Step Change Implementation of CDIO – The Aston University Story

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ABSTRACT

The aim of this paper is to provide a comprehensive account of the experience of Mechanical Engineering & Design (MED) at Aston University in adopting a system level implementation of the CDIO framework at EQF Level 4. This is Aston's first experience of CDIO and represents a step-change in learning and teaching philosophy from a long-established traditional engineering science didactic format. The paper describes the reasons for changing, the innovative teaching and learning practices that have been employed, how it has been implemented, and the experiences of staff involved during its development and practical implementation.

The account shows the progress that Aston has made in its first semester of implementation and details some of the cultural challenges it has faced, along with some of the unexpected benefits of improving learning and teaching practice. Through building engineering and design programmes around large 30 credit active learning modules based upon the CDIO framework Aston academics have found that early stage implementation has increased efficiencies in terms of reduced assessment loading by 54 % and reduced space utilisation requirements by 37 %. Furthermore the changes have been made without significant increase in workload beyond the creation of new learning experiences, and without sacrificing academic challenge. Successful implementation of the new CDIO based programmes have been demonstrated as being effective at increasing student engagement, creativity and problem solving in both practical, active learning sessions and conventional declarative knowledge learning sessions.

KEYWORDS

CDIO Implementation, reasons for change, efficiency savings, collaborative teaching

INTRODUCTION

In 2010 the Mechanical Engineering & Design subject group at Aston University (Birmingham, UK) significantly revised its taught programmes with regards to learning and teaching practice for all 1st year undergraduate students (European Qualifications Framework Level 4). Large active-learning modules based upon the CDIO learning framework were introduced into each semester around which all mechanical engineering and design programmes were based. The importance attached to this project based learning approach is reflected in the fact that this now accounts for 50% of learning and assessment activities at Level 4 and is supported by specialist science, maths and technical modules.

At the time of writing the first cohort of Level 4 undergraduates have recently completed the first CDIO based module and are about to complete the second. It was decided from an early stage that greatest flexibility in carrying out ‘design, build, test’ type CDIO activities would best be served at Aston using whole day sessions. While this offers many benefits it was also found to require careful management in terms of pace, activity levels and in ensuring an adequate balance between instruction, active and reflective learning.

Opportunity and Justification for Change

The Mechanical Engineering & Design (MED) subject group within the School of Engineering and Applied Science (SEAS) at Aston University has undergone radical change in the past 18 months. After bifurcating from former companion subject group, Engineering Systems and Management (ESM), MED was able to refocus on the needs of its core students without them being tempered by those of students on other programmes.

This, in conjunction with a period of staff turnover, gave the opportunity for consideration of the courses on offer and the development of fresh perspectives on the quality of the student experience, debate on how best to meet the needs of industry, and reflection on how the courses could better equip students with the skills for their professional careers.

Staffing at the time of course redevelopment stood at 16 full time equivalent academic staff and 9 technical support staff. Student distributions were approximately 100 per year of study with approximately 65-70 % of students residing on mechanical or design engineering programmes, and the remainder on product design programmes.

Review of the pre-existing 1st year programme

Biggs refers to conventional professional education as being one of amassing declarative knowledge of independent subject areas [1] which is an erudite description of the majority of traditional engineering degree programmes, and specifically those in MED. Following an instructivist pedagogical model material was delivered in a predominantly didactic lecture and tutorial format where students acted as passive recipients of knowledge [2] there was little opportunity for learners to develop the creative problem-solving, flexibility in knowledge application and interpersonal skills that are expected in graduates by the UK Engineering Council [3], and by industry leaders [4]. Furthermore, in order to address specific areas of declarative knowledge within a modularised structure there was a large number of low credit bearing modules (see Figure 1) with a heavy analytical or theoretical bias: 120 credits spread over 11 modules in 2 semesters at level 4, with a similar pattern replicated at level 5. Although this was administratively efficient, offering flexibility in timetabling and assessment, and permitting academics to deliver material aligned to their specialism, this resulted in a high assessment load for both staff and students with unavoidable parallel repetition of assessment types with limited opportunity for formative development in terms of group and technical report writing.

