FACILITATING ACTIVE LEARNING IN THE CLASSROOM

Caitríona Ní Shé and Lisa Looney

Mechanical and Manufacturing Engineering, Dublin City University, Ireland
E-mail: lisa.looney@dcu.ie

ABSTRACT

In the context of a relatively traditional second year module in for mechanical engineering students, *Strength of Materials*, changes were made to module delivery to facilitate more active learning. The motivation was a perceived need to improve the level of understanding achieved by the students. Justification for the changes was an assessment of student learning style preferences, which indicate a strong preference for active learning. Results show that changes in how lecture and tutorial activities were managed increased the level of student engagement during classroom sessions. In addition, 'small step' approaches to problem solving proved popular among students. The study also indicates that both students and lecturers need time to become practiced in the new approach, and that benefits of changes to traditional 'talk and chalk' lecturing may take time to become apparent.

INTRODUCTION

Strength of Materials 1 is a second year core module taken in first semester by all mechanical engineering students in Dublin City University (DCU). In this module students gain basic analytical skills fundamental to more advanced design and materials modules that are undertaken in senior years. The content involves elastic analysis of basic components such as beams and shafts, is relatively standard, and will vary little between engineering schools. Dr. Lisa Looney, senior lecturer in engineering has been module coordinator for the subject at DCU for a number of years. Based on exam statistics, and her interaction with students during tutorials, she became concerned that many students fail to genuinely understand concepts that are fundamental to their development toward competent engineering practitioner. She therefore decided to examine ways in which the students could gain a deeper understanding of the required concepts.

Students take in and process information in different ways, and there are many different techniques of classifying both student learning style and lecturer teaching style. The Felder/Silverman model [1] was selected for this project. The model has been tried and tested globally [2] and has previously been used in studies at Irish third level institutes [3, 4]. The model is not entirely original using well-known psychological types (Jungs theory of psychological types) and other learning style models (Kolbs Learning Style model) in its development, and it also relies on the experiences found in engineering schools. The model proposes that there are four dimensions to students learning style: *Active/Reflective, Sensory/Intuitive, Visual/Verbal and Sequential/Global.* Students use all dimensions of learning and, within each dimension, will have a preference that is anywhere along a scale from one extreme of the dimension to another. For example when analysing a student's learning style in the active/reflective dimension it may be found that the student only learns in an active way, learns more from reflection than action, or learns with an equal mix of both. Active students learn by doing and like to try things out and work with others. Reflective learners learn by thinking things through, by examining and manipulating information and working alone.

Research has long indicated [1] that there is a mismatch in engineering education between the students' learning styles and the lecturers teaching styles, which has serious consequences. It has been shown that when lecturers modify their teaching styles and students develop their learning styles, students can greatly increase their learning within the classroom [5, 12, 6]. The aim of this study was to establish what modifications to teaching style might be conducive to improving student learning, and to monitor the success with which such changes were implemented.

METHODOLOGY

The learning style preferences of students were initially assessed, and then the existing teaching approach modified in light of the results. Students were told of the planned approach and given feedback on their learning style profiles. The tools used to assess the project were classroom observations, student surveys, student input into a learning journal and assessment results.

Over a number of years Felder and Soloman [7] developed an Index of Learning Styles (ILS) to assess where on the scale between the extremes of each dimension the student preference falls. This is a self scoring online instrument that can also be downloaded and completed manually. It has been checked for test-retest reliability, internal consistency and construct validity [2]. The score is given on a continuous scale from one extreme of the dimension to the other. The scores are 11a, 9a, 7a, 5a, 3a, 1a, 1b, 3b, 5b, 7b, 9b, and 11b. A student scoring 11a on the Active/Reflective dimension is an extremely active learner, while a student scoring 11b is an extremely reflective learner. In May 2006 the students (then in first year) were all given a printed copy of the Index of Learning Style (ILS) instrument and asked to fill it out during class time. These were then collected and individual scores calculated. In September 2006 when the students returned to University, any students who had not previously completed the ILS were asked to do so. A total of 46 ILS forms were collected and collated for the Strength of Materials class. For the purposes of describing the strength of preference of a student's particular learning style, the scale was grouped according to the following: Strong preference = score of 11a, 9a, 9b, or 11b; Moderate preference = score of 7a, 5a, 5b or 7b; Mild preference = score of 3a, 1a, 1b, or 3b.

