that most students found the active learning classes more engaging and interactive than typical didactic lectures, while a minority found them stressful. Typical didactic lectures were found by many to be uninteresting, although a minority of students valued these classes as effective.

Figure 1: Words or phrases used by students to describe A) active learning or B) typical lectures were sorted into positive, qualified and negative categories in response to the following questions: i). Use three (3) words or phrases to describe your reaction to the active learning component of these lectures" (AL) and ii) Use three (3) words or phrases to describe your typical experience of traditional lectures in your course.". Representative examples are shown in the table. Over 1000 comments were received and analysed



* indicates a significant difference from the number of positive comments



(ANOVA, $p<0.05$).

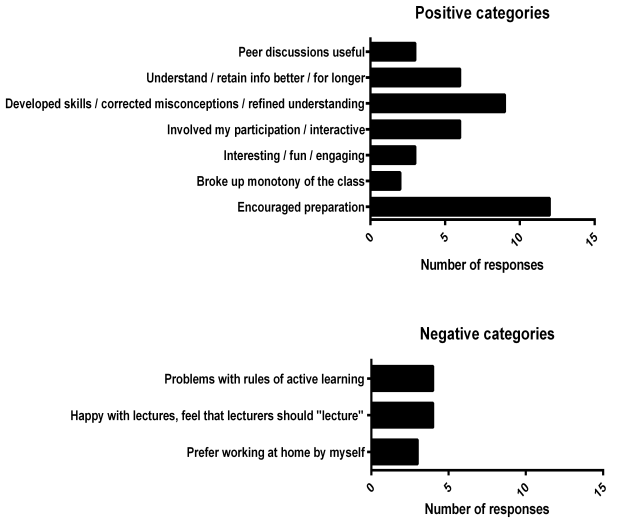
Unsolicited comments from university unit evaluation process

All units (individual subjects) in the Faculty at this University are evaluated at each offering, and within those evaluations there is the opportunity for anonymous open-ended comment. Comments from all units involved in pilot and implementation phases were scanned for direct references to active learning. The comments that related to active learning were collected by searching for the keywords "active learning" and related terms, and then grouped where possible into categories as shown in Figure 2. Of the 45 students that referred to active learning experiences in unit evaluations during the implementation phase, 34 (75%) made positive comments, and 14 (24%) made negative comments. Table I shows example comments grouped by theme.

Table I: Unsolicited comments regarding active learning grouped into themes

Positive themes	**Exemplar Comment**
Active learning is engaging	*"broke up the monotony of the class"*
Active learning helped with application of theory, problem solving skills	*"really helped us start to grasp an idea of how the information that was given to us could be applied, even if we didn't get the right answer"*
Active Learning methods move the learning process into the classroom	*"better grasp the concept while still at uni rather than having to go home and needing to relearn it on my own"*
Units that did not involve active learning should introduce active learning	*"Need more active learning rather than just talking to you through the entire lecture"*
Active learning encourages students to work consistently throughout semester	*"problem-based learning and Keepad questions really encourage students to work at home in order to keep pace"*
Negative themes	**Exemplar comment**
Exam-driven style of learning suits me better	*"It is better for the lecturers to prepare some exam type question and tell us the correct way to answer the question"*
Active learning activities require sufficient student preparation tasks in order to be effective	*"It is fair enough to have 'active learning', but it is a complete waste of everyone's time when the lecturers turn up with nothing to present and we are expected to discuss for the whole period. A lot of these concepts are new to us, and we don't have enough background knowledge to simply discuss"*
Active learning activities should finish with the instructor "closing the loop"	*"The difficulty with active learning is that students are asked to answer questions and are given no feedback as to whether they are correct or not"*

Figure 2: Quantitation of positive and negative comments regarding active learning extracted from student evaluations of units in the implementation phase. Comments were sorted into positive and negative categories and then into common themes as shown