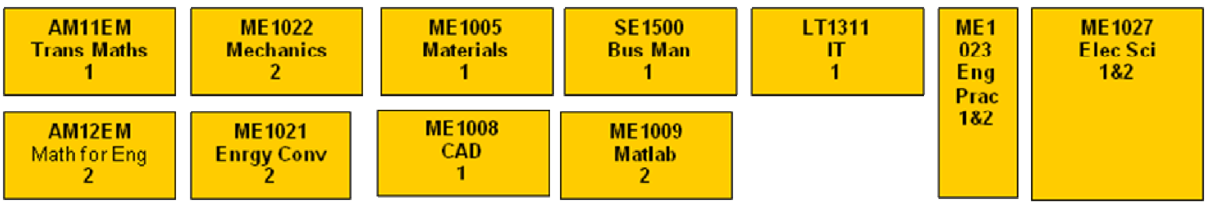

Figure 1: Pre-existing year 1 mechanical engineering programmes

Not only was this was inefficient and burdensome from an academic and student perspective but the combination of modularisation and high work-load for the undergraduates predisposed a strategic learning approach in the majority of students, with an inherent compartmentalisation of knowledge. Dawes asserts that such compartmentalisation impairs learning as it can prevent the learner from anchoring new knowledge in the context of what they know and at worst can instil a block to the formation of new concepts [5]; i.e. “I’m not very good at thermodynamics”. This also led to an apparent inability of many students to adopt a system level approach to design and analysis and consider aspects of several specialisations in a single endeavour. In a survey of engineering professionals Adams *et al* acknowledged the importance of time for reflection on past experience [6]. With such a heavy workload, and a disjointed modular system, there was neither opportunity nor a structure in place to encourage students to reflect on their learning strengths, weaknesses and experiences, or the wider relevance of their acquired knowledge.

A further concern was there was limited opportunity for the students to gain or demonstrate creativity, problem solving or practical skills. The UK Engineering Council’s Quality Assurance benchmark statements asserts “the creative way of approaching all engineering challenges is being seen increasingly as a 'way of thinking' which is generic across all disciplines” [3] indicating the fundamental importance of both problem solving and creativity for all sectors of engineering. It was observed that for students working at Level 5 and 6, progress within individual and group project work was consistently frustrated by procrastination, with the majority reluctant to make decisions for fear of failure. This lack of confidence was again identified as being in part a consequence of over-assessment; with no clear ‘right answer’ the students would consistently defer to academic or technical guidance in order to ensure success. It was also a result of poorly developed problem solving skills, with few opportunities within the analytically biased programme for the students to make valuable mistakes from which they could learn from and reflect upon without the penalty of jeopardising their degree classification. Instilling a cautious attitude to problem solving and decision making is viewed negatively in industry, evidenced again by Adams’ survey [6] that confidence and willingness to take risks were essential elements of practical problem solving.

Lastly was the issue of life-long learning. Discussions with several academics on the programme revealed several instances where BEng and MSc graduates were returning to their former academic tutors for guidance and assistance in non-specialist areas after they had started work. Symptomatic perhaps of a lack of confidence, perhaps persistence in the deferral pattern established within their strategic undergraduate learning, or inexperience of self-directed learning. The ability to learn independently is arguably the most important skill of a practitioner of any professional discipline – particularly in fields such as medicine and engineering where technological advances are rapid and as such professional development is a requirement. It was clear that this dependent culture, although inadvertently created was inappropriate for future sustainability of the programme and its graduates.

Desirable criteria for the new programme structure

It may be surmised that although the programmes in MED were strong in the development of analytical skills and practical skills a misalignment had developed between the teaching and learning practices employed and those required to induce the creative, team-working, problem-solving and independent learning skills required in the work-place with a knowledge and understanding of wider business and engineering issues.

In order to improve alignment the programme would need to facilitate increased confidence and experience in solving problems creatively and taking solutions through from concept to reality, drawing on knowledge from various sources and facets of underpinning science, and for independent knowledge creation. To further improve alignment with industry the course materials and activities were also needed to encourage a holistic approach to problem solving which accounted for cost, value and social responsibilities. Finally the activities must provide opportunity for and encourage students to make mistakes and reflect on their learning, their actions and the consequences, without jeopardising their academic success through inappropriate or excessive assessment.

