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Student engagement for a large unit in an active learning space

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Mass education is a fact of the 21st century, whether educators like it or not. Growing demand for higher education will continue to increase class sizes, bringing challenges in relation to students' engagement and learning outcomes. Appropriately designed and equipped learning spaces may improve students' engagement and outcomes in large classes. This paper describes our experience revamping a large operations research unit's practical classes. The aims of the revamp were to increase students' interaction with tutors and each other, and to develop students' verbal skills and confidence through short unrehearsed presentations. We narrate three iterations of our action research cycle, with reflections based on feedback from students and tutors, and also from peer observation. Of particular note is how the innovations relied on the design and technology of the active learning space.

Keywords: Active learning space, large class, student engagement

Background

Students' success at University hinges upon engagement, the "quality of effort and level of involvement" (Pascarella and Terenzini, 1991, p610). More engaged students receive better grades (Astin, 1993; Indiana University Center for Postsecondary Research, 2002) and more often persist with their studies (Pike, Schroeder & Berry, 1997). Evidence links student engagement to teaching quality (Australian Council for Educational Research [ACER], 2010), and to the learning environment (Brooks 2011, Matthews et al., 2011, Oblinger 2006, Brown 2005). When staff adopt approaches promoting student activity and collaboration, their students exhibit greater engagement, better attitudes towards the subject, better retention rates, higher academic achievement and the development of higher order thinking skills (de Caprariis, Barman & Magee, 2001; Cohn, 1999; Tanenbaum, Cross, Tilson & Rodgers, 1998;

Dundes, 2001; Felder & Brent, 1996; Johnson, Johnson & Stanne, 2000; Jungst, Licklider & Wiersema, 2003; Michaelsen, Knight & Fink, 2002; Millis & Cottell, 1998). Further, it has been argued that the provision of innovative learning and teaching spaces can be a powerful agent to support teachers to adopt such innovative practices (Oblinger, 2006).

Universities in Australia (Radcliffe, Wilson, Powell & Tibbetts, 2008) and worldwide (OECD, 2006; Scottish Funding Council, 2006) are building a new generation of learning spaces for classes of various sizes, designed to support active and collaborative pedagogy. However, the role of space in promoting pedagogical innovation has not been a prominent theme in the higher education literature (Jamieson, Fisher, Gilding, Taylor and Trevitt, 2000) and, therefore, it is unclear that the mere provision of space will suffice to change teachers' practices and students' experiences. Nevertheless, evidence is emerging which shows that space can promote pedagogical innovation (Hunley and Shaller, 2009).

C5C Forum and the research associated with that space

C5C Forum is a new learning space at Macquarie University, opened at the start of the academic year (February) 2011. The room's capacity is 100, and its design supports a number of different learning and teaching approaches, such as individual and group work, class discussions and student presentations. The audio-visual system accepts input from various sources, including a resident PC, external notebook, Blu-ray player and document camera, and has an annotation feature. Thus a presenter can display visual input (or optionally two different visual inputs to two separate screens) and write over the images projected. The furniture arrangement is more open than in a traditional lecture theatre, allowing tutors to circulate to any part of the room. Microphones fitted on tables allow students to participate in discussions with the entire class.

Associated with C5C Forum is a campus-wide research project funded by a Macquarie University 2011 Priority Grant. It explores how academics from several disciplines use the flexibility of C5C Forum to improve engagement and learning. One of the groups involved in the project is the STAT279 teaching team.

The second year operations research unit STAT279 is one of the largest units within the Department of Statistics (750 – 1000 students annually). Over 90% of its students are from overseas. The unit covers a range of operations research topics at an introductory level. It involves two formal classes: lectures (three hours per week) and practicals (one hour per week). Two lecture streams are run per semester, with four lecturers sharing the preparation of teaching materials and lecturing. The lectures are fairly traditional, but a portion of the lecturing time is spent on “active learning,” where students solve problems with the lecturer's help.