Impacts of active learning strategies on student learning

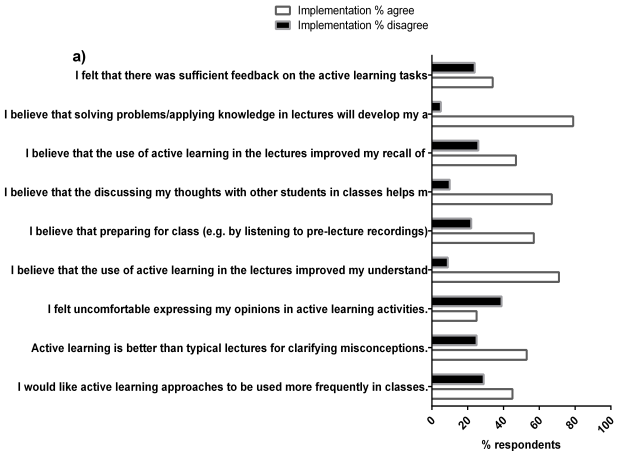
Figure 3 shows student responses to a number of questions inviting comparison between their experience of active learning and 'traditional lectures'.

A majority of students indicated that they would like active learning exercises to be used more frequently in classes, that they viewed active learning as *"better for clarifying misconceptions than traditional lectures"*, and that the use of active learning increased their understanding of the topic (by a seven-fold majority; Figure 3). Additional questions designed to further examine perceived impacts on learning following the implementation phase indicated that students believed active learning preparation to result in deeper learning, and that critical thinking skills such as solving problems and applying knowledge were developed as a result of practice during active learning (Figure 3). A majority of students (79%) were in favour of increased active learning during the pilot phase; the percentage agreement that active learning should be used more frequently after the implementation phase was 45%. Subsequent discussion revealed that for some students, the right balance between active learning and more didactic teaching had been reached, whilst for others, the best model involves all classes being active.

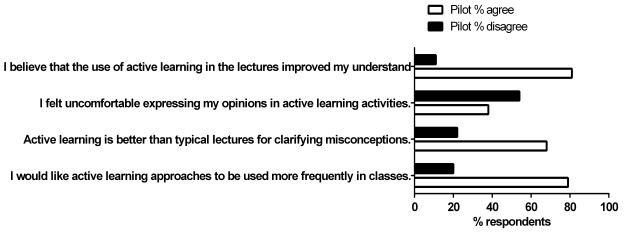
In the 2012 pilot phase, a small majority (53%) of students agreed with the statement *"I learn better in traditional lectures than with active learning"*; after the first year of implementation this fell to 34%; more students disagreed with this statement than agreed (Figure 4). In year two of implementation only 15% agreed whilst 64% disagreed that they *"learn better in traditional lectures"* (Figure 4).

Figure 3: Student survey regarding receptions of the impact of active learning.

a) *Implementation phase*: n=119; 42 Pharmaceutical Science students and 77 Pharmacy students.



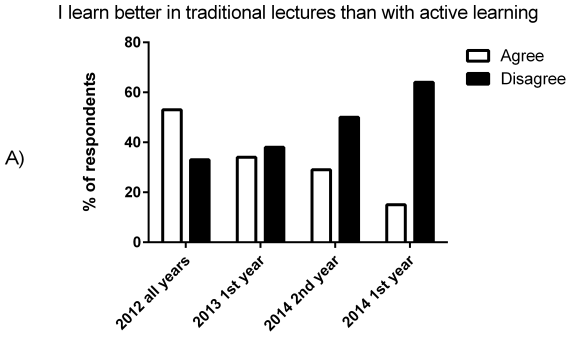
b) *Pilot phase*: n=222; Pharmaceutical Science students and 78 Pharmacy students. Note that an option "neither agree nor disagree" was provided; data not shown.



