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Bridging the Gap for Diploma Students Taking a Degree Unit as Elective in Engineering

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BACKGROUND

In a multi-sectoral university, it is an advantage to have cross-sector interactions between the sub-degree programs and Higher Education programs. One of these interactions is to have teaching activities for these two sectors together. In our setting, the Diploma of Electronic Engineering (DEE) students were allowed to select from a small pool of pre-determined units as electives in their final year of Diploma studies. One of these electives was DEE3224 Mechanics of Structures, which shared a common lecture with first year Bachelor of Engineering's unit of studies, HES1125 Mechanics of Structures.. The credits a student obtains at this level will be transferred to the Bachelor of Engineering Program of choice, if he or she articulates to a degree program in Civil, Mechanical or Robotics and Mechatronics Engineering. To enrol in this unit, the students must have completed the pre-requisite unit, Materials and Processes and completed Engineering Mathematics 1 and Foundation Physics. However, from empirical result data, it was found that diploma students underperformed when compared to degree students and contributed to a high failure rate in the unit.

PURPOSE

The aims of this paper are to identify the causes of poor performance among Diploma students and to study whether having separate tutorial and laboratory sessions coupled with a coached problem solving approach could improve the students' performance in the unit.

DESIGN/ METHOD

An informal interview with the Diploma students and lecturer teaching the unit was conducted to determine the reasons behind the problem. Besides having a separate tutorial and laboratory session for these students, a coached problem solving approach was applied in the tutorial sessions. The same teaching materials, i.e. lecture notes, tutorial questions and laboratory sheets, were used. The performance of the current cohort of students was compared to the performance of students from the previous semester. Student feedback collected at the end of the semester was also referred.

RESULTS

Results from the interview showed that a majority of the students found it difficult to follow lecture because of poor background in mathematics and physics. They were embarrassed to ask questions in class as there were many other students, usually more than a hundred students. Besides, they felt inferior in front of degree students. As a result, the students showed poor attendance and did not participate actively in class. It was also observed that some students had a poor command of the English language. Some of the students were also working part-time and actively involved in club activities; thus the lack of commitment and attention in lectures. After separating the tutorial and lab sessions as well as applying a coached problem solving approach, it was found that students were more motivated to come to class and learned more about the subject. The passing rate of the unit also improved.

CONCLUSIONS

The performance of Diploma students taking a degree unit as elective was studied. Students responded well to the coached problem solving method. The approaches taken were effective and could bridge the gap for Diploma students in big classes.

KEYWORDS

student performance, big classes, coached problem solving approach, tutorial sessions

Introduction

Course Setting

Swinburne University of Technology (Sarawak) is a multi-sectoral university, which provides students with a range of sub-degree programs and Higher Education programs. In a multi-sectoral university, it is an advantage to have cross-sector interaction between the sub-degree programs and Higher Education programs as it provides the flexibility of pathways between programs. The Diploma of Electronic Engineering (DEE) is a three-year or six-semester sub-degree program designed to comply with the Malaysian regulatory system that is delivered in Swinburne University of Technology (Sarawak). This Diploma program provides pathways into engineering degree programs at Swinburne Sarawak and Australia (Swinburne University of Technology, 2006). The entry requirement for this program agrees with the student selection in the Malaysian Qualifications Agency (MQA) published in 2011, which includes Malaysian Certificate of Education, better known as Sijil Pelajaran Malaysia (SPM) or its equivalent. According to Malaysian Qualifications Agency (2010), SPM is equivalent to O-Level or Australian Year 10. To enter this program, students must achieve at least three credits inclusive of Mathematics and Physics or Science subjects.

