Teaching First Year Design by Mechanical Dissection

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Subject area: Mechanical Engineering design, materials, and manufacturing processes.

This case study has been developed from data gathered through a demonstration of the teaching and learning materials available, interviews with the tutor, student questionnaires and focus group.

Background

This report covers a series of activities based on the dissection, or disassembling, of a component from a motor car with the aim that the students should learn about the rationale behind that component's design. The activities are part of a class taken by *ca.* 130 first year students studying for M.Eng. and B.Eng. degrees at a Scottish university. This class was introduced to replace more conventional lectures on materials and manufacturing in the first year. Most of the students are Scottish, with some from Northern Ireland and few from the rest of the UK; there are very few overseas students. All the students have very good academic entry qualifications, however, in the tutor's opinion, few of them have any practical experience of "tinkering with cars".

For the purpose of this class, the year group is split into four cohorts going through a cycle of tasks, of which the activities associated with the mechanical dissection is one. Each cohort starts at a different point of the cycle, and thus will undertake the mechanical dissection at a different stage of their first year. This report is based primarily on evidence from those students who undertook the car dissection towards the end of the year. Students work in groups of four, they work in the same groups for several other parts of their first year course.

Students are aware that they will undertake a mechanical dissection of a car before enrolling at university, the exercise is highlighted in the degree prospectus and open days. At the beginning of the first year, the structure of this class is explained to the students so that they know when in the year they will be working on the car dissection. Then when their turn comes, students will spend a couple of hours, three groups at a time, selecting a part of the car (for example the front or rear suspension, or a part of the braking system) and removing that part. The following day each group meets with two lecturers to discuss the physical principles behind the component's function, and to select a couple of parts for further examination. These parts are examined under the microscope to ascertain the materials and processes involved in their manufacture. The students then have three weeks to research the function, physics, manufacture and design of the components, and to produce a poster explaining these. Typically this takes them about six hours. They present their draft poster to two members of staff, who discuss the content with them and inform the students of any further work necessary to bring the poster to an acceptable standard. The students then have to produce a brief PowerPoint presentation covering the same material as the poster for a plenary session at which two students, chosen at random, from each group describe their component to the rest of the cohort. After their presentation, each group has to field a couple of questions from one of the other groups of students. In preparing the poster and presentation students will need to explain topics not covered elsewhere in their first year course.

Reasons

The overall aim was to show the students how the rather theoretical academic work they cover in their lectures is relevant to the practical challenges of engineering. The tasks associated with producing the poster and presentation also build skills in team work and communication and encourages independent learning. The lecturer says that "*above all, the class is designed to build the students' confidence and provide an enjoyable and stimulating focus to the first year Mechanical Engineering course*".

The lecturer had personal experience of a similar mechanical dissection as a student and knew of other institutions where similar exercises were used, and so he recognised that it might be a suitable activity for the design course *"it was a way of taking something that might be considered to be mechanical engineering... and helping the students to [acquire] an appreciation of the things that go into the design process, and hopefully draw on their background knowledge in physics ...[to] help them to integrate some theoretical knowledge into an appreciation of what a component has to do in service, and therefore what you have to make it out of and how you manufacture it and how those things are actually linked".* A car was chosen because they are easy to obtain at reasonably low cost, they are familiar to all students, and they comprise many components which cover different aspects of engineering.

Lecturer's Perspective

The lecturer found that introducing the exercise was "quite straightforward". There is a requirement for a suitable space at road level to park the car while it is disassembled, which might be a problem for some. Also timetabling so

that students all get access to the car and a chance to discuss their work with tutors was fairly complex. There was some initial outlay on tools and safety equipment for the students, however the cost of the car was small (each car provides about 16 components).

Key to success was the allocation of staff time to this exercise: the approach relies on a multidisciplinary discussion with small groups of students when they remove the component and when they have produced their draft poster. This requires input from several academic staff. However there is an atmosphere of support for making efforts to enhance teaching within the department where this activity took place so the required staff input was available.

The lecturer feels that as a result of this class there is an opportunity for students to do something which is practical and fun, but with a serious message. The students *"learn a lot about a little, they learn in-depth about a particular strand"*, for example they might learn about casting iron, but nothing about forging or aluminium. The interviews ensure that the staff are clear whether the students have really understood their topic. Finally, the students *"are forced to learn in a different mode"* as they have to investigate problems for themselves rather than listening to lectures.

Students' Perspective

The student response to the dissection exercise seen through questionnaire returns and group interviews[1] was overwhelmingly positive. All bar two of the students agreed that the car dissection had helped them understand design engineering, two-thirds of them agreed strongly; all bar three of the students disagreed with the statement that learning this way was boring, nearly two thirds disagreed strongly, none agreed. Similar results came from questions probing whether the tasks were clear, whether the dissection was an "unnecessary" part of the course, and whether it improved the students' motivation to learn. Reasons why students viewed the approach favourably included the strong perception that it improved their engineering knowledge, improved their presentation and other skills, and that it enhanced their motivation to learn, was enjoyable because it was a "hands-on exercise" and linked theory to practice.

There were some negative comments. A minority of students felt that the time allocated to practical hands-on task of working on the car was less than they had expected, *"two hours wasn't much in the whole year so I was bit disappointed"*. While more time working on the car may not have had much educational benefit, the mismatch with their expectations seems to have reduced their motivation to learn from the exercise. Other negative comments centred on students disliking having to give a presentation to other students (though they frequently recognised the benefit of doing so) or details about timetabling, which were largely unavoidable.

Issues

- Supporting the exercises that follow-on from the dissection is time consuming, requiring discussion between each group of four students and at least two staff knowledgeable in different subject areas.
- In replacing traditional lectures with this exercise there has to be acceptance that students will learn "a little about a lot" and the learning outcomes will centre on ability to learn or work in a team, rather than being exposed to a content-full syllabus.
- Some students were expecting more hands-on practical work than there was.

Benefits

- The exercise clearly succeeded in its objectives of enthusing the students and showing them the relevance of the academic material covered in the lectures. The tutor and students also believe it helped in improving students' communication skills and increasing their self-reliance while learning.
- The close contact between staff and student groups means that the staff can be sure the students understand the material.

Reflections

On the whole, the difficulties associated with this exercise are associated with the time and effort required from the teaching staff while the benefits are student centred. The lecturer running this class feels that the benefits to students make the exercise worthwhile and the students agree with him. The students said this exercise *"is probably the only thing that everyone spends the whole first year waiting for",* it *"expands on so many skills",* and that it *"allows you to see how an engineer would think".*

[1] 31 questionnaires were returned, 28 from the students at the final presentation session, a return rate of over 90%. Three other questionnaires came from students in other cohorts who weren't involved in the rest of the evaluation but had the opportunity to fill in the questionnaire online. Ten students were interviewed in two group interviews.