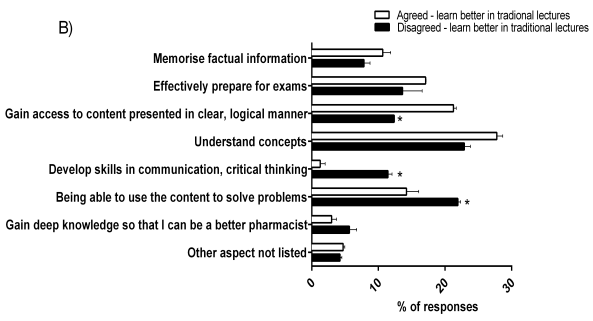
In order to understand why students would perceive that they learn better in traditional lectures despite reporting a range of benefits to their learning from active learning, students were later asked a clicker question examining their definition of *"learn better"*. Students who agreed with the statement *"I learn better in traditional lectures than with active learning"* were asked to answer the question shown in Figure 4, after which the same question was posed to those students that disagreed. A clear difference between the two sub-groups can be seen in terms of the outcomes that define *"learning better"* to them. Students who preferred traditional lectures valued gaining access to content presented in a clear, logical manner, whilst students who disagreed that traditional lectures were superior favoured developing skills in communication and critical thinking, and in being able to use content to solve problems (see Figure 4b).

During the pilot phase, 38% of students indicated that they *"felt uncomfortable"* when expressing their opinions during active learning classes, compared to 54% who did not feel uncomfortable. Further analysis of the data showed that a significantly higher proportion of students who felt uncomfortable expressing opinions also reported speaking a language other than English at home in the same survey (41% of students who spoke languages other than English at home reported feeling uncomfortable versus 28% of those who spoke English at home; t-test, $p<0.05$). To advance the goal of increased student comfort in participating in class discussion, tutorials were run by Library and Learning Skills staff at the beginning of the implementation phase to discuss anxiety about speaking in class and practice communication skills. At the completion of the implementation phase, the number of students who *"felt uncomfortable expressing opinions"* fell to 25% (see Table I).

Figure 4: A) Increasing student agreement that they learn better with active learning than traditional lectures over time as the approach was implemented. Students were asked to agree or disagree with the statement *"I learn better in traditional lectures than with active learning"* at the end of the pilot stage and then at the end of semester one for the first two years of implementation.



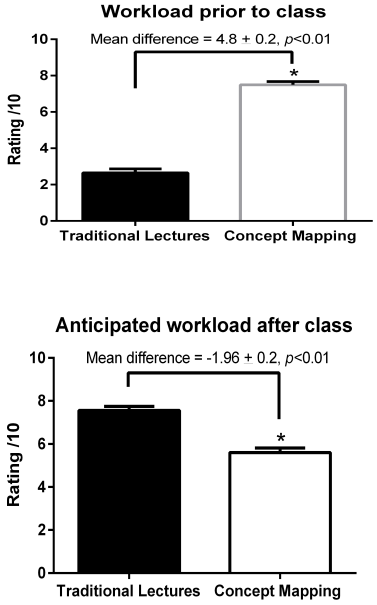
B) Following the survey shown in A), students were later asked *"What does "learn better" mean to you? Pick three responses that best indicate what aspects of learning are most important to you".* First, students that agreed with the statement "I learn better in traditional lectures" were asked to respond via an audience response system, followed by students that disagreed with the statement. The percentage of respondents in each sub-group that chose each option are shown. N=80 respondents for the "agreed that traditional lectures better" group, n=84 respondents for the "disagreed that traditional lectures better" group, ANOVA.



* indicates a significant difference from the "agreed – learn better in traditional lectures" group.

Student workload was addressed for a particular active learning approach (concept mapping), in which students were asked to rate the time they spent preparing for classes in producing draft concept maps, and the time required for study after classes. Figure 5 shows that students reported an increased workload for this active learning approach prior to class but an anticipated reduction in workload after class.

Figure 5: Student perceptions of workload prior to and following concept mapping classes compared to workload prior to and following traditional lectures. Following classes, students were asked to rate their workload on a 1-10 scale, where 10 represents the greatest workload they had experienced at university and 0 represents no preparation.

