Case Study

A Student-led Design Course Related to Sustainable Engineering

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Abstract

Over a four-year period a second year mechanical engineering design course has been developed with an increasing emphasis on student-led learning and sustainable engineering. A history of these developments is given, highlighting the latest full academic year and its associated student feedback.

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1. Background

In the academic year 2005/06 the second year Engineering Design course offered by the School of Mechanical and Systems Engineering at Newcastle University was overhauled to be based entirely on project-based learning. In groups of five, students undertook a two-term design project. They were given a design brief which was developed in conjunction with a local engineering company which manufactured caravans. The design brief was changed slightly in the 2006/07 academic year. Assessment in both years was by group presentations and reports at the end of each term and by the submission of an individual logbook. In the academic year 2007/08 the lead author, who had previously taught on the Design course, became module leader. The co-authors continued as before. Maintaining the benefits of project-based learning, group sizes were increased and innovative topics relating to 'green engineering' were introduced. Assessment load was reduced and re-distributed so that it took place more often, rather than in two end-of-term 'peaks'. Priority was given to formal written feedback which was provided within one week of submission. Under the title of 'greening our homes' the 2007/08 topic considered domestic scale energy generation and energy conservation measures. It was found that the students engaged with the 'green' topic far more than with the previous caravan projects. This may have been influenced by the growing sense of their place in society which was emphasised during the course. Students also commented positively on the creativity allowed them and the sense of ownership of their learning which this engendered, as well as the regular assessment and feedback.

2. Methodology

Despite the positive outcomes from the 2007/08 academic year, further innovations to the course were sought, in particular by setting aside time for students to manufacture and assemble their designs. A lab space was obtained, together with basic workshop tools for each group. The 2008/09 design topic was entitled 'from kilobytes to kilowatts'. Ten groups of students, of no less than seven per group, were given a redundant computer and printer. From these they had to design and manufacture a wind turbine, tested in a wind tunnel at the end of the first term. In the second term, having learnt from this experience, each group was given a budget and allowed to take their designs forward as they saw fit. A mixture of assessment methods continued to be used, including presentations, reports, 'weekly updates' and assessments of the wind turbines themselves. The 'weekly updates' consisted of two sides of A4 paper: on the front side was a set of questions asking the students how the design had progressed over the past week, what challenges had been overcome and what information sources had been investigated alongside the key data obtained from them. The reverse side comprised a list of the UK-SPEC (UK Standard for Professional Engineering Competence) criteria that the module was expected to cover. Students were asked to give an

example of how each aspect of UK-SPEC (recently re-termed by the IMechE as 'learning outcomes') had been met. For the groups' interim and final reports a peer-moderated marking scheme was employed.

3. Issues

The fundamental issue has been a paradigm shift to open-ended learning. Rather than briefs to design an isolated component or simple assembly within a fixed set of criteria, projects with a wide range of possible solutions are given. This paradigm is more challenging for students and staff, but also more interesting for all parties. The teaching methodology supports the paradigm in that impromptu lectures are given depending on student demand. These are augmented by formal lectures which cover the fundamentals of engineering design so that students are given sufficient background information to allow them to tackle the technical challenge. The three members of teaching staff are all engineers with significant and diverse industrial experience. It is perhaps surprising that this industrial experience has made each of them open to design projects which are so open-ended. Each appreciates that engineering is a dynamic subject and that, in industry, key skills not only include technical expertise but also 'soft skills' such as team working, presentational abilities, dealing with suppliers and budgeting.

4. Benefits

The key to the success of the course has been in placing students at the centre of their learning: they help to determine what they need and want to learn. Initially, some students found this a new and potentially unusual experience. However, once they realised that they had the opportunity to take the wind turbine design in a direction they wanted, rather than regurgitate a 'solution' offered by staff, there was excitement at the sense of ownership. Students greatly appreciated the availability of, and requirement for, hands-on work and relished the chance of applying some of the theory they had been taught in other engineering modules. Tactically it was also felt that the use of the 'weekly updates' showed not only staff commitment to rapid and personalised (in the sense of the group) feedback but also allowed positive staff-student communication on a semi-formalised basis.

5. Evidence of success

The main evidence of success comes from student feedback, which was overwhelmingly positive, especially for the 2008/09 academic year. Examples of student comments include the following, which have been grouped into different areas.