Felder and Silverman [1] recommend that lecturers should talk to students about their learning styles and give them instruction on how to learn more effectively. The first class of the Strength of Materials module was given over to exploring the goals of learning (versus passing an exam). The dimensions of the ILS and the proposed changes to the teaching style of the module were explained. A presentation was made to the class of the overall ILS data. Each student was then given, in writing, the outcome of their learning style preferences, with results for the whole class. This was followed up in week 4 with a workshop with an external researcher who spoke to them on studying/note taking techniques that work well for individuals with specific preferences.

To monitor the changes in the teaching style, a research assistant sat in on the classes and observed the behaviour of both the teacher and the students. Observations were made on the amount of time spent teaching in a particular way (lecturing / tutorial / questioning), and the frequency and nature of interactions. The participation of the students was noted throughout. Groupings of students during tutorial activities were also recorded. Over the semester, class observation data was gathered from a total of 13 of the classes, 9 two-hour classes and 4 one-hour classes, representing two thirds of all classes. Attendance at classes was monitored.

Throughout the module the students were asked to complete a number of online questionnaires: one at the beginning of semester, one in week 3, one in week 8 and a final one after the module exam, but before results were known. All this data was recorded using moodle, DCU's e-learning environment, and then transferred onto an SPSS database for statistical analysis. Students taking this module also kept a learning journal, and the journal entries were examined for any additional feedback relevant to the classroom approach being taken.

RESULTS AND DISCUSSION

Learning style preference: Considering only the active/reflective dimension, 72% of the DCU cohort show a preference for active rather than reflective learning (n=46). The current data is consistent with international data [2] for engineering students (Figure 1), and contrasts with a preference for reflective learning found among business studies students [8]. Interestingly, of the 10 studies contributing to the international mean for engineering, results closest to those for the DCU students relate to manufacturing engineering students, University of Limerick [4].

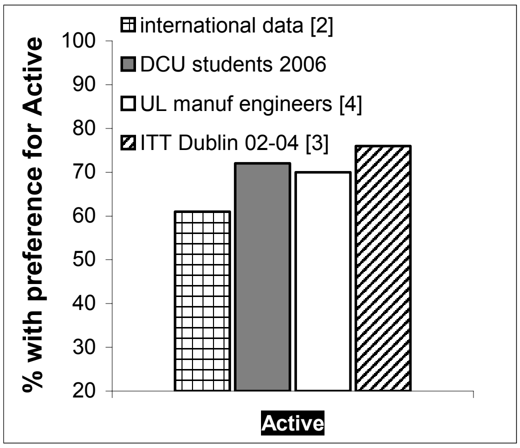

Figure 1: DCU students Learning Style in the Active/Reflective dimension, compared with other studies of engineering students

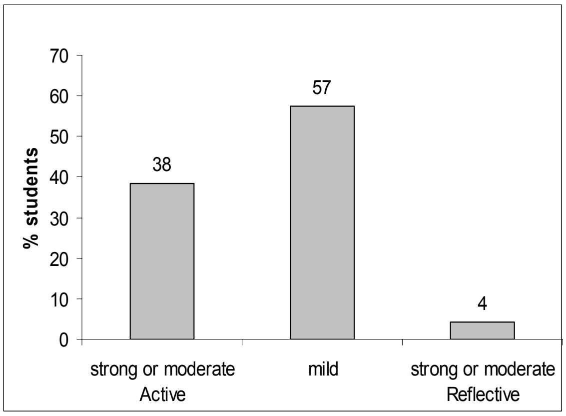

Figure 2: Strength of DCU students' preferences across the active/reflective dimension

Most research has indicated that it is the strength of preference of the dominant learning style that influences how a student learns in the classroom. For 38% of the DCU students, the preference for active learning is a strong or moderate preference (figure 2).

Matching teaching styles to learning styles: Educational modules should aim not to match the students' preferences, but to provide a balance, so they have some opportunity to work in their favoured style, and are also be challenged to develop their weak learning styles [9]. The approach used traditionally in Strength of Materials class was reviewed to assess the extent to which delivery addressed the newly identified preference for active learning. Module delivery over a 12 week semester has been by lecture (2hrs/week), tutorial (1hr/week) and laboratory (3 X 3 hr sessions in total), with a 2 hour end of semester exam accounting for 80% of module marks.

One way of increasing active teaching time is by giving more student exercises and encouraging greater participation by the students [10]. Students were encouraged to participate more during lecture time both by asking questions and encouraging them to ask questions. In order to support active learners, the lectures and tutorial breakdown was changed. It was planned that all classes would become a mixture of lecture and tutorial with any continuous lecture aspect limited to a maximum of 20 minutes. Tutorial exercises were modified to guide a step-by-step approach to solving problems, with each step requiring only a few minutes work. Students were separated into groups of 3 or 4 with the intention that group and cooperative learning would become established over the semester. 2 of the 3 separate hour sessions were incorporated into one 2hr class (with a break) in order to facilitate this new approach. It is worth noting that laboratories (which are obviously active) were excluded from this particular study. There are a range of issues surrounding their implementation, which go beyond student learning style, and will be considered separately.