To establish cross programs interaction and articulate into the Bachelor of Engineering, Diploma students are allowed to select from a small pool of pre-determined units as electives in their final year of studies (Swinburne University of Technology 2006). One of these units is DEE3224 Mechanics of Structures (MOS), which features a combined lecture with a first year Bachelor of Engineering unit HES1125 Mechanics of Structures. The credits a student obtains at this level will be transferred to the Bachelor of Engineering Program of choice, if he or she articulates to a degree program in Civil, Mechanical or Robotics and Mechatronics Engineering. To enrol in this unit, the students must have completed the pre-requisite unit, Materials and Processes. The students would have also completed Engineering Mathematics 1 and Foundation Physics at that time. On the other hand, there is no requirement for degree students to enrol in MOS.

MOS is a unit that includes the studies of engineering statics and structural analysis. There are 42 lectures (three 50-minute lectures a week) and 14 tutorials (a two-hour tutorial a week) per 14-week semester. On top of that, students are required to do four hours of laboratory works per semester and are expected to do 7.5 hours of self-study a week. The assessments for the unit include 15% for laboratory work and reports, 20% for tests and 65% for final exam. To pass this unit, the student must achieve 35% of each major assessment and achieve an aggregated mark of 50% in the unit. A major assessment is one that contributes to 20% and above of the final grade of a unit.

As MOS is a first year common unit for engineering program, there are a large number of students enrolled in the class each semester. The number varies from 100 to 180 students each semester. Consequently, the number of Diploma students taking this unit is usually small compared to the number of students in degree programs. On average, Diploma students contributed to 15% of the total number of students in class. It was noticed that over the last few semesters, Diploma students did not do well and contributed to a high failure rate in the unit. Hence, it was decided after 2008 to separate the tutorial sessions between degree and Diploma students with the aim of improving the passing rates for this unit. Having separate tutorial sessions resulted in reduced class size and allowed small group teaching to take place. According to London Deanery (2012),

> *Teaching in a small group enabled learners to take part in discussion, active participation, feedback and reflection, and to consolidate learning, clarify understanding, and explore ideas and concepts.*

Teaching in large classes

Educators around the world acknowledged the differences and challenges in teaching large classes as compared to small classes (Felder, 1997, Mulryan-Kyne, 2010, Hsiao et al., 2010, Exeter et al., 2010). According to Mulryan-Kyne (2010),

> *The increase in the size of class in tertiary education had increased the demands that were being made on staff and institutions. These demands included increased accountability, demonstrable quality assurance and increased research and development. These demands placed considerable burdens on staff and were exacerbated by tight budgets and limited resources.*

And according to the Teaching and development institute (2002) in Exeter et al. (2010),

> *Teaching in large classes requires the same skills and commitment as teaching smaller classes, such as the need to motivate students, being systematic, organised and developing stimulating assessment tasks. These requirements become increasingly difficult with large classes, as expanding student numbers are often accompanied by increasing diversity of the student population, and greater demands and complexities in teaching and assessment.*

Efforts by staff to establish relationships with students are likely to result in too many demands being made on staff. There is a large volume of marking and student feedback as well as consultancy in addition to their teaching role. Besides that, some other important factors to consider when teaching large classes are the students' background, age and experience. As class size increases, the students are more diverse in terms of age, experience, cultural background and socioeconomic status. As quoted from Mulryan-Kyne (2010)

> *Whereas once those attending college were the brightest and the most highly motivated, and unfortunately also the most privileged; now college classes are comprised of students who vary in ability, interest and motivation.*

It is difficult to manage students with different capabilities and customize teaching to the students' levels. It is a challenge to observe and evaluate students' responses and provide individual attention that the students need. In large classes, there is also less opportunity to receive and give feedback to individual students and to engage students with the course content. Low student participation would then lead to high degree of student anonymity and thus, a lack of commitment and motivation for the students to enhance their learning (Exeter et al., 2010).

Apart from the problems mentioned above, other problems faced in teaching in large classes include poor interaction and discussion between lecturer and students. When the number of students increases, there will be less informal exchanges between students and lecturers. Consequently, it is difficult to get to know and relate to students and to establish a rapport with the students (Hsiao et al., 2010). There is also an increased stress associated with 'performing' to large classes, maintaining discipline in class and the limitation of teaching resources (Exeter et al., 2010).