The practicals are also run in large classes, due to limited resources. Prior to C5C Forum, Macquarie had no high-capacity learning spaces enabling group work or convenient interactions between students and academics. The practicals were run in tiered lecture theatres with a capacity of 150. They were mostly run by casual tutors, with two present during each class: one leading the class, and the other assisting by taking attendance and helping students. During the practicals, students were presented with one or two problems to solve, with guidance from the tutors. At the end of the class, fully worked solutions would be presented, so that students could check their answers. The layout of the theatres (very steep and cramped) hindered mobility, letting students “hide:” students seated away from the aisles knew staff could not view their work, and would often not engage in the learning activity.

Many students would simply wait to copy the model solutions, making no effort to solve the problems independently. Staff felt that the lack of engagement in the class was undermining the learning experience, but it was not until in 2011 that a suitable learning space, C5C Forum, became available. We ran the STAT279 practicals in C5C Forum for four semesters (2011–2012). This paper describes our efforts to increase engagement in the new space using an action research framework.

Learning spaces

The issue under consideration is student engagement and learning experience in a large operations research unit's practical classes. For years, the practical classes had been run in unsuitable steeply tiered theatres with a capacity of 150 (see Figure 1). Their high capacity, along with budgetary pressure, encouraged the timetabling office to increase class numbers from our intended 80, toward full capacity of 150.



Figure 1: The E7B T2 theatre

The structure of the practical was simple. The leader would introduce and briefly discuss a problem or two, and then the students, using provided worksheets, were to attempt solutions. Collaboration was permitted. After some working time, the leaders would present and interpret model solutions.

Peer observation (the unit's lecturers observing practical classes) and feedback from tutors revealed that many students, rather than engaging with the exercises during working time, were simply waiting for the model solutions. Furthermore, the theatres' layout precluded tutors' reaching most of the students to assist or encourage them. We had tried several strategies to engage students in the theatres, with little success. In 2011, the opportunity to move into C5C Forum arose.

C5C Forum is one of the most technologically advanced learning spaces at Macquarie. It has a capacity of 100, with fixed tables and chairs arranged in six concentric arcs (see Figure 2). The room's layout allows students in one row to swivel their chairs to face students sitting in

the row behind, making the formation of in-class groups straightforward and non-interruptive. The room is spacious, providing easy access to students, whether they are working individually or in groups. The podium area is also spacious, and unimposing for students to approach. The two projection screens are clearly visible from everywhere in the room.



Figure 2: C5C Collaborative Learning Forum

The layout of C5C Forum seemed to enable us to run the STAT279 practicals as originally intended, with students working on problems in groups. We hoped that forming smaller groups within the large class would give the students some of the benefits of smaller classes, such as collaborative learning and easy access to tutors. We also hoped that, through group discussions and interaction with tutors, the students' engagement during the practicals would improve.

Methodology

This study employs an action research approach: a collaborative process (Carr and Kemmis, 1986) in which a group of practitioners/researchers utilise data from a variety of sources (Koshy, Koshy and Waterman, 2011) "to improve both their practice and the quality of their understanding" of a particular social context (Winter & Munn-Giddings, 2001). It is a dynamic and cyclical process (Elliot, 1991; Kemmis & McTaggart, 1982; O'Leary, 2004) involving iterations of action, observation and reflection (Waterman et al. 2001, p12).

We now recount our action research chronology over three time periods, 2011a, 2011b and 2012 (where a and b stand for Semester 1 and Semester 2 respectively). In each section we describe the practicals' delivery mode, the observed result and how our reflections drove future changes.

2011a

Action

During 2011a, we ran the practicals in C5C Forum for the first time. We used the same lesson plans as before, but with a new emphasis on group work. That is, the leader would start each class by introducing the problem(s). The students were then instructed to form groups and

work together to solve the problem(s). The tutors would circulate, assisting students. After working time, the leader would present model solutions.

As previously, most of the practical classes were run by casual staff; however, during 2011a, all four lecturers taught in at least one practical per week, either leading or assisting. Furthermore, they observed other classes sporadically, documenting their impressions. The casual tutors' experiences with the new space, feedback on student engagement and other observations were sought and documented throughout the semester.