Problem Based Learning

Modern engineers are required to have specialist technical knowledge as well as interpersonal communication skills, effective team, project and self management methods and techniques, and awareness of social and ethical concepts and responsibilities. Hasna describes the challenge facing the modern engineer well as “whilst trying to incorporate more human skills into their knowledge base and professional practice, today’s engineers must also cope with continual technological and organisational change in the workplace” [2].

The principal themes which resound under the consideration of the new programme structure were those of student-centred problem solving and creativity, encouraging independent learning, the flexible application of multi-disciplinary underlying science, with capacity for reflection and within a structure which aligns academic activities to those of professional practise.

PBL has been used successfully for medical professionals since its inception for the training of physicians at McMaster University (Ontario, Canada) in 1969 and is believed to contribute to a student’s motivation by encouraging active intellectual processes at the higher cognitive levels, enhancing the retention, transfer and modification of information to meet individual student needs [7]. This suggests that implementation of PBL should not have a negative effect on declarative knowledge, but offers significant enhancement through its conversion to functioning knowledge.

Savin-Baden advocates PBL as having largely unrealised potential, offering opportunities in providing skills for lifelong learning, to develop key skills, independence in enquiry and the confidence and ability to contest and debate [8]. He goes on to evidence experiences of PBL practitioners with reference to the capability for managing diversity in terms of facilitator and learner, a promising sign for a course which provides for both analytical engineering students and less analytically focussed designers.

It was clear that through the implementation of such a structure a number of the issues identified in the programme and its participants would be addressed, and through adopting a system or organisational level implementation would facilitate better alignment to student-centred learning. Kolmos *et al* are clear to indicate, however, that in order to ensure cohesion across such a level of implementation requires a clear strategic vision across the organisation [9]. The structure, clear vision and vocational alignment made CDIO an attractive strategy for MED to achieve its aims.

IMPLEMENTING A FUNDAMENTAL CHANGE IN PEDAGOGY

Phase 1 – Establishing the CDIO Modules and Culture at Level 4

Aspects of problem-based learning had been employed previously within the programmes, but only on a small and isolated scale with little interaction with other modules. Most notably the role of the academic had remained constant. The adoption of a new programme-wide delivery structure required academics to re-assess their pedagogical practice in order to align with the ethos of problem-based learning: to alter their academic role to one of being a facilitator as opposed to a deliverer of taught material. Importantly this consistent position was required to be adopted throughout the faculty in order to ensure success. This was seen as being the most important and fundamental change which was required. To address this sessions on best practice were arranged, and other members of staff were encouraged to attend and experience CDIO sessions in order to observe and discuss any concerns.

The restructured programme structure takes the form as shown in Figure 2. This induced a significant amount of work in the planning and writing of new course materials for what constituted 50% of Level 4 undergraduate study. Beyond this further effort was required in preparing Quality Assurance Audit (QAA) and professional accreditation documentation, acquiring finances, resources and financially planning for the next phases of implementation. As such, a conscious pragmatic decision was made to minimise impact on the content and sequencing of the material within the underpinning science modules until the CDIO modules had been established. Accepting an interim period of disjoint between declarative and functioning knowledge building activities until such a time as the appropriate oversight and academic efforts could be applied.

