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Enhancing learning on a first year engineering programme with a student design project

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This contribution reports on, and evaluates, the use of a design project for enhancing student learning on a first year module in electrical engineering at Dublin Institute of Technology. The project objective, as outlined to the students, was to design and build a, possibly innovative, everyday device that can generate electricity from sources of "free energy", so as to encourage first year engineering students to use their natural design creativity in a freeform, brainstorming manner. The project allows students to further develop their academic interests, assists student retention and facilitates student interaction, among other advantages. The work encourages students to appreciate that engineering is a creative activity, and helps bring some excitement and fun to the first year experience.

Introduction to the undergraduate programme

The learning method is used with students on the Electrical Systems subject in the first year of a three-year, level 7, degree programme in Electrical Engineering. In the Republic of Ireland, candidates apply for such programmes (in common with all higher education programmes) through a national office, in which points are given for examination results in six subjects taken in the *Leaving Certificate* (the terminal examination at second level education), or equivalent. The maximum point score possible for a candidate is 600, with 55% of candidates scoring more than 300 points in 2007, for example (CAO, 2007a). Minimum points levels for programmes are set by student demand for the limited number of course places; in common with worldwide trends, student demand for technology courses is decreasing, leading to, for example, a minimum points level for the programme of 150 in 2007, with a median points level of 245 (CAO, 2007b). Though there is some debate as to whether the points scored by candidates in an examination process dominated by a terminal examination is the best predictor of subsequent success on an engineering programme, nevertheless it is clear that many, if not most, of the students entering the programme have lower academic ability when compared to their wider peer group.

In a typical year, 35 learners commence the degree programme, the majority of which come directly from second-level education; there are a small number of students who are mature learners (categorised as students over 23 years of age in the Republic of Ireland) and a further small group of international students.

Finally, in the Republic of Ireland, Level 7 programmes are distinguished from Level 8 programmes, which in Engineering are four years in duration, require a much higher minimum standard in Mathematics at the Leaving Certificate examination (or equivalent) and allow successful graduates to work directly for chartered membership of engineering professional bodies. Successful Level 7 graduates in engineering may directly achieve associate (or equivalent) membership of the professional bodies.

First year issues in engineering programmes

There is increasing evidence of a gap between student expectation and experience of engineering programmes. In surveys conducted of incoming engineering students at Dublin Institute of Technology (DIT) from 2003 to 2005, the most popular reason for choosing an engineering programme was '*I was always interested in how things work*' (Conlon, 2007), followed by '*I am interested in designing things*', '*Engineering is a good career*' and '*I want to build things*'. This practical orientation of students is reinforced by responses to a question asking why students came to DIT specifically; the most popular response was '*DIT has a good reputation for engineering*' followed by '*DIT courses are more practical and applied*'. However, having attended their programme for an average of two months, 43% of students admitted that they had '*no clear understanding of what their course was about before they came to DIT*', with many expressing surprise at the extent of the mathematical and scientific content of their programme. Such experiences are also documented by Edward (2002), among others, who suggests that incoming engineering students 'expect practicality and find abstraction ….expect physical construction and find mental reduction'.

In summary, many students choose to become engineers because they like the idea of inventing, designing, building and creating products. However, first year college experiences often involve theoretical study and didactic, 'follow the procedures', laboratories. It was our experience that total concentration on these (very necessary) aspects led to student disengagement and retention problems. These problems emerged first in the 1990's in the engineering programme that is the subject of this paper; Table 1 summarises the experience from 1991 to 1997, inclusive.

Table 1: Assessment and progression statistics 1991-1997

	1991	1992	1993	1994	1995	1996	1997
Number presenting for exam	62	88	113	132	110	108	118
Number passing exam	18	20	32	46	30	41	30
% pass rate	29	23	28	35	27	38	25
% progression rate (overall)	50	51	44	51	40	56	36

Despite extensive efforts to encourage better student attendance and improve the learning environment, the progression rate only improved slowly in subsequent years, partly due to a gradual reduction in the number of students entering the programme after 1997.

A revised programme was introduced in 1997, with further revisions in 2002 and 2005. Since 2005, the author has had academic responsibility for the Electrical Systems subject, one of the central technical subjects in the first year of the programme. This subject is structured into two thirteen-week modules; in each module, students are scheduled for two hours of lectures and two hours of laboratories in the subject each week. The subject is assessed as follows:

- Terminal examination (50% of subject mark), held after the completion of the second module.
- Laboratory work (25% of the subject mark), assessed continuously over both semesters.
- Individual student project work (12.5% of the subject mark), assessed in the middle of the second module.
- Module 1 assessment (12.5% of the subject mark); this is an exclusively multiple-choice examination, held after the completion of the first module.