Observed changes - Lecture Segments: The changes were implemented as planned. Over the course of the lectures research assistants observed greater participation levels by the students. This is illustrated by the rate of student questioning and responses. Student questions per session rose from one in the beginning, to 15 in week 10. Of the 10 questions Lisa asked in an early class, 9 went unanswered, whereas by week 10 she asked 20 questions, all of which were responded to by students. It was observed that the students became quicker in responding. Lisa made a conscious effort to learn students' names, and this did help with eliciting responses.

Observed Changes – Tutorial Segments: When observed in class, the breakdown of the tutorial questions did not appear too successful in the beginning. Some groups were finished steps quickly and proceeded to chat or, if they got stuck, they stopped working and waited for Dr. Looney to get around to them. Most of the observed tutorials were based on the students spending between 2 and 5 minutes on a step and then Dr. Looney (or in two incidents a student) putting answers on OHP and then moving to next part. When the time went beyond 5 minutes a lot of the students ended up chatting. However one research assistant observed that by week 9 tutorial steps were finally working. This was due in part to students getting used to it and also to Lisa managing the time better. It appears to be a good idea but needs an adjustment phase and good time management.

The literature [11] recommends that students should be formed into groups that match their learning styles. This did not work out as planned. The classroom was a lecture room with long benches (about 30 rows x 12 seats). The students rarely (and reluctantly) moved to form organised groups. Effectively they rejected the 'allocated group' and just formed groups of 2-6 students that happened to be beside each other on a given day. There was a lot of interaction between groups when they were on same bench or directly in front and behind. Both research assistants observed that the level of student activity and participation in tutorial exercises increased over the semester. The lecturer also felt that that student activity and participation had increased over previous years.

Questionnaire Responses: On a Likert scale from *1, strongly disagree* to *5, strongly agree*, the students report a good level of consultation between students in solving tutorial questions (3.9), and students being invited to make suggestions on solutions to problems (4.2). Students were positive about both the breakdown of the tutorial into small steps (3.7) and the fact that the tutorials help in their understanding (3.6 and 3.7), although a minority (6) said in their journals that they did not like the lecture/tutorial mix.

By midway through the semester 75% of students reported having contributed in class, whereas only 50% said they had contributed on other modules. 77% said that the subsequent discussion helped understanding. The reason most cited for not contributing was a lack of confidence in having enough knowledge to ask a question, followed by shyness, and a concern that peers would find the question too simplistic. This lack of confidence in knowledge grew as a reason for not participating from the early weeks. The majority of the students (67%) reported studying on their own, as they do for the other modules. The survey data indicates that over half the students learnt from the lectures, but most tended to study just before the exam. The students appear to be taking a surface approach to their learning, which the changes to module delivery did not effect as we had intended.

Exam Results: Table 1 compare Strength of Materials 1 overall results for 2003/04 to 2006/07.

Year	No. of Students	Min.	Max	Mean	Std Dev.
2003	70	14%	89%	58.26%	17.42%
2004	57	16%	82%	49.51%	13.31%
2005	51	14%	87%	57.82%	14.20%
2006	47	23%	84%	59.45%	16.75%

Table 1: MM211 results since 2003

It is evident that the mean result for 2006 is slightly higher than the previous years with the standard deviation greater, but statistical tests show no significance. At the very least, the changes in approach do not seem to have been detrimental to students' overall performance and, given that both lecturer and students took time to become proficient in the new approach, it is considered that it may take a longer timeframe than 12 weeks for the benefits to be reflected in exam performance.

CONCLUSIONS

- Mechanical engineering students at DCU have a strong preference for active learning, which is not facilitated by traditional lecture approaches.
- Students do respond to efforts to incorporate questioning and short active participation by them in class, however it requires practice by both lecturer and students for it to work well.
- Careful planning of tutorial steps, good time management by the lecturer and knowledge of students names are important in maintaining student attention.
- It is difficult to maintain a formalised group structure in the context of a lecture, and a lecture theatre setting.
- Benefits of a more active class may not been seen in exam performance over a short implementation time of 12 weeks, but an initial attempt to adopt the approach, and all the experimentation that involves, did not detrimentally effect student performance.

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