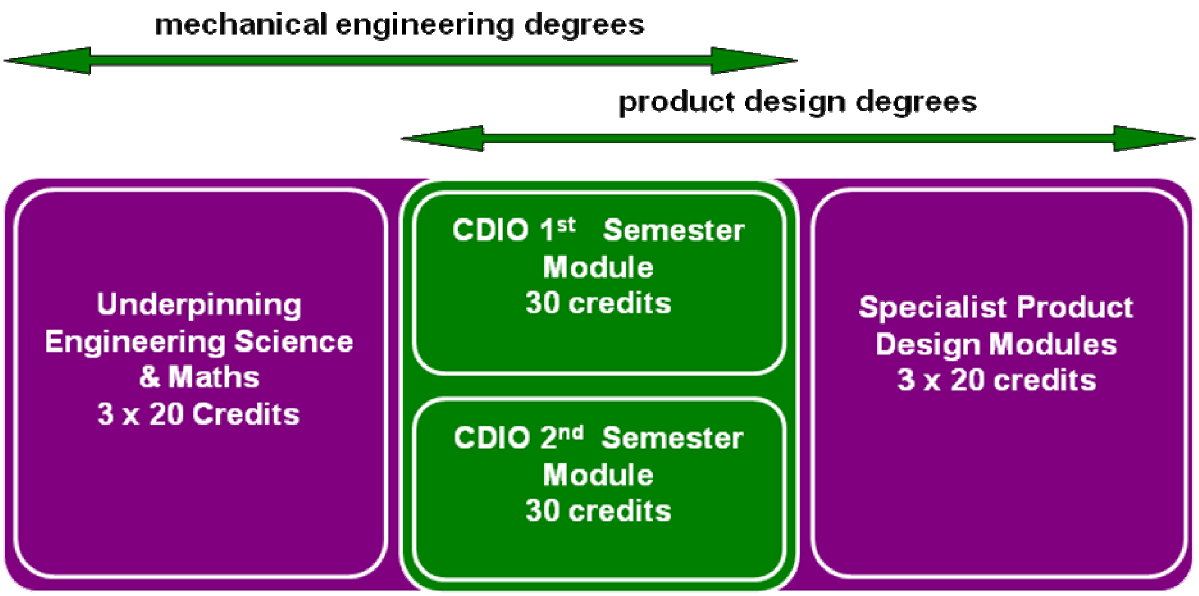

Figure 2: Revised design and engineering programme structure (year 1)

Phase 2 – Progressing the CDIO Modules and Culture at Level 5

The second phase will be embarked upon in October 2011, extending the good practices and refining the format for the uninterrupted continuation of the current CDIO undergraduates into their studies at Level 5 and for the next intake of Level 4 students.

Phase 3 – Aligning Engineering Science Modules with CDIO modules

The final phase of introduction is planned for October 2012 when the sequencing of the underpinning science modules will be altered to better facilitate application and reinforcement of these concepts within the CDIO modules at both Levels 4 and 5. This phase will also incorporate an appraisal of the Level 6 BEng and BSc programmes, and Level 7 MEng and MSc courses, identifying where improvements and efficiency savings can be gained from the adoption of universally adopting CDIO.

IMPLEMENTATION OF PHASE 1

Structuring Sessions

Active learning approaches to contact sessions had been used with success previously within MED, but usually these were limited to aspects of design or manufacture, or centralised timetabling constraints had resulted in these activities being over a protracted period of short contact sessions significantly limiting progress opportunities and permitting only a single Design-Build-Test iteration per semester.

Opportunities were explored for incorporating intensive multi-day CDIO project sessions at the start or end of each semester, however it was discounted over concerns of student perception of the material as being additional to and separate from the conventional programme material. The large module sessions were instead focussed on whole day (8 hour) intensive sessions occurring every week of the normal semester. In this way a perception of CDIO being at the core of the degree programmes could be reinforced and the declarative knowledge from other modules could be reinforced or functionalised within a much shorter time period of their introduction in other modules.

There were concerns that the use of whole day learning sessions was inefficient, with the risk of students becoming more apathetic, less responsive and lethargic beyond a half day session. Attempts were made to divide the session into 2 separate half day sessions within each week, however this significantly constrained timetabling during Phase 1 of introduction, where academics were still required to support the conventional programmes at Levels 5 to 7. Instead this led to the consideration of methods for maintaining student engagement.

Sessions were structured to create a high-productivity atmosphere, through the use of time-sensitive activities based around what Masek describes as subject-centric 'trigger' problems interspersed with time-limited mini-lectures that are aligned to the contents and objectives of that period of the session [10]. Continual monitoring of the reception of the material, understanding of concepts and canvassing of opinion from the students was administered through the implementation of personal response systems (TurningPoint™, Reivo Ltd, Twyford, UK). The sessions were further structured to follow the phases of the CDIO cycle, with full completion of the cycle within each session, or across 2-3 sessions in cases of larger and more complex activities. In this way more sedentary theoretical and analytical phases were tackled earlier in the morning session and a heavy focus on more energetic and practical work in the afternoon session, closing out with a reflective wrap-up period.

