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EFFECTIVE IMPLEMENTATION OF CONTEMPORARY PRINCIPLES ON LEARNING AND TEACHING A FUNDAMENTAL FIRST-YEAR ENGINEERING COURSE

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Statics is the most fundamental component of Engineering Mechanics, and it is usually delivered in the first year in a common core course for engineering programs. The delivery of this key unit to the fresh first-year engineering students is very challenging and thus teaching pedagogies, strategies and methods should be further developed in response to the challenges in this important course which critically facilitates the transition of the students from high school to university and establishes their foundation knowledge on Engineering Mechanics. This paper reports the effective implementation of contemporary learning and teaching principles in a first-year core engineering course-Statics. The learning and teaching activities designed in this course include independent learning and collaborative learning, problem and project-based team work and peer learning, and progressive assessments. Effective teaching pedagogies, strategies and methodologies are developed on the basis of these educational principles to engage and motivate the first-year engineering students at most. The proposed methodologies are demonstrated effective in engaging a medium to large size class and the results of formal course surveys demonstrate the efficiency of these methods.

Keywords: Learning and teaching principles, Collaborative learning, Problem and project-based team work, Progressive assessments, Engineering education.

1 INTRODUCTION

Statics or Fundamentals of Mechanics is usually delivered in the first year in a common core course for engineering programs, as the most fundamental component of Engineering Mechanics. The delivery of this key unit to the fresh first-year engineering students is quite challenging with medium (with the number of student more than 40 and less than 100) or large classes (with the number of students more than 100). There are three main challenges: a) medium and large classes are much more impersonal compared to smaller classes, making it more difficult to engage students; b) fresh engineering students usually find themselves in a challenging first-year transition environment in which they have to negotiate their acculturation to university, especially at the University of New South Wales (UNSW) Canberra where they are also simultaneously introduced to military life; c) first-year core introductory engineering

courses traditionally focus more on abstract theoretical knowledge such as physics and mathematics, etc. Therefore teaching pedagogies, strategies and methods should be further developed in response to the challenges in this important course which critically facilitates the transition of the students from high school to university and establishes their foundation knowledge on Engineering Mechanics. One of crucial issues facing medium- to large-class lecturers is the need to engage first year students in order to enhance student learning and ensure satisfactory student learning outcomes as required.
In this engineering education research, the pedagogies, strategies and methods of teaching are developed in response to these challenges and a case study is established using a teaching practice of a medium sized class with about 100 students in the first-year engineering course in 'Statics' at UNSW Canberra. The teaching pedagogies, methods and strategies deployed in this course are based on a combination of both contemporary western as well as ancient Chinese principles of learning and teaching, and also reflect the authors' extensive teaching experience and practice.

2 BACKGROUND AND CONTEXT

'Statics' forms a solid basis for other core engineering courses such as Dynamics, Mechanics of Solids, Structural Mechanics, Structural Analysis and Design, Finite Element Analysis, and Computer Aided Design, etc. as the foundation engineering mechanics course. For instance, at UNSW Canberra, Statics is a core subject in the first year curriculum of three Bachelor of Engineering programs in Mechanical Engineering, Aeronautical Engineering, and Civil Engineering. Similarly, at the University of Western Sydney (UWS), a first-year unit – Fundamentals of Mechanics is delivering statics to engineering students as a common core unit for five Bachelor of Engineering programs in Civil Engineering, Construction Engineering, Electrical Engineering, Mechanical Engineering, and Robotic & Mechatronic Engineering. High school Math is the Prerequisite and in particularly the required knowledge includes basic algebra, scalar and vectors, trigonometry, and integration.