Realising the issues that arise from teaching large classes, researchers started to study on innovative methods to address the problems. Some have taken the numbers to work to their advantages. They introduced group works to improve learning in class where the more able students help their peers. Results showed that students in cooperative learning condition outperformed those who study alone (Exeter et al., 2010, Hsiung, 2010, Mulryan-Kyne, 2010). By proper monitoring, students were also found to be able to improve their soft skills where they learn to share responsibility and help one another. This is an important skill to have when students start to work in the real world. Other innovative teaching strategies in large classes were demonstrated in Exeter et al. (2010), Hsiao et al. (2010) and Mulryan-Kyne (2010). These studies however, focused on students taking courses at the same level. In this study, the focus was on Diploma students taking a degree unit as elective.

In order to bridge the gap for Diploma students taking MOS as an elective, this study aims to identify the cause of poor performance among Diploma students and to study whether separate tutorial and laboratory sessions coupled with a coached problem solving approach could improve the students' performance in the unit. A coached problem solving approach is a type of group-based strategy. However, the differences between coached problem solving approach and other cooperative learning and team-based learning strategies are students are not graded as a group and they are not solving problems that require multiple individuals. The emphasis of this approach is on students collaboratively solving problems with the faculty present (Walser-Kuntz, 2012). According to Steinert (2004), promoting thinking and problem solving are identified as tutor characteristics which contribute to effective small group tutoring.

Methodology

Participants

The participants identified for this study were Diploma students taking MOS as their elective. These students were known to underperform compared to the same cohort of degree students taking the unit in the last few semesters. The performance of these students was measured in terms of attendance and participation in classroom activities. Besides that, their tests and final exam results were also compared to the average results of degree students. Although some degree students were found to be under achieving as well, the study focused on the group of Diploma students who were assigned to a separate tutorial session. To study the effectiveness of coached problem solving approach, the performance of the current cohort of Diploma students was compared to the performance of Diploma students from the previous semester. Although there have been minor modifications to the lecture content taught each semester, the overall structure of the course and course materials have remained relatively unchanged. The results of this study would therefore not be significantly affected by the course materials from different semesters. Results from the current degree students were also compared to the results from the degree students in the previous semester as control.

Materials

The same teaching materials, i.e. lecture notes, tutorial questions and laboratory sheets, were used. On top of that, additional tutorial questions were designed to guide students to understand the unit in the tutorial sessions. The questions were not pre-set but were developed on-the-spot according to the pace of the students. For example, to study the internal loadings on a beam, a question where a supported beam loaded with a point load was first given. Once the students managed to determine the reactions at the supports and draw the shear force and bending moment diagrams of the beam, an additional point load was added to the same beam. Students were then asked to determine the new reactions and the changes made to the diagrams. Additional loads were continuously added on one by one and the effects of each load on the beam were determined. The characteristics of the load were then changed; from point load to uniformly distributed load and moment. Comparisons were done to improve students' understanding of the topics discussed. The level of difficulty of the problems increased as students became more fluent with problem solving and content throughout the semester.

Procedures

Interviews were conducted with the Diploma students over the semesters to find out their perspectives of the unit and possibly identify causes of their underperformance in the unit. The interviews were done informally so that the students would be comfortable to give an honest answer. The students interviewed were the students who failed the unit in the previous semesters. Besides that, all the students taking the unit in the current semester

were also interviewed at the beginning of the semester. In total, twenty students were interviewed and some of the questions asked were:

How can we improve your participation in class?

Do you attempt all the tutorial questions after each lecture?

How long do you spend a week (on top of the contact hours) in the unit?

Do you do self-learning or try to search and read outside classroom teaching materials?

The lecturer teaching the unit was also interviewed and student feedback on teaching (SFT) which was conducted by the Student Operations at the end of each semester was referred. In the SFT, students were able to comment on teaching and gave suggestions which they feel can improve the teaching in the unit anonymously. This helped to determine the reasons for the students' underperformance and to design suitable measures to address the issues faced by the students.