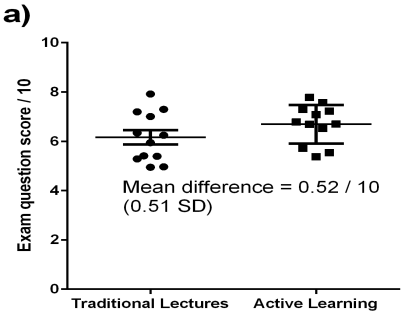


* indicates $p<0.05$, t-test, n=126

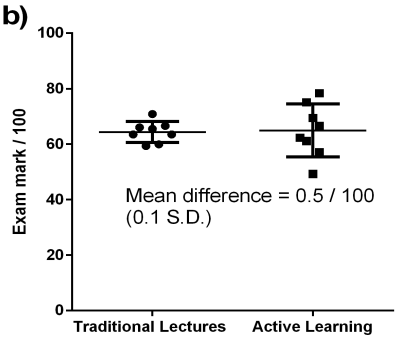
Student examination performance

The active learning pilot was not designed or powered to test for an effect of active learning on student achievement outcomes. Nevertheless, it is interesting to note that when compared to student exam performance on the same topics as previous years, performance was about 0.5 marks out of 10 (0.51 SD) higher in the 2012 active learning pilot group (t-test, p=0.07; Figure 6a). Analysis of the implementation phase revealed no significant difference in first year average unit mark between exams conducted prior to the active learning approach in 2011 (64 + 4 %, n=8 units) and those at the completion of the implementation phase in 2013 (65 + 8%; n=8 units, Figure 6b). Differences between cohort capabilities were examined as a potential source of variability in exam performance. Entry scores for Bachelor of Pharmacy students fell by around 2% over the period 2011 to 2013, whilst those for the Bachelor of Pharmaceutical Sciences remained the same.

Figure 6: a) Pilot phase exam performance for topics taught after active learning compared to performance on the same topic from previous years after traditional lectures



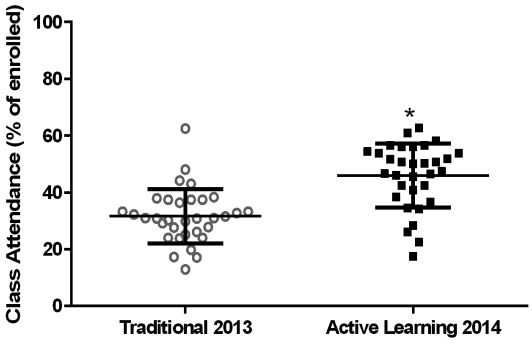
b) Implementation phase average unit marks for topics taught after active learning implementation in 2013, compared to the same unit in 2011



Attendance and clicker use

In semester one 2013 and 2014, head counts were taken for lectures in all units of study. Attendance was significantly (73%) higher on average for active learning units than for those yet to be transformed (66 + 2 %, n= 32 for active learning versus 38 + 2 % n=90 counts). In a controlled study, data for second year units in 2013 (prior to active learning) was compared to that for the same units in 2014 where active learning had been implemented (Figure 7). There was a 43% increase in attendance with the introduction of active learning in 2014 compared to the same units prior to active learning in 2013 (t-test, $p<0.0001$, n= 32). As part of the active learning approach, all students in the year level being transformed were supplied with a "clicker" audience response device. We followed the head count with a student survey to determine whether the assessment of active learning in classes using clickers impacted on student decision-making regarding lecture attendance. In first year units, 56 % of first year students agreed with the statement *"the use of clickers, and associated mark allocation, affected your decision to attend lectures"*, whilst 24% disagreed.

Figure 7: Student attendance as a proportion of total enrolments for all units of study in semester one 2013 (traditional) versus 2014 (active learning). 3-6 head counts were taken for each unit in weeks 7 and 10 of a 12 week semester. Circles represent active learning lectures, filled squares represent traditional lectures



* indicates p<0.0001, t-test, n=32.