Session Staffing - Team Teaching

In order to maintain a safe working student-staff ratio of 20:1 sessions are manned by a minimum of 5 supervisory staff. Sessions are led by a minimum of 2 academics, one of whom is responsible for primary material delivery and timing of the sessions and the latter being responsible for supplementary material and monitoring student engagement. The remainder was made up through technical support staff and post-graduate demonstrators.

The role of secondary academic has proven to be an important one, alleviated from the responsibility of pacing the session the secondary academic is better positioned to observe body language and observe which concepts are not being followed or understood, as well as interject when the lead has omitted or poorly-explained any material with supporting explanation or examples.

When the session shifts into a period of activity having multiple academics can better service a large number of groups through addressing questions and facilitate academic attention to be paid to groups which require it without significantly reducing time available for others.

Fundamentally from an academic perspective the principal advantage of the team taught paradigm was the collaborative planning of sessions and activities provides a free exchange of ideas, enables potential pit-falls or obstacles to be identified prior to implementation, and also allows the academic team to adapt to staffing issues at short notice.

OBSERVATIONS, REFLECTIONS & INTERIM EVALUATION

At the time of writing MED's CDIO module coordinators had successfully completed the first implementation of the first CDIO module with a mixed cohort of design and engineering students at Level 4 and were in the process of closing out the second module.

Staff Reflections

The largest and most fundamentally important observation made has been in the attitudes of the students taking part in CDIO as observed by academics and technical staff. The students are generally more enthusiastic and pro-active when it comes to participation within the CDIO modules, with a clear evidence of thought, planning, resourcefulness and enthusiasm being brought to every session. There is demonstration of a perceived ownership of the learning environment with high levels of attendance to voluntary self-study sessions in the laboratory and other non-teaching spaces. Perhaps most surprisingly is an attitude change in the students within the more conventional didactic declarative knowledge modules which support the active learning modules. Like-for-like comparison with students of previous years showed that those learning through the CDIO programmes were keener to participate in class discussions, and there is a notably higher incidence and interest in volunteering answers and suggestions to in-class questions.

Academics introduced the new CDIO based programme as being a new venture for Aston, and continually reinforced the experimental nature of the programme and acknowledged the importance of student opinion. The students appeared to react strongly and positively to this, offering opinion and ideas in a predominantly supportive sense.

Generally staff attitude was positive with a large number of academics keen to see and take part in the learning, and attempts were made to be inclusive where possible. However there is still more work to be done in this area as some are reluctant to be involved and in a notable exception two academics who had been asked to lead CDIO sessions used the opportunity to run traditional laboratory sessions and scheduled additional didactic lectures to support assessment. This refusal of the academics to engage with the new learning paradigm proved interruptive with a significant portion of students continuing this work through into later CDIO sessions and led to a temporary collapse of the established working and learning patterns.

At the opposite extreme there were instances where some academics were keen to engage with the process and join sessions as led by other academics. Before each session there would be a briefing session where all academics and technical staff were issued with details of the session and its timings, appraised of the activities, any rules of engagement or other specific session requirements. It was found that when asked questions relating to the activities the additional academics would often give conflicting or inconsistent information as a result of not attending the briefing sessions. In some cases this was seen to cause disquiet amongst the students and create a perception of disorganisation or inequity. This could have been tackled through general release of detailed session notes to the students but this was judged to risk creativity and it was considered desirable that students would be encouraged and practised at enquiring for further information, establishing limits and pushing boundaries. This pattern of questioning practice had clearly been established within the first 3 weeks of semester 1, with the delay between students embarking upon an activity and their posing of considered questions notably diminished.

Significant effort was required in the generation of sufficient course material to fill each session whilst maintaining an appropriate balance of delivery to activity and maintaining alignment with the module learning outcomes. It was found here that the collaborative composition of the schedule for the session between the lead and secondary academic was extremely beneficial for providing fresh ideas, experience and perspectives as well as sharing material preparation, resource collation and consolidation or ‘kitting’ of activity equipment. Acquisition of any non-standard laboratory equipment or large quantities of supplies (i.e. eggs, golf balls, wind turbine components) was often hampered by the university purchasing system with frequent reliance upon informal mechanisms (individual purchase and later reimbursement). This added the unforeseen benefit of clearer visibility of project costs and in cases of severe resource limitations considerable feats in creative problem solving.