The Diploma students were enrolled in separate tutorial and laboratory sessions from the degree students. In the short two-hour tutorial sessions over the 14-week semester, students were exposed to a coached problem solving approach. In this approach, students were exposed to interactive lectures and problem solving in groups. Each tutorial session starts with a revision of the topics discussed in the lecture. In order to engage students, 'leading' questions were asked to introduce the content. This also helped the lecturer to indirectly assess the level of understanding of the students. The key points for the lecture were then summarised and the students were asked to attempt some simple problems. By solving problems in class, the lecturer was able to identify and clear up misconceptions faced by the students. The lecturer was also able to provide help immediately. This approach emphasized formative assessment instead of evaluation.

The problems the students did in class were different from the problems asked in the tutorial templates which were given at the end of each lecture. These new problems were designed to connect ideas in the tutorial sessions. Once the students managed to solve the simple problems and understand the basic of a theory, details were added to the problems in a scaffolded manner. The purpose is to introduce additional information to the students incrementally and to help students develop problem solving strategies.

Although it was observed that a high-achieving individual student could potentially work on his or her own, it was believed that the students would benefit from doing group work. By doing group work, students worked collaboratively to solve complex problems and thus they were given the opportunity to teach others, verbalize their thinking, defend their reasoning, observe how other students had taken notes, and hear different approaches to solving a problem. Research indicates that the quality of a solution improves when a group works together to solve a problem (Hsiung, 2010 and Exeter et al., 2010).

However, from the lecturer's experience, group work ceased to be effective if the group is big. Some students will be excluded and will not participate in discussions. Thus in this study, each group of students consisted of not more than four students. The students were randomly selected to form groups in order to ensure a better mix. The more able students could then help others to understand a theory. Occasionally, the groups of students were asked to compete against one another to develop team spirit and add fun to the working session. The group who managed to solve the problem correctly within the shortest time won the competition. At times, students were also encouraged to volunteer to solve problems on the whiteboard.

Results

Students' perspective

A collective feedback produced from the interviews with the students is shown in Table 1.

Table 1: Feedback received from students over three semesters

Semester	2, 2010	1, 2011	2, 2012
Number of students interviewed	2	8	15
Prefer tutorial over lecture class size (%)	100	87.5	73.3
Spend time on self-learning and attempt tutorial questions (%)	50	25	26.7
Actively involved in club activities or working (%)	0	50	26.7

Results show that student learning was affected by the size of the class that the unit was conducted. Students expressed that there were too many students in the class and thus, they were easily distracted. Not much active-learning activities could be conducted and students lost their attention after a short period of time. Some students also voiced that it was difficult to follow lectures because the lectures were too fast. Besides that, they were also embarrassed to ask questions in front of other students. They felt inferior compared to degree students and they appreciated the separate tutorials as they could grasp their explanations and eventually the topics taught. Therefore they would prefer to have longer tutorial sessions than lectures. It was also found that the students did not spent adequate time learning the unit or to practice solving problems. The students did not manage to finish answering the exam questions on time. Some students were also found to have time management issues as some were working part-time or night shift or were too engaged in club activities. They were then too exhausted to attend lectures or to participate in classes.

Student feedback on teaching showed that the students enjoyed the new teaching approach. They found it easier to follow and understand a topic during tutorial than the three hours of didactic teaching approach. They also shared and appreciated the lecturer's personal interaction with the students. Some of the comments received were:

> *"the lecturer is helpful and attended to every students' questions"*
>
> *"the lecturer is willing to motivate students to work hard in their studies"*
>
> *"she gives the feeling of not to miss my lecture and please come again with her fun and interesting method of teaching"*
>
> *"her teaching is interesting"*
>
> *"she helps student in an effective way"*
>
> *"she gives a new way of thinking to students to think and encourage the students to be advanced"*

Lecturer's perspective

According to the lecturer teaching the unit, the main challenge in teaching Diploma students in a large class was that the amount of interactions between students and the teacher were limited. Students did not get to know each other and did not have a close relationship as compared to small classes. The students were also less committed and had a low motivation to the unit. Some students were frequently late if not absent for class and some were even browsing the internet during lectures. These students chose to sit at the back of the class and adopted a passive role in class.