Observation

The new audio-visual set-up enabled the leader to project the problem onto one screen while advancing through the solution on the other. Easy access to students gave tutors a clear overview of students' progress, letting them assist as required. Students were clearly more engaged with the material than in previous years, with many producing well-structured, correct solutions. Initially students were timid, but during the semester they grew braver and started to ask questions about the content and other aspects of the unit.

There was, however, little group work. Students commented that they did not see the value of group work and would rather work in pairs or alone. Moreover, there remained a number of students not participating, but simply waiting for solutions.

Peer observations revealed some inconsistency in the way the leaders were running the practicals. For some, in particular, time management was problematic. Also the introduction of the problem and the summary of the solution were delivered quite differently by different leaders. Some variation was natural and expected, but the degree of inconsistency was surprising, and raised concern among the project team.

Reflection

We rethought our assumption that we could simply tell the students to work in groups. Still believing in group work's effectiveness, we now sought methods to encourage it, rather than demand it. We also desired a further increase in the proportion of students engaging with the material at all.

2011b

Action

Reflections from 2011a inspired a revision of the practical delivery plan for 2011b. We abandoned forcing students into groups. Rather, students were told to work individually, in pairs or in small groups according to their preferences.

To encourage participation and engagement with the problems, the solutions were no longer presented by the leader at the session's end. Instead, we now randomly selected a group of about five students per class to present their own solutions, with each student solving an allocated part of the problem.

Also, we wrote detailed lesson plans to increase consistency. Each week's lesson plan outlined a time allocation (for introduction, working time, etc.) and how the leaders were to introduce and summarise the problems (see Appendix for a sample lesson plan). We expected the new format to be slower, so we chose a subset of the practical problems to be solved and presented (though the practical material is distributed to students in a "study pack" printed in bulk, annually, and therefore now slightly disagreed with the session format).

As in 2011a, the practicals were delivered by both the lecturers and casuals, and peer observations were conducted. At the semester's end, students were surveyed regarding the practicals' delivery mode, their learning experiences and the space.

Observation

The new format, particularly the plan that students should present solutions, met considerable resistance from tutors before the semester began. Mostly, they felt unprepared to deal with student refusal to present and incorrect or badly presented solutions. These concerns surprised us, as most of the tutors had many years' higher education experience. After we provided written suggestions for dealing with various contingencies, the practicals went ahead with the delivery mode described above.

Based on peer observations, the level of engagement was much better than in 2011a. We observed only sporadic group work; most students worked alone or in pairs. The solution presentations varied greatly in quality. Due to the large number of students with English as a second language, the presentations were mostly written silently, without spoken explanation, though this improved somewhat during the semester. Compliance was almost complete, and the few students who did refuse to present solutions (only 3 or 4 students over the semester) were required to present during the following week's class.

The lesson plans increased consistency considerably. Most tutors found the lesson plans useful. Whenever problems were found with a lesson plan (during the first or second class of the week) we changed it immediately to improve that week's remaining practicals. Tutors appreciated this.

Results for selected questions from the student survey appear in Table 1. The results show that students found the space supportive of the learning activities, and that students were reasonably comfortable with presenting solutions and viewed the experience positively. Students also found it useful to see other students present solutions.

Reflection

The 2011b format seemed successful. Engagement had improved, though not, as originally planned, through group work. Tutors had grown more confident with student presentations during the semester, and we expected further improvement from continuing the format into 2012.

Table 1: Student Feedback to Changed Learning Space

Response variable description (Likert scale variables)	Mean (sd)	Range
The arrangement of the seats and desks effectively supported students to engage in the range of teaching methods used in this class.	4.17 (0.81)	1–5
I was given the opportunity to work with other students on these in-class activities.	3.95 (0.83)	1–5
Overall, I am satisfied that this class provided me with a high quality and valuable learning experience.	3.98 (0.82)	1–5
Being able to present solutions to the class helps prepare me for life after university.	3.84 (0.88)	1–5
I was (or would have been) willing to present my solution to the class.	3.86 (0.77)	1–5