Follow up for students that did not attend classes

Twenty out of the 322 enrolled first year students (6%) did not participate in any of the in-class assessments, which were largely clicker questions. These students were all contacted to determine whether they required support or whether there was any impediment to the engagement with their studies. Of the 20 students, 12 responded. Seven indicated that they preferred to learn at home via recorded lectures, and five indicated that they were enrolled in 2nd and 1st year units and had clashes preventing their attendance. Comments from students who preferred to learn at home included *"I am not close to many people at uni and find I understand and tune in better in my computer chair, I also find that I arrive 5-10 mins late because of traffic in the morning and I end up missing a question... arriving 5 mins may mean I miss out on the overview slides which are important when developing a solid mind map... so I since listen to lectures at home."*

Discussion

Student perceptions of impact of active learning strategies on their learning

In this study, an active learning approach was introduced in a strategic, carefully staged manner, which resulted in changes in student behaviour and attitudes. Broadly, students enjoyed active learning, perceived a range of benefits to their learning, and performed as well or better on exams. In a separate analysis, we found that the exam questions asked in the active learning implementation phase were far more challenging as determined by analysis of Bloom's levels of exam questions, which found a 53 % increase in questions that addressed higher order cognitive skills (White *et al.,* in print).

Felder (2007: p.183) advises the following when introducing active learning: '*When you use a proven teaching method that makes students uncomfortable, it's important to let them know why you're doing it'*. Our strategy in this regard was to routinely explain to students the teaching approach in terms of both "how" and "why". Many students appeared to understand the pedagogy employed in the active learning approach, based on the formal evaluation and comments extracted from unit surveys. This was seen in unsolicited comments, including that active learning "really helped us start to grasp an idea of how the information that was given to us could be applied, even if we didn't get the right answer". A majority of students agreed that active learning activities helped develop critical thinking skills, improved their understanding, and that active learning was superior to traditional lectures in clarifying misconceptions.

In contrast to this array of positive feedback, a majority of students surveyed after the pilot phase reported that they *"learn better"* in traditional lectures. Literature reports show similar perceptions; Fox-Cardamone and Rue (2003) in fact found that a much higher proportion (around 80%) of students expressed a preference for traditional lecture-style teaching.

Nonetheless, the contradictory data suggested that a more detailed conversation with students was required concerning the intent of the teaching approach, and about how they viewed their own learning. With this aim, a session was introduced in the orientation week program prior to the implementation phase, to describe the active learning approach to students and discuss student learning approaches and priorities.

The proportion of students reporting that they *"learn better in traditional lectures*" fell from 53% to 34%; more students disagreed with this statement than agreed. The fact that 34% of students still perceive that they learn better in traditional lectures indicated that a further action was required, albeit that we expected that it would take time for the culture at the campus to change. At the completion of the first year of the implementation phase, we developed a workshop to help students link the benefits they report from active learning methods to benefits in both exam performance during their time at university and their ability to excel once they graduate. Workshops involving future work scenarios and related tasks that require students to discuss the knowledge, skills and attributes they will need as graduates were conducted in year two of implementation, involving group discussion of the expectations of students and instructors, as suggested by Modell (1996). We asked students to design class activities that would help them gain the knowledge, skills and attitudes. This was a transformative event: the students listed "workshops, group work, mind maps, active learning", essentially describing our active learning approaches. When this cohort were asked 12 weeks later the same survey question, only 15% agreed and 64% disagreed that they learn better in traditional didactic lectures. We attribute the consistent increase in the proportion of students that regard active learning as

better for their learning as a consequence of specific strategies such as the orientation metacognition exercise, as a natural progression as students experience more active learning and see development of skills, and also as a consequence of our development as active learning practitioners.

Solutions to issues raised by students regarding active learning have been suggested by pioneers in the field (Modell 1996; Felder 2007). Common features of those reports align well with negative views from a minority of students in our pilot study, with major themes being that active learning is a waste of time, *'not helpful because students tend to guess or copy one another'* (Welsh 2012: p.85). Skepticism of the validity of information and concepts emerging from peer discussion was occasionally seen, with peer discussion seen to be inferior to validated content within didactic lectures; *"we don't have enough background knowledge to simply discuss"* as expressed by one of our students. Research shows that student resistance to active learning is often associated with anxiety related to receiving potentially incorrect information from peers. To address this perception, a theme running through all of our workshops and discussions following the analysis of our active learning approach has been to 'close the loop'; for example to provide some staff-validated, student-derived answers to problems to the cohort following active learning exercises.

How much active learning is enough?