Logistically pacing the learning and activities for an 8 hour session proved taxing for the majority of academics that engaged in the process, with many sessions over-running and leading to sacrifice of the crucial reflective wrap-up period at the end. With more practice of preparing the sessions it became clear that by maintaining a strict time regime for activities had a dual benefit of both improving timing but also in catalysing engagement and higher levels of activity. Naturally this works best if the students have grasped the concepts and the material prior to the activity – but the rapid diagnosis, redelivery and reinforcement can limit any slippage.

Groups had been allocated randomly, which inevitably resulted in some groups being from a single discipline (i.e. purely from design programmes, or engineering programmes) as opposed to a clear mixture. At this level there was a not a stark difference in the performance of these groups from those of more mixed teams. However it was globally observed that tasks involving mental arithmetic or algebraic manipulation there were consistent difficulties in most teams. This remains an area of concern and one which will be the focus of development in subsequent implementations.

Assessment and feedback

The experimental nature of the module, offering a significant departure from conventional teaching methods facilitated a more experimental approach to assessment and feedback methods. Each session bore an aspect which was assessed independently through the evaluation of design-build-test success, but there were also longitudinal assessments in the form of personal response system activity for individual and peer assessment, and in the form of a reflective journal or 'blog' which accounted for the student's learning and activity throughout the session.

Personal response systems

Turningpoint^{TM} PRS (Personal Response System) handsets were assigned to each individual within the class, and each individual was assigned to a group. This permitted the use of the data from the PRS systems to monitor individual and group attendance, provide individual and group formative assessment and individual and peer summative assessment. Furthermore feedback could be provided instantly by the academics in the session thus better enabling feed-forward for later use in the session and beyond.

Implementation of PRS enabled the efficient use of concept questioning techniques to establish comprehension of freshly introduced concepts and the reinforcement of previous material with the large group.

Individual and group reflective blogs

At the end of each CDIO sessions students were encouraged to reflect on their experience of the day, and to relate their experience to the learning outcomes listed in the module module specification and record their thoughts and experiences on an online blog within the blackboard VLE. Mid-way through the teaching period students were then asked to read through their blogs and identify and provide supporting evidence and incidences of their demonstration of specific learning outcomes within their blogs. This required formal reflection on both the quality of their learning and the quality of their blog as a record of their work.

The blog was also extended to the academics coordinating each session. A teaching blog with academic-only access enabled communication of both administrative data (such as PRS reports and attendance records for tier-4 and DTUs (Defence Technical Undergraduate Scheme) student monitoring), advisory notes or recommendations for other academics pertaining to the teaching facilities, group problems and observation of students that are struggling. This document also served as evidence for Quality Assurance Audit (QAA) purposes in terms of module reflection reports and strategic recommendations for programme and school boards.

Peer reflection and feedback

A particular innovation was made in the assessment of a typically difficult area of group-project work which is the apportioning of marks for team work. Each individual was asked to appraise themselves and their team-colleagues against a series of characteristic statements. The statements were designed to be equally positive and negative so as to avoid overt assaults on any individuals and reflect a previous exercise where they were asked to reflect on their team working and management strategies. The results were then collated for all individuals and returned, providing each individual an honest reflection of any discrepancy between how they saw themselves and how their group perceived them to be. This exercise indicated that in the majority of cases individuals were accurate and honest about their levels of commitment to the course and their support of other members in their group, and in some cases group members viewed the contributions of their colleagues more positively than they did themselves.

EFFICIENCIES

A number of efficiency gains have been identified as a result of implementing the revised CDIO-based programme at Aston, and these may be categorised as marking and assessment and space utilisation. These figures have all been put into the context of the 2 years prior to implementation.

Table 1 shows a breakdown of the number of modules on the two programme streams (engineering science based and design based) and indicate the number of students and the number of individual units of assessment requiring academic attention. Assuming each module has on average 3 units of assessment it is clear to see that the number of formal assignments which must be completed by students are reduced by 54.6 % under the new architecture. Meanwhile formative and summative data collection frequency has been increased through the administration of in-session PRS tests and regular group discussion with academics.