In current study, only the course – Statics in UNSW Canberra has been chosen for the case study. Aiming to develop the students' graduate attributes specified by Engineers Australia in Stage 1 Competency Standards on Accreditation and UNSW, this course has been designed through specifying learning outcomes. For effective course design, teaching strategies and learning activities must be aligned with the expected students' learning outcomes (Biggs 1999). The learning outcomes specified above could only be achieved through the use of effective teaching strategies that deployed appropriate learning and assessment activities. The teaching methods and strategies deployed in this course are based on a combination of both contemporary western as well as ancient Chinese principles of learning and teaching, and also reflect the authors' extensive teaching experience and practice. The assessments in this course include ten hand-in tutorials, one laboratory component, one mid-session quiz, and one final examination. The assessments are designed to engage the students in the whole learning process, and to develop collaborative, independent and reflective learning so as to achieve the learning outcomes mentioned above. The assessment tasks and the weight of each of the assessable tasks were designed accordingly (see Table 1).

Table 1. Assessment tasks and weight.

Assessment task	Weight (%)
Ten Hand-in Tutorials	25 (2.5% each)
Lab	15
Quiz	10
Final Exam	50

3 SOMETHING OLD AND SOMETHING NEW: DRAWING ON EFFECTIVE TRANS-CULTURAL LEARNING AND TEACHING PRINCIPLES

Learning Principles Informed from Ancient Chinese Analects: In the Analects (Waley 1938, Slingerland 2006), the authors found a record of the "classified teachings" or "ordered sayings" of Confucius (551-479 B.C.E) and his disciples, and these actually represent the fundamental ideas of the contemporary principles on learning and teaching. For example, the saying of "Two heads are better than one" and "There is always someone to learn from" coincides with the principle of peer and collaborative learning. The verses in the ancient Chinese Analects, i.e., "People can get something new when reviewing and reflecting what they have learnt", and "He who learns but does not think will be lost and he who thinks but does not learn will be in great danger" emphasized the importance of reflective learning, which is one of the contemporary principles on learning. The problem-based and project-based learning in the contemporary principle agrees well with the saying recorded in the Analects (The Analects 2011), i.e., "Is it not pleasant to learn with a constant perseverance and application?"

Tuning Large Lecture Class with Small Tutorial Class: Traditional large class teaching via lectures needs to be supplemented with participation in effective small group learning. Both the realities of teaching large classes in undergraduate programs, especially in foundational courses, and the efficacy of active learning in small group settings should be well identified and tuned. Large class lectures can be used as the springboard for whole-class discussions and other teaching strategies to promote active learning (Cooper *et al.* 2000). Small group learning has proved to be a most effective way of engaging students in active learning and thus can make a significant difference in the quality of students' learning (Fink 2004). Small groups learning and teaching allow for better rapport and more effective communications among students and between the students and the lecturer. Therefore to engage the students effectively and enhance the students' learning, both large class lectures and small group learning strategies were used in this course.

Progressive Assessments: Progressive assessments and effective feedback provide critical levers for enhanced learning. The significance of assessment in higher education has been stated often in the literature. According to Isaacs (2001) many students treated assessment as central to their academic activities at university, and assessment could and did play an important role in their learning. He also stated that what students learnt, their time-on-task, and the nature of their learning were determined for most part by the extent and nature of the assessments they were exposed to and engaged in. Gibbs (1999) stated that assessment was the most powerful lever lecturers had at their disposal to influence the way that the students responded to courses and behaved as learners. Appropriate and effective assessment tasks and timely feedback can improve student engagement and enhance their learning. The assessment methods and assessment tasks should be designed to align with the expected students' learning outcomes (Brown 2001). Based on these principles on assessments, ten hand-in tutorials (assignments) were designed with nearly one assignment in each academic week during the whole session. The students were required to solve several problems using the theories they learned from the lecture in each hand-in tutorial. By setting each hand-in tutorial an individual weight towards the final marks, the students were successfully engaged in active learning.

Independent Learning and Problem and Project-Based Collaborative Work: Assessment tasks based on collaborative work, including the problem-based hand-in tutorials and the project-based 'design/build/test' lab work were designed. The 10 problem-based hand-in tutorials were set to enhance deep understanding of concepts and theories and to improve their problem solving abilities. The project-based 'design/build/test' lab work was set especially for students to use the theories they were learning to formulate, analyse and solve real engineering problems, and also to develop the deep understanding and application of knowledge in real-life engineering situations under team work conditions. These assessment tasks turned out to be very effective in engaging students in active learning. At the same time, students gained valuable opportunities to develop effective collaborative team skills and improve generic skills such as effective communication skills, time management skills and leadership.