In response to the survey questions, a large majority of students in the pilot phase (79%) agreed that they would like more active learning to be used in future; predictably this fell (to just below 50%) after the substantially increased use of active learning in the implementation phase. The stated intention during the implementation phase was to increase the use of active learning to at least two active learning exercises per class for about half of all 'lectures' during the first year of the implementation, and to increase further the following year. Staff reported that the proportion of active learning in classes rose to around 30% of class time for an average of 47 % of lectures in 2013, in agreement with this aim. Students and staff appear to prefer a mix of didactic content provision (before and during classes) and active learning exercises (before, during and after classes). Whilst the ideal proportion of class time devoted to active learning activities in classes is unclear, it is clear from staff plans that the use of active learning will increase in first year units from the first year of implementation to the following years.

Students perceived that their workload increased when preparation was required for classes, as assessed within a specific active learning approach involving students watching pre-recorded videos prior to classes in which they developed concept maps. The reported increase in workload prior to class, compared to traditional lectures, indicated that students were engaged in the preparation tasks. The significant decrease in workload after class appears to indicate that students perceived the preparation and active learning in classes to have been effective in that less work was required to presumably achieve the same outcomes. This is not to say that students have completed their learning once they finish active learning classes: post class activities, often online, remain important in consolidating and extending higher order abilities, and can build on the in class active learning exercises.

Student engagement and attendance

Student attendance in first and second year units involved in the active learning implementation was far higher than those in all other year levels. A number of factors may have contributed to this outcome, including the possibility that first year students attend a greater proportion of classes irrespective of the nature of the class. It is clear, though, that active learning methods contributed to the higher attendance observed in first year units, given that the majority of first year students agreed that clicker use and mark allocation influenced their decision as to whether to attend or not. Attendance at clicker sessions correlated strongly with performance in the unit, a finding replicating that of Freeman *et al*. (2007) in an introductory biology cohort; in that study clicker marks were predictive of final grades.

Attendance at didactic lectures emerged in recent years as a problem in our Faculty. Attendance in lectures in 2007 was recorded at around 70% (unpublished data), however the attendance counts reported in this study in units not involved in the active learning approach were down to below 50%; many of our staff attribute this decline to the introduction of lecture recordings in all units in 2007. Literature reports of the impact of recordings on student attendance are varied (Williams & Fardon, 2007; Gomis-Porqueras *et al*., 2011). A study of the impact of one recording system eClass, showed no change or only slight decline in attendance (78% in unrecorded units vs 72% for recorded units in one arm of the study (Brotherton & Abowd, 2004). Massingham and Herrington's research into student attitudes show (Massingham & Herrington, 2006) that the availability of online lectures was one of the main reasons for non-attendance. In a national survey conducted in Australia, 68% of students who did not attend lectures believed that they could learn as effectively using digital audio recordings as they could by attending the corresponding lecture in person (Gosper, 2008). There is a lack of longitudinal data addressing the impact of recordings on attendance; our early data showed no impact of recordings on attendance, yet seven years later our average attendance fell to below 50%, indicating the need for further investigation.

Clearly, our active learning approach, and specifically the use of clickers and associated marks, contributed to the 70% higher attendance in our first year active learning units compared to units in other year levels. As staff and students become more skilled and accustomed to active learning, it is likely that classes will increasingly provide a learning experience that is superior to that of watching recordings at home.

