CDIO AND RESOURCES - CAN WE DO IT ON THE CHEAP ?

Gareth Thomson

Mark Prince

Aston University, Birmingham, UK

ABSTRACT

Universities are continually under pressure to do more in terms of delivery, for less in terms of resources. For engineering and design courses, particularly those where a high level of practical project work is expected, this can be a particular challenge. Restriction of resources can be manifested in many ways, including limits on staffing, modest equipment availability, and constrained consumable budgets. Sometimes this may be a temporary situation, such as when infrastructure lags new project based teaching initiatives but can equally be an ongoing pressure as budgets are squeezed. This paper looks at some of the pressures associated with running practical based teaching programmes and explores some ways in which some measures of mitigation can be put in place.

KEYWORDS

Project-based learning, Resource management, Cost-effectiveness

INTRODUCTION

Universities are continually under pressure to produce increasingly high qualities and volumes of teaching and research for given levels of resource. For arts, business and social science subject areas, taught largely through lectures, this is generally achieved by increasing class sizes. For science and technology based courses there is often pressure to use similar methods to ensure cost effective courses are delivered. This is most often embodied by common first year classes within Engineering faculties. This limits the amount of practical teaching, the level of two-way interaction between staff and students and can produce bland programmes designed to fit a range of disciplines. The reduction in practical classes also makes way for the rationalisation of specialist teaching space and technical support.

UK Context

In England funding for teaching of domestic University students comes from the Higher Education Funding Council for England (HEFCE). This allocates block grants to University based on a complex formula but is significantly driven by the numbers of students and the degree subjects they are undertaking. The funding regime can be seen in table 1.

Table 1
HEFCE Undergraduate Funding Regime 2010-11 [1]

Type	Description	Multiplier	Resource (£)
A	Clinical medicine, dentistry etc.	4	15804
B	Lab based science and engineering	1.7	6717
C	Courses with field or studio element	1.3	5136
D	Other courses	1	3951

These figures are typically supplemented by fees of around £3375 which are chargeable to students. Once these are factored in, the ratio of funds per student between engineering (Type B) and say business courses (Type D) will drop from 1.7 to around 1.4. It is this more modest differential which engineering programmes within the UK must use to cover the smaller class sizes, need for specialised workshops, laboratories and equipment, specialist support staff and increased consumables. It should be stated at this stage that following the Browne report into the funding of Higher Education funding fee levels are likely to increase dramatically from 2012 to around £9000, with government funding only existing to support the differential to the strategically important A and B type programmes [2]. The implications of this change are still unclear and discussion of this is beyond the scope of this work.

CDIO Context

CDIO is very much focussed on providing a student centred learning experience based on learning by doing. As such it features within its standards, a requirement for among other things, design build experiences (standard 5) and CDIO workspaces (standard 6) [3].

To achieve these, institutions must balance the demands associated with delivering high quality CDIO learning with possibly constrained budgets and resources. Can we do CDIO on the cheap ?

INTRODUCING CDIO ACTIVITIES

Our own experiences relate to introducing CDIO as part of a family of Mechanical Engineering and Product Design programmes. These typically have an intake of around 60 and 40 students respectively and prior to CDIO were largely taught separately. Both degrees normally last three years, with an optional industrial placement year between years two and three.

CDIO is currently rolling out from year 1 and as a major new initiative some limited funding was secured. This provided for basic redecoration of a workshop space and sets of hand tools for groups of students. Our operating budget for consumables and our technical and academic staffing was much as in the previous lecture based programmes.

Our situation was therefore constrained and this was further hampered by the improvements to the workshop being delayed, preventing access to this space by the students for much of the first semester. CDIO activity was therefore forced to operate from pooled general classrooms. This limited the activity possible and also prevented students returning between timetabled sessions to further develop their project work.

The aim of the first semester module was to introduce students to CDIO and let them experience a number of engineering and project management concepts. This was to be achieved through a variety of one to three week mini-projects.

The second semester module had a theme of sustainability and was primarily based around a windbelt – a novel form of wind turbine. This featured a mix of short, tightly controlled mini-exercises capped with a four week main project.

A variety of images from the projects can be seen in figures 1-3. Figure 1 shows the Rube Goldberg week 1 exercise in which students, having been newly set into teams constructed chain reaction type systems from scrap material.