Table 1
The number of units of assessment has been significantly reduced through CDIO implementation

	2008-9			2009-10			2010-11		
Programme Stream	number of students	programme module count	Total assignments	number of students	programme module count	Total assignments	number of students	programme module count	Total assignments
Engineering	67	11	2211	59	11	1947	74	6	1332
Design	50	11	1650	31	11	1023	28	5	420
Total	117		3861	90		2970	102		1752

The first CDIO module (ME1501) replaced 3 pre-existing 10 credit modules, and their space requirements are compared in
Table 2, showing that the initial investment of £20,000 in upgrading an under-utilised engineering laboratory into a dedicated CDIO workspace has resulted in a 37% reduction in learning space requirement within just the first semester.

Table 2
Significant reduction in space utilisation through employing a dedicated multi-use learning space/laboratory

	Equivalent 3 x 10 credit modules	New CDIO module
	2 x 44 hours in lecture theatre 1 x 22 hours in computer laboratory 10 x 3 hours in engineering laboratory	11 x 8 hours in engineering laboratory
Total	140 timetabled hours	88 timetabled hours

EARLY INDICATIONS OF OUTCOMES

Despite the efficiency savings and the significant overhaul of the level 4 undergraduate programmes the interim results are favourable.

Table 3 shows a summary of the module board results of the 2 years prior to implementation (based on modules which have been replaced by the CDIO module) and this year (2010-11). The results indicate that despite the significant changes there has been a maintenance of consistent academic challenge in both Engineering and Design based streams with average grades remaining consistent between years.

Furthermore, if we assume that the instances where students have scored zero in a module (classed as a non-attempt) it may be seen that reducing the number of small low credit bearing modules and the incorporation of true continuous assessment, monitoring and feedback has eliminated this in the new structure. The number of individual module fails from the 3 years also shows that despite the maintained academic challenge the instances of failure have decreased, but with the significantly higher credit bearing of the CDIO module the number of 10 credit module equivalents being failed has increased as a result of the 30 credit weighting of the CDIO modules. This has effectively reduced the opportunity for less committed students to progress through strategically focussing on their strengths and relying upon examination board processes.

Table 3
Summary of module board results from pre-implementation with those of 2010-11

Programme Stream	2008-9 Pass rate (%)	2008-9 mean grade	2009-10 Pass rate (%)	2009-10 mean grade	2010-11 Pass rate (%)	2010-11 mean grade
Engineering	97.0	61.2	93.2	61.5	93.2	60.6
Design	83.4	52.6	95.3	60.5	82.8	54.8

Engineering & Design	2008-9	2009-10	2010-11
number of students	117	90	102
number of non-attempts	11	16	0
Individual module fails	35	25	13
10 credit module equivalents failed	35	25	39

CONCLUSIONS

Aston's experience of CDIO has been extremely positive, with the implementation providing a catalyst for experimentation with new learning and teaching paradigms and techniques, as well as in establishing new cultures and modes of working within the faculty. The translation of the engineering and design programmes away from didactic teaching and towards student centred active and problem based learning is already beginning to indicate some of the expected outcomes of a PBL environment. Students are demonstrably taking higher responsibility for their learning and benefitting from higher motivation and engagement. Academic standards are being maintained consistent with levels prior to implementation at the same time as considerable efficiency gains are being made in terms of formal assessment loading and space utilisation.

Despite benefitting from a critical mass of CDIO practitioners there is still significant progress to be made in terms of establishing a PBL culture at Aston. This is, after all, experiential learning and a cultural change is required in academics and technical staff as well as students. Further efforts are required to induce more widespread adoption of the practices and inclusion of a larger proportion of the staff through education to eliminate misconceptions around what CDIO represents ("I already do project work"), or concerns over potential for additional work in a burdensome climate.

Academics whom have embraced the culture have found it to be an exciting and refreshing approach to engineering education, although the process of implementation has been intensive. It is demanding in terms of financial planning and coordination. Although not significantly more demanding than composing any new taught programme material it does require a higher degree of coordination and cooperation between academics to support the team teaching paradigm; Learning outcomes, material for delivery, resources for reinforcing activities require identification, development, procurement and compilation well in advance. Furthermore new approaches to collaborative material preparation and delivery is breaking down conventional feudal barriers of module ownership and demonstrating key benefits and encouraging experimentation with learning and assessment tools and techniques.

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