Improving student comfort with speaking in classes

A minority of our students expressed concern at publicly expressing ideas during classes. This view emerged in both the survey and in unsolicited comments when the unit was evaluated. Active learning approaches present significant challenges to some students and often lead to discomfort (Seddeggi & Overton, 2003), ranging from embarrassment to anxiety (Hoekstra, 2008; Hillyard *et al*., 2010; Jones *et al*., 2012). Educating students about learning styles, metacognition and the value of group work and active learning instructional strategies usually encourages meaningful and productive collaboration (Trees & Jackson, 2007; Blunt, 2008; Hillyard *et al*., 2010). Trees and Jackson (2007: p.26) point out that to accomplish a change in learning environment students must *"buy into' this goal and change their behaviour accordingly"*. Significant discomfort with communicating verbally with peers and instructors may hinder a 'flow state' (Csikszentmihalyi, 1997) and therefore learning, and thus we sought to address this issue at the completion of the pilot phase. We were committed to continue the use of peer discussions in class, as students themselves reported that this approach helps them develop skills in communication, a finding in agreement with that reported by Blicblau and Dini (2012) when introducing active learning in an engineering capstone unit. Smith and colleagues (2009: p.122) found that peer discussion *'enhances understanding, even when none of the students in the discussion group originally knows the correct answer'* based on an analysis of assessment performance. Our students frequently expressed the view that peer discussions were helpful: *"It really helped to discuss the questions and answers with friends, to evaluate how to respond"*, and a seven-fold excess agreed that peer discussion helped their understanding.

On reflection, our approach requires that students be provided with: i) opportunities to develop confidence in speaking publicly; and ii) alternative learning modes that play to their strengths. At the conclusion of the pilot, we developed sessions run by the Library and Learning Skills staff within the University, aimed at developing confidence within group discussion and specifically raising the need to *"be wrong first in order to be right"*. We also ran workshops following the pilot for staff aimed at helping them create an environment in which students felt safe to contribute. We also noted an increase in student confidence in classes as the implementation phase progressed. The number of students who *"felt uncomfortable expressing opinions in active learning activities"* fell to 25% in the implementation phase from 38% in the pilot phase.

Conclusion

A range of strategies were used to assist students to fully engage with the active learning approach we introduced (see Table II). The majority of students perceived that active learning improved their understanding of content and effectively developed skills in critical thinking and communication. This indicates that our methods of explaining the approach, implementing the activities in order to bring about conceptual change in students about learning and teaching were effective. While a subset of students believed that they learnt better in traditional lectures than with active learning, this proportion of students was reduced during the implementation phase, as strategies (including classes discussing the process of learning) were implemented between pilot and implementation phases to develop student understanding of the benefits of active learning. Student attendance was improved by the use of clickers and associated clicker marks during the implementation phase. Exam performance was maintained or improved, on exams that required greater use of higher order cognitive skills. The evidence presented in this study demonstrates that the student experience in our classes has been transformed from passive observer to active participant. As our students (and staff) become more sophisticated in their teaching and learning approaches, we anticipate that student learning outcomes will continue to improve.

Table II: summarises the strategies used to involve students in the active learning approach

Strategy	Literature basis	Activities	Outcomes
Pilot group explained the reasons for the new teaching approach to students	Modell (1996)	Each active learning activity began with an explanation of the approach	Some evidence that students demonstrated an understanding of the approach in surveys, using the term "active learning" appropriately
Discussions with student body (involving key opinion leaders)	Loeser et al. (2007); Sefton (2004)	Student Liaison Committee discussions over 2013. This allowed for issues such as clicker marks to be raised by students, but also allowed the pedagogy of the approach to be discussed on numerous occasions	Agreement at each stage of active learning approach with key student leaders Student leaders became involved with promoting evaluation of teaching via Facebook communication
Evaluation of student attitudes and feedback to students on survey outcomes Address attitudes to active learning and class expectations of students	Modell (1996)	Classes run to specifically develop student attitudes to active learning were held at beginning of implementation phase	A reduced number of students agreed with the statement "I learn better with traditional lectures than with active learning" following implementation phase
Allocation of marks for in-class assessments ("clicker questions")	(Freeman et al. 2007)		>50% of students reported influence of clicker marks on decision to attend classes. Attendance higher in first year classes than other year levels

Limitations of the study

Interpretation of the attendance disparity between first year units (that involved strategic implementation of active learning) and other units (that largely involved didactic lecturing) is complicated by the lack of historical data showing attendance by year level. Data from 2014, comparing attendance in second year classes to that of 2013, will provide a clearer answer as to the magnitude of the effect of active learning strategies on attendance. The data regarding student workload relies on self-reporting rather than a more direct measurement. It was not considered ethical to run a controlled, randomised trial at the scale of the implementation we made, given the extensive evidence that active learning is effective at improving student outcomes.

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