Figure 1 : Rube Goldberg Exercise

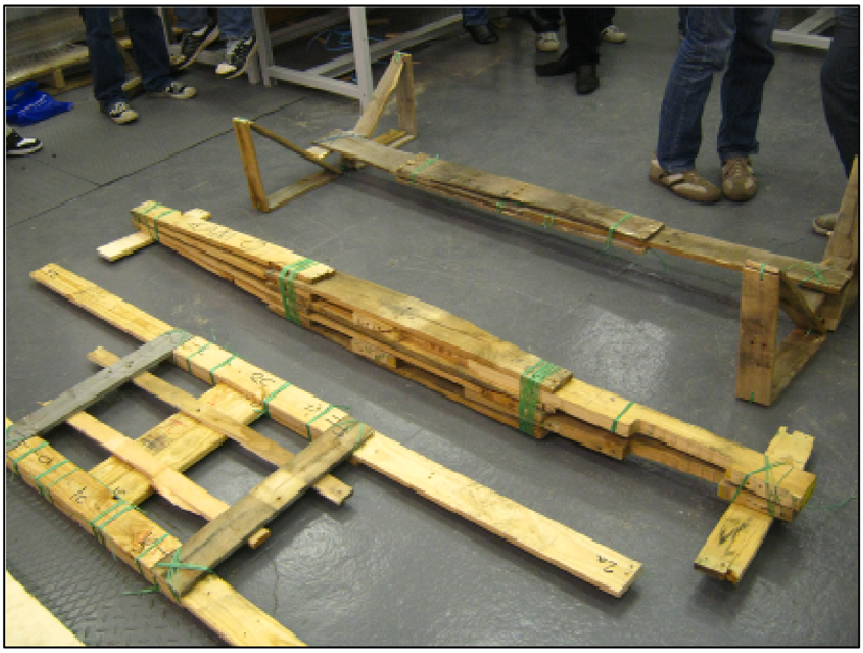

Figure 2 : Bridge Project

Figure 2 shows an example of the first semester bridge project. In this case wooden pallets were provided to each group to build a small bridge to span a 2m gap. Fixings in this case were restricted to string to encourage careful thought in the build and design of the bridges.

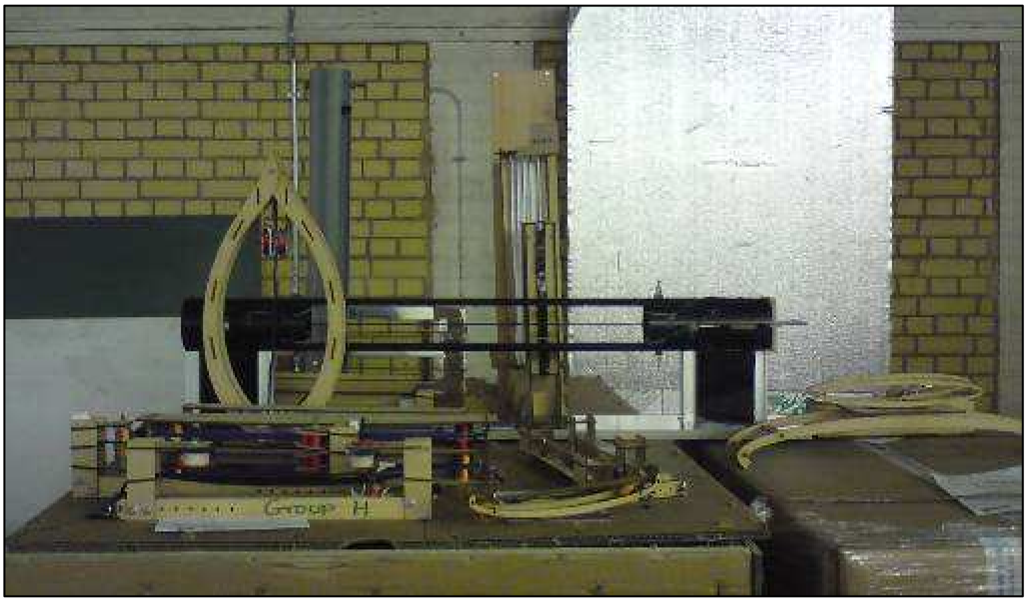

Figure 3 : Windbelt projects

Figure 3 shows a variety of windbelts produced as part of the second semester capping exercise. In most cases a mix of university (copper coils, MDF, magnets etc.) and student sourced materials were used.