Besides that, the lecturer found it challenging to manage students in a large class. It was difficult to manage students entering and exiting the lecture hall, which often resulted in teaching session starting late. The lecturer also had to deal with the noise level during in-class tasks. It was also difficult to engage every student in classroom activities as the lecturer was not able to supervise the students individually. Thus, some students failed to contribute

to group activities in class. For that reason, the lecturer tried to engage students in the tutorial sessions.

The lecturer also felt that the Diploma students were unprepared to deal with the large class size that confronted them. This was because they were used to small classes. The maximum of numbers of students in each Diploma class was 25. Even in secondary schools, the number of students was capped at 50 students per class. The students might have experienced a 'culture shock' as they were not used to the environment and teaching style.

Comparison between the students' attendance to the attendance from the previous semester showed that the students' attendance in tutorial classes improved when coached problem solving approach was applied. On average, 80% students attended the tutorial sessions compared to 65% in the previous semester.

Through coached problem solving approach, the lecturer was also able to assess student learning informally and paced her teaching to the capability of the students. In the small tutorial class, students were more willing to participate in classroom discussions and activities. It was observed that these students generally had a poor background in mathematics and a poor command of the English language. Consequently, the lecturer did some revision and provided step-by-step guides to solve a problem.

Through coached problem solving approach, the lecturer was also able to guide the students to estimate the time required to solve a problem. This helped students to plan their time when sitting for a test or final exam to minimise the chances of having not enough time to attempt the whole paper. The students were taught not to leave any problems blank.

After this approach was applied, there were more interactions between the lecturer and the students and among the students themselves. This helped to build understanding and a sense of community in the classroom. Comparison of the test and final exam results also showed that there was an improvement in the results in general. In total, there was a 40% improvement in the Diploma students' passing rate in the unit as compared to the previous semester. There was also a 19% increase in the average aggregated marks of the unit, from 46% to 65%. The marks of the degree students were used as control and results showed that there was only 1% difference in the average aggregated marks in the semester as compared to the average aggregated marks of degree students in the previous semester.

Although there was an improvement in teaching, the lecturer felt that this method can only be applied in small classes of not more than 25 students. This was because the method required a lot of time and effort from the teaching staff. A lecturer also needs to be enthusiastic and careful in monitoring student progress to cater for the needs of individual students. Above all, the lecturer felt that it is important to praise and give continuous encouragement to the students for the approach to be successful.

Conclusions

Implication

The performance of Diploma students taking MOS, a first year degree unit as elective was studied. In general, Diploma students found it difficult to perform in this unit because of the large class size. Besides that, the lecturer observed that the students had a poor background in mathematics and a poor command of the English language.

Results from this study show that separate tutorial and laboratory sessions coupled with a coached problem solving approach can improve the Diploma students' performance in the unit. The approach has improved the students' learning experience and has increased the passing rates of the Diploma students in the unit. Students enjoyed the teaching approach and were satisfied with the current model. The approaches taken were effective and could bridge the gap for students in big classes. This is important for the retention of students in engineering.

However, it is also acknowledged that this approach is only suitable for small classes. The requirement of the approach demands additional effort from the lecturer as each student has a different learning ability.

Limitations and future research

This study has a few limitations. The first limitation of this study is that it focused on Diploma students from different semesters. Although it involved the same unit and only one instructor, the outcomes of the study might be influenced by classrooms effects such as facilities, time-tabling and improved teaching materials and exam papers. Besides that, student feedback on teaching was also not conclusive. Not all students responded to the SFT and thus some comments might not be captured. Future research needs to focus on students taking the unit in the same semester. Strategies to gather feedback from all students also need to be formed.

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