I was (or would have been) confident to present my solutions to the class.	3.75 (0.94)	1–5
I found it worthwhile to see other students presenting their solution to problems.	4.31 (0.75)	1–5
I found it useful when teaching staff came and discussed my work with me at my desk.	3.85 (0.87)	1–5
The other students in this class were friendly and supportive, and I felt I belonged to a community of learners.	5.00 (1.17)	1–7
The teachers in this class were available, helpful and sympathetic to my needs as a learner.	5.81 (1.23)	1–7

2012

Action

New study packs were printed including only the problems to be solved and presented, with each problem divided into chunks labelled “Student 1,” “Student 2” etc., and including gaps for solutions. Thus the lectern form now exactly matched the students’ worksheets, streamlining the students’ workflow.

Observation

These sessions appeared to run more smoothly in 2012 than in 2011b, according to peer observation and informal staff feedback. With one semester’s previous experience with the format, teaching staff were able to set a positive and focussed tone from the outset. We did not hear of any student refusals to present, and most students appeared quite comfortable. Students more often augmented their written solutions with spoken explanations than in 2011b.

Comments on the practicals in student surveys in 2012 were mostly positive. One interesting example frames the presentation experience in a way reminiscent of the hero’s journey (Campbell, 1949), “[Practicals] were very helpful. I do not like speaking in front of the class but the fairness of everyone had to was good and I think it helped in the long run even if I did not enjoy doing it.” One student said that the practicals “were in great rooms.” The only specific negative comment about the practicals held that the problems were too easy, providing insufficient preparation for the exam.

Discussion

This article describes how an action research method was used to improve the structure and delivery of practicals in a large quantitative university unit. The situation before 2011 was clearly unsatisfactory, but the action research framework was instrumental not only in making pedagogic improvements, but also in articulating the problems needing fixing. In particular, we began with the intuition that we wanted students to discuss the practical problems with each other, but when the action research method required us to articulate our motives and relate them to learning outcomes, we saw that our real target was student engagement, of which group work was simply one mode. Changing our focus to engagement led us to redesign the sessions to facilitate and motivate engagement, without prescribing the mode.

We identified six factors in the improvement in student engagement which could add to the literature on importance of learning spaces:

- We introduced detailed lesson plans to ensure consistency of delivery. Our example lesson plan, although specific to our unit could be adapted for use in other units.
- The new teaching space is arranged to allow students more interaction with each other and with staff. We have clearly documented the benefits of the new learning space, both from teaching staff's perspective and with student surveys. These might encourage others to build and use such spaces.
- It is much more comfortable than the previous space, allowing students better interaction with each other and academics. Today's successes may inspire renovation or design of tomorrow's teaching spaces. It has two independent projectors, facilitating a problem-solving class style. Problem-solving ability is increasingly recognised as a desideratum of university graduates, by academicians and the wider community.
- We now run more practical sessions, with smaller class sizes, which would not have been practicable in the previous space for timetabling reasons. We consequently expect more engagement in this space, and will document this as the project progresses.
- The student presentations, which would have been awkward in the previous space, are natural and effective in the new space. While student presentation is a traditional classroom activity, the authors believe it has declined with the massification of higher education. Our work demonstrates that it is practical and relevant to large modern classes.

Five of these six factors relate to the teaching space.

One limitation of this study is that most of the evidence we have used is qualitative and subjective.

Our efforts to improve engagement in STAT279 and the campus-wide project on teaching spaces are ongoing work. From 2013, STAT279 practicals will run in a newer space which we hope will provide further improvements. It has a capacity of 60, with seats in groups of six arranged around ten tables. The room has no central screen; rather, each table has its own screen, which can be controlled from the table, or centrally from the lectern. We expect this room to provide all of the benefits of C5C Forum, but to more effectively encourage group work, which we still believe to be educationally effective (and a valuable skill in itself). Further, we plan to study the extent to which groups formed in class may persist outside class as voluntary co-study relationships, and what kind and arrangement of campus facilities will enable this learning pattern.