Experiences of individual student project work

The project objective, as outlined to the students, was to design and build a, possibly innovative, everyday device that can generate electricity from sources of "free energy". Students were given some background information (including a showing of the motivating 2006 Faraday lecture on DVD, which focuses on the necessity to develop renewable forms of energy), given real world instances of energy transfers and some examples of sources of "free energy" (an energy generating rucksack, a clockwork radio). The project could be done individually, or as part of a team of two persons. The project assessment (which took place towards the end of the module) was weighted as follows: originality (25%), hardware design and construction (40%), oral explanation (20%) and written explanation by means of a report of two pages maximum length (15%).

The learning objective was to encourage first year engineering students to use their natural design creativity in a freeform, brainstorming manner, with little formal guidance from the tutor. Participation was not mandatory, though strongly encouraged.

A flavour of the project work submitted is provided by the photographs in Figures 1 to 4, taken by the author, of four student projects in the 2007-8 academic year.

Figure 1: Mechanical to electrical energy. Students: J. Cope, V. Abromaitis

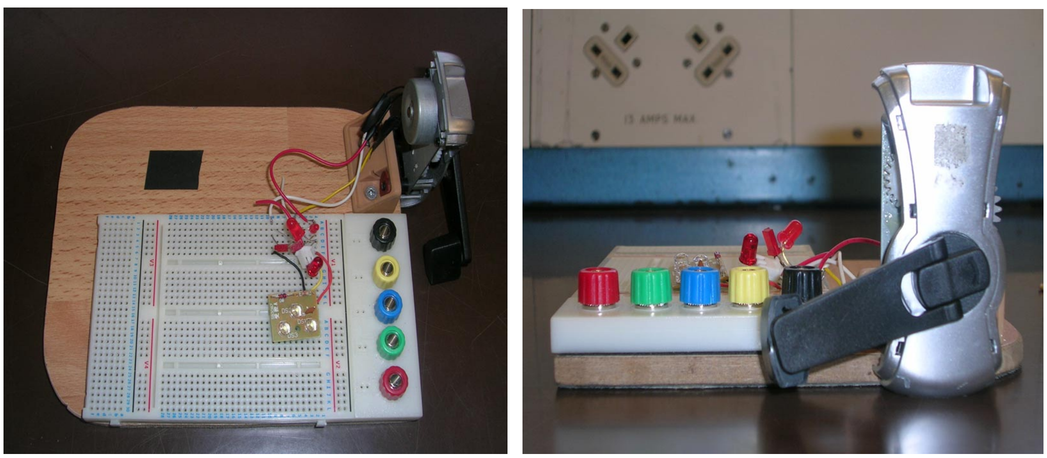


Figure 2: Energy from potatoes. Student: G. Smith

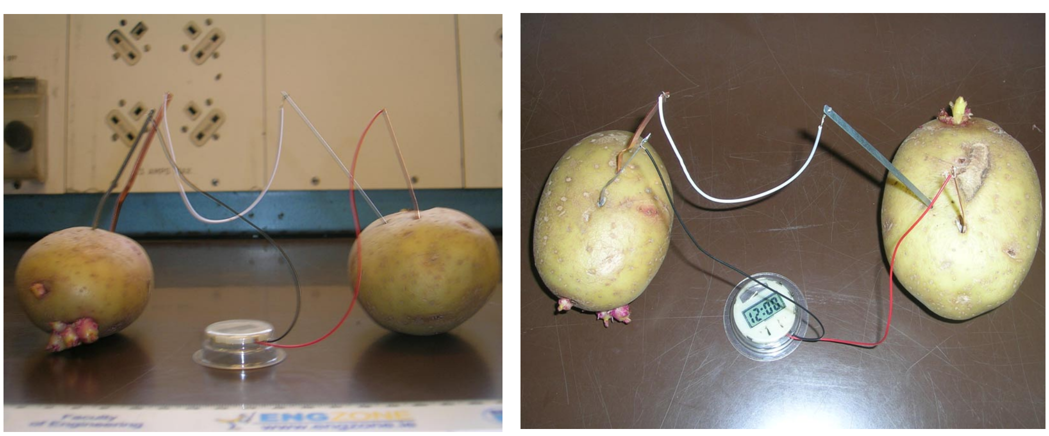


Figure 3: Solar powered tractor. Student: N. Smith

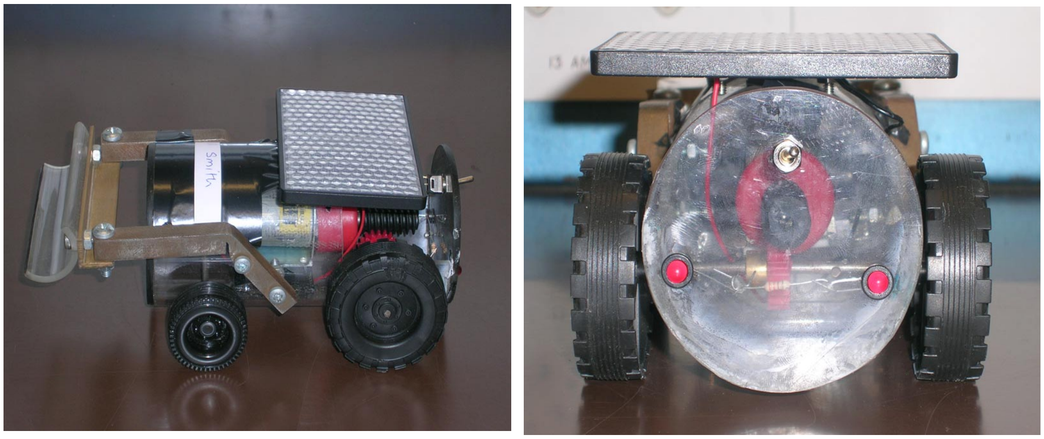
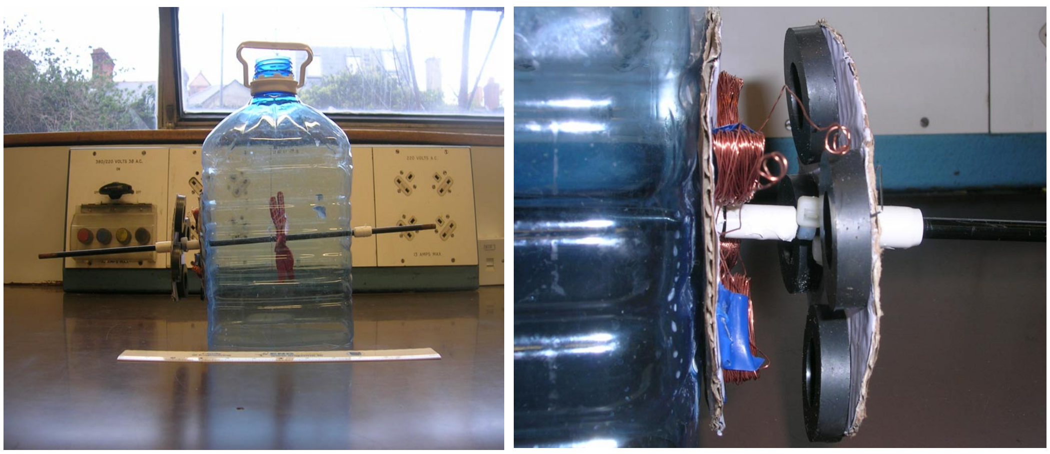


Figure 4: Mini-hydro station. Student: S. Flanagan



Assessment and progression data

Table 2 summarises assessment data for 2003-4 (prior to the introduction of the revised programme) and for the three academic years from 2005 (after the introduction of the revised programme).

Table 2: Assessment and progression data 2003-4, 2005-2008 inc.

	2003-4	2005-6	2006-7	2007-8
Number registered on programme	37	21	33	38
Number who left before summer exam	5	3	7	4
Number sitting summer exam	32	18	26	34