The aim of these exercises was to help students develop an enthusiasm for engineering and design. Setting open ended projects with no predetermined outcome allowed students to consider a risky, innovative and fun approach to their work.

COST ANALYSIS OF PROJECTS

While it can be difficult to give an exact cost per student per module we have attempted to evaluate this to help in allaying fears that practical modules are often massively costly. Where possible low cost materials were utilised, with extensive use being made of redeployed packaging card and pallets.

Tables 2 and 3 outline the activities carried out in the 1st and 2nd semester year 1 modules. These include contact time for academic and technical staff but not the additional hours associated with class set up or marking. While these were not insignificant it was felt that once the programme was rolled out these would be in proportion to the taught hours.

From a staffing resource issue it is generally the total staff man hours associated with delivering a course which are of concern, whereas for materials, the cost per student are the more common pressure.

Table 2
CDIO 1.1 Design & Exploration

Activity	Concepts	Material Cost (£)	Academic Time (man hours)	Technician Time (man hours)
Rube Goldberg (1 week)	Ice breaker, What is CDIO ?	20	14	12
Golf Ball Packaging (2 wk)	Estimation, Design Communication	30	14	6
Visual Communication	Technical Drawing & Sketching	10	7	0
Bridge Building (2 week)	Prototyping & analysis in build	200	14	6
Pump Stripdown (2 week)	Intro to materials & manufacture	200	14	14
Capping CDIO (3 week)	Reinforcement of lessons	50	21	14
	Total	510	84	52
	Total / student	5.10	0.84	0.52

Table 3
CDIO 1.2 Prototyping & Development

Activity	Concepts	Material Cost (£)	Academic Time (man hours)	Technician Time (man hours)
Product stripdown (1 wk)	Material use and reuse, Design for Sustainability	100	14	0
CDIO Academy Ideas Generation (1 wk)	Ideas Generation – Conceive	10	7	0
Wind Turbines (2 wk)	Energy conversion, efficiency in systems	200	21	3
Wind Belt Investigation (3 weeks)	Experimental investigation, product improvement, Idea evolution. CAD	200	21	6
Capping CDIO (4 weeks)	Reinforcement of lessons Business considerations	200	28	14
	Total	710	91	23
	Total / student	7.10	0.91	0.08

DISCUSSION

The material costs per student for running the two CDIO modules was around £12.50. These modules account for half of the total student experience in their first year but in relation to the income (Table 1) these costs are insignificant.

The staff hours for CDIO can appear relatively high. Several sessions were double staffed with academics however this became much less the case as the programme evolved. Nonetheless had these programmes been taught entirely through lectures the contact hours would have been near identical. Under our previous programme the six modules replaced by CDIO would each have featured around 30 contact hours – 180 hours for the year as against around 175 through CDIO.

CDIO has also replaced many traditional lab courses where students were rotated around labs in small groups under the supervision of technicians. Typically a single lab exercise could take between 30 and 50 hours of technician support time but whole class CDIO teaching has significantly improved matters.

CONCLUSION

This exercise has shown that CDIO with its high level of practical and project work need not be a significantly expensive exercise in comparison to more traditional methods. It is naturally the belief of the CDIO community that improved retention and quality of graduates are a key measure of the cost-effectiveness of a programme. These do however tend to be longer term aspirations which can be difficult to quantify when faced with pressure as finance, staff and space requirements are tightened on an annual basis. It will be a major challenge to the CDIO community to share positive ideas and experience to ensure CDIO can be seen as a cost effective activity.

WORKSHOP

As part of the 2011 CDIO Conference a workshop will be held to pilot a new low cost CDIO learning activity. We seek interested parties to join us in refining this and sharing ideas for economic CDIO based activities.

REFERENCES

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Biographical Information

Gareth Thomson is the course director for Mechanical Engineering undergraduate degrees at Aston University, Birmingham, UK. He has particular interests in systems design and evaluation. .

Mark Prince is a lecturer at Aston University. His specialist teaching areas include CAD/CAE and he is module leader on the first year sustainability CDIO module.

Corresponding author

Dr. Gareth Thomson
Mechanical Engineering + Design
Aston University
Birmingham
B4 7ET, UK
+44 121 204 3608
g.a.thomson@aston.ac.uk