Also we are discussing a study of staff attitudes to pedagogic innovation and technology in teaching teams. Staff resistance to the student presentation format took us by surprise, and required some scrambling to allay. Staff confidence and faith in the lesson plan is essential to effective learning. Therefore we plan to survey and/or interview casual staff in regard to future innovations to gain insights into their attitudes and concerns.

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Appendix: Lesson Plan for Week 13 Practical

Purpose:

This Practical focuses on Queue module. Problem is a Single server queue from a limited population problem. Like last week, we want students to understand that the hardest parts of a queueing problem are the identification of the parameters as well as the identification of the queue model (so that the correct formulae can be used for calculations). It is important to talk about the differences between the Single server queue from a limited population and Single server queue with a limit to queue size. I usually give students an example like the following by asking them questions.

1. Suppose I am a cleaning lady. If I am working in a hotel and my job is to clean the rooms in the second floor, what kind of queue model applies to my situation?
Single server queue from a limited population
2. Again, suppose I am a cleaning lady, and I own my business. I can only clean 5 places in a day; what kind of queue model applies to my situation now?
Single server queue with a limit to queue size

The difference between the two is the **customers** (the rooms) are always the same for the limited population (say I am not going to clean any rooms other than the rooms in the second floor) and the **customers** are different for the limited queue problem (I would be cleaning different people's homes or offices). If you don't feel comfortable with the cleaning lady analogy (for instance because, in the second example, there's no obvious reason why cleaning jobs couldn't remain in a queue for more than one day), you can make up a different one, but do try to illustrate the difference.

Problem set:

The problem in the Practical is based on the Queue module and does not depend on any other prior knowledge. We expect the students to have problems differentiating between limited population and limited queue models.

Mode switching plan:

1. Problems Introduction (10 minutes)

Practical Leader: Introduce the Practical problem. With the help of the students, identify the queue model. (Don't just get the answer—really discuss it. Perhaps ask them what would have to be different to make it a limited queue model instead.) Define the parameters of the problem, again with the class's help. As previously, try to make this part interactive. The format is the same as last week.

2. Working Time (15 minutes)

Working time, with the usual format. If students are not asking for any help, go to them and ask them questions to start discussion. Five (5) students are needed for presenting the solutions.

3. Presentation of Solution (20 minutes)

Presentation time, with the usual format. Allocation of students to the parts of the solution is indicated on the solution form.

Student Allocation: Dear Leaders, please give students opportunity to say something about their findings. Remind them the numbers do not talk, they need to do the talking 😊

Student 1: To calculate P_0 and P_1, P_2, P_3 and P_4 , using the two formulae given. (Space is provided for the student to compute the probabilities on one page, and there is a table to collect the answers on the following page. If the student neglects to transcribe the values into the table, it's probably easiest for the tutor to do that after thanking the student.)

Student 2: To calculate the probability that less than two escalators are broken down. Tell us what s/he is doing.

Student 3: To calculate the probability that at least two escalators are broken down. Tell us what s/he is doing.

Student 4: To calculate the average numbers of escalators waiting to be fixed and in the system. Tell us what s/he is doing.

Student 5: To Determine the average waiting time for the escalators in the queue and in the system. Tell us what s/he is doing.

4: Leader's Summary and Conclusion to the Class (5 minutes)

Instead of specifics of the problem it would be better to talk in general terms and point out how they apply to this specific Problem.

Points you need to emphasise (mostly the same as last week):

- **Identifying the parameters** of any queue problem is not easy but requires thinking (and **paying attention to time units**) ☺
- Identifying queue model is easier when they correctly identify **what the service is**, and **who is being served**.
- Differentiating between the **queue** and the **system**: emphasise that system is always larger than queue (unless they are both empty) therefore the average length of the system will always be larger than the average length of the queue. Similarly the average waiting time in the system will always be longer than the average waiting time in the queue.
- Deciding what should be the “n” in the probability formulae.
- Make sure they **write the units** for the relevant parts of the solutions.

Teaching staff's comments:

(Please comment on any issues with the Practical material (contents, length and so on), students' engagement, timing and the mode switching plan.)

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