Reflective Learning: In addition to the learner's autonomy and collaborative learning, reflective learning is significant and helpful to develop students' deep learning in this course. The students were advised the effectiveness of reflective learning in the first lecture through citing Confucius and the value of learning by doing revision and reflection regularly, including chapter reviews, establishing relationships between topics in each chapter and with other topics. They were also encouraged to reflect on what they learnt from this course, build the knowledge frame for this course, and develop the link between this course and other courses and also between the course and real engineering practice. To motivate and ensure students' engagement with reflective learning, the mid-session quiz and the final exam played important roles and engaged students successfully in reflective and active learning.

4 RESULTS AND DISCUSSION

To investigate the effectiveness of the teaching and learning strategies employed in this course the official course evaluation - Course and Teaching Evaluation Improvement (CATEI) at UNSW was conducted in the final stage of the course in 2010. The CATEI course survey has ten questions as listed in Table 2 and the responses are classified as Strongly Agree (SA), Agree (A), Moderately Agree (MA), Moderately Disagree (MD), Disagree (D), and Strongly Disagree (SD). The course evaluation report for Statics in 2010 is summarized along with the mean rating for each of the ten questions in Table 3.

Table 2. CATEI course survey questions.

Number	Question
Q1	The aims of this course were clear to me.
Q2	I was given helpful feedback on how I was going in the course.
Q3	The course was challenging and interesting.
Q4	The course provided effective opportunities for active student participation in learning activities.
Q5	The course was effective for developing my thinking skills (e.g., critical analysis, problem solving).
Q6	I was provided with clear information about the assessment requirements for this course.
Q7	The assessment methods and tasks in this course were appropriate given the course aims.
Q8	The information/materials provided for this course helped me to learn independently.
Q9	The aims of this course were met.
Q10	Overall, I was satisfied with the quality of this course.

The four most common comments are: 1) small class tutorials were very helpful in developing deep understanding of the concepts and theories and in developing confidence in problem solving for the assignments; 2) More revision from the lecturer for each chapter will be appreciated; 3) More interesting activities such as the design/build/test lab work will be desired; and 4) More examples solving relating to practical applications in the real world will be preferred.

Table 3. Summary of CATEI results.

Question	SA (%)	A (%)	MA (%)	MD (%)	D (%)	SD (%)	Mean Rating (Out of 6)
1	27	64	6	0	0	0	5.22
Q2	25	56	13	3	1	0	5.01
Q3	30	54	13	0	0	0	5.18
Q4	29	50	19	0	0	0	5.10
Q5	36	49	13	0	0	0	5.24
Q6	31	54	11	0	0	0	5.21
Q7	34	50	13	0	0	0	5.22
Q8	27	44	23	3	0	0	4.99
Q9	27	60	10	0	0	0	5.18
Q10	29	56	11	1	0	0	5.15

5 CONCLUSIONS

Contemporary and ancient learning and teaching principles have been implemented innovatively in the teaching practice of a medium-sized class, Statics at UNSW@ADFA, through designing teaching and learning activities accordingly, which were demonstrated to be effective in engaging the students during the whole course and in enhancing their learning. The assessment method has a significant impact on student learning which should be designed well to align with the course aim, student learning outcomes, teaching strategies and learning activities. Progressive assessments are effective for engaging students and thus it is suggested that progressive assessment tasks should be designed in the course. Independent learning and collaborative learning are both effective learning methods, and teaching and learning activities should represent a well-balanced combination of both of them. Independent learning is essential for the students to develop their own understanding of theories and skills for problem solving. To encourage and ensure collaborative learning in small groups, problem and project-based assessments are essential. Problem-based assessments are very helpful in improving students' problem solving abilities. Project-based assessments exposed students to the opportunity to identify, formulate and solve real engineering problems using the theories they learnt. Reflective learning is demonstrated to be very useful and effective to enhance student learning.

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