Mean multiple-choice test mark	no data	39	43	44
Mean mini-project mark	no data	56	47	51
Mean laboratory mark	no data	53	54	65
Mean exam mark	no data	42	41	45
Mean module mark	no data	46	45	51
Number – passed module (1^{st} attempt)	20	11	14	26
% pass rate (1^{st} attempt)	63	61	54	77
% progression rate (after supplemental)	88	61	65	no data
Median points on entry	325	285	275	245

At first glance, the introduction of the mini-project assessment (and, indeed, the other assessments) has not had the desired effect of improving retention. A confounding factor, however, is the progressive reduction of the median points of the student cohort on entry to the programme (which reflects, however imperfectly, student ability) from 2003-4 to 2007-8. In this context, the improvement in student performance in the 2007-8 academic year is welcome; this perhaps reflects an overall improvement in the learning and teaching environment, as well as increased student performance, as reflected for example in the quality projects shown in Figures 1 to 4.

Conclusions

The author has used a freeform design project as part of a suite of learning and assessment options in a first year module in electrical engineering for the past three academic years. The benefits of the design project are as follows:

- it allows young engineering students to use their creativity and to further develop their academic interests;
- it establishes a balance between students' expectations of their programme, and the nature of the academic work;
- it assists student retention;
- it introduces competitiveness in a fun and undemanding form;
- it allows students to interact and associate with one another through a common interest;
- it gives students an opportunity to show interesting work to their friends and family.

A minority of students does not participate, or participate in a minimal manner, in the design project. The author intends to further motivate all students in future years, by demonstrating the successful projects of previous student groups and by discussing the learning benefits to be obtained from such project work.

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