Evidence that students felt that they learnt a great deal and applied engineering knowledge include: *'I feel as though I have learnt more in this module than the entire 1st year'; 'improved a whole range of skills rather than just dry theory'; 'a lot was learned from the achievements and failures'; 'it is good to apply what we have learned'; and 'application of knowledge gained from past years'.*

Confirmation that students felt that they enjoyed the learning experience and recognised that it was different to 'traditional' lectures was shown by the following remarks: *'very enjoyable, made learning not a chore'; 'enjoyable to put knowledge into practice'; 'good fun therefore a better atmosphere for learning'; refreshing to not always have lectures, but to learn ourselves'; 'enjoyable learning process';* and one longer statement included *'taking the project into our own hands allowed the team to explore the project in many ways and determine our objectives and achievements. Again this allowed a more advance learning into the project, whereas if it was taught, then the opportunity to 'explore' would not be permitted'.* Students also acknowledged that *'research played a huge role into finding solutions, and with all this research provided self learning which probably could not have been absorbed if it was taught in lectures etc'.*

Evidence that students felt that they had experienced professional engineering was supported by the following comments: *'the course gave the feeling that I was working as a real engineer; learning professional engineering skills'; 'it was a good way to get introduced to professional engineering'* and one team described themselves as *'a group of young future professional engineers who now have experience in managing long-term engineering projects as part of a team'.*

That students enjoyed the hands-on aspects of the module was shown by the following comments: '*we actually got to do stuff'; 'a lot has been learnt through the duration of the entire*

project, knowledge which could not have been conveyed from lecturer to student other than through (this) type of practical learning'.

Evidence that students valued 'green' and realistic projects was clear from the following comments: *'applying engineering for relevant project (environmental issues)'; 'able to apply this course to real life'* and *'it was refreshing to actually apply engineering knowledge to a real application'.*

That the opportunity for creativity was recognised and appreciated was shown by the feedback: *'encouraged imaginative thinking'* and *'creativity that you do not get from any other module'.*

Additional positive comments included: *'made new friendships within the group'; 'the course was run in a professional manner and we were treated as such'; 'money to spend/be trusted with'; 'whole process from design concept to testing showed continuity';* and *'budgeting and component sourcing from companies'.*

As well as student feedback, other evidence of success included that attendance was always well above 90% at classes and that, at the end of second year, the number of students choosing the engineering design stream option in the subsequent third year doubled, from 13 to 27.

6. How can other academics reproduce this?

To reproduce the methods described in this case study a number of elements are required. Firstly, the availability of a 'workshop' area over two terms (with benches, tools, etc) was deemed crucial. In their own words, our mechanical engineering students enjoyed the opportunity to '*get their hands dirty'* and to '*see what worked and what did not work'*. Moreover, the inclusion of testing provided not only competition between groups (which facilitated intra-group camaraderie) but also a definitive target which all the groups appreciated. A budget of up to £100 was offered but, as students were partially judged on a power output per pound spent, it was found that many groups were consequently very frugal. Close supervision, support and monitoring were carried out by the three members of academic staff, but this was not overt – rather they acted as "knowledgeable and interested clients" with a vested interest in the success of each team's performance. The "client" team brought their own skills to the project and acted as a strong point of reference for the students. Beyond these practical aspects the approach was to trust in the students and allow their creativity and imagination as much freedom as possible. Aside perhaps from civil engineering, the wind-turbine project described here could be used by other engineering disciplines – indeed, it was felt that the necessary inclusion of a significant electrical engineering aspect (often an area avoided by mechanical engineering students) helped to challenge the students and show them the crucial multi-disciplinary nature of modern engineering.

7. Reflections

As noted above, a key factor was deemed to be allowing the students to build their designs, alongside the creative opportunities inherent within a complete process that began with a design brief and ended with the testing of a manufactured and assembled prototype. Informed by student feedback, staff continue to develop the module. Changes have been made (i.e. groups are constructed based on the results of Belbin tests; less time is allocated to the wind turbine built from the redundant computer and more time is given to the students' designs based on a freer choice of components) to this year's module (2009/10) and assessment is ongoing. Although increased numbers of students have selected Design as their MEng degree stream, the same number of individual third-year projects still need to be set, therefore there has not been a negative impact in terms of resourcing. It is felt that the Design module has been improved year on year, with parallel increases in student satisfaction and student learning. Part of the ethos of the module is supported by comments taken from the 2005 *'Educating Engineers in Design'* publication from the Royal Academy of Engineering*:*

> And what do we need to teach? We don't. We need to give the opportunity to gain experience and awareness in multi-disciplined team environments and let the confidence of youth loose on a prepared world. What can we give students in a university department? Experience of working in multidisciplinary teams working on realistic projects*.*

8. References

Joyce, T. (2009) A project-based learning Design course: experience, developments and assessment, *The Higher Education Academy Conference*, 30 June–2 July 2009, Manchester, UK.

Royal Academy of Engineering (2005) *Educating Engineers in Design*. Available from http://www.raeng.org.uk/news/publications/list/reports/Design_Engineering.pdf [accessed 19 January 2010].