Developments in Engineering Education Standards:

Advanced Curriculum Innovations

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Chapter 8
Engineering the Future:
CDIO as a Tool for Combating Retention Difficulties

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ABSTRACT

With the demand for engineering graduates at what may be defined as an unprecedented high, many universities find themselves facing significant levels of student attrition—with high "drop-out levels" being a major issue in engineering education. In order to address this, Aston University in the UK has radically changed its undergraduate engineering education curriculum, introducing capstone CDIO (Conceive, Design, Implement, Operate) modules for all first year students studying Mechanical Engineering and Design. The introduction of CDIO is aimed at making project / problem based learning the norm. Utilising this approach, the learning and teaching in engineering purposefully aims to promote innovative thinking, thus equipping students with high-level problem-solving skills in a way that builds on theory whilst enhancing practical competencies and abilities. This chapter provides an overview of an Action Research study undertaken contemporaneously with the development, introduction, and administration of the first two semesters of CDIO. It identifies the challenges and benefits of the approach and concludes by arguing that whilst CDIO is hard work for staff, it can make a real difference to students' learning experiences, thereby positively impacting retention.

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BACKGROUND

Engineering Education in the UK: Time for Change

Viewed by many as the link between science and society, the Royal Academy of Engineering (RAEng, 2010) provide an insightful vision of engineering, "Engineering is about turning ideas into reality, changing and shaping the material world for the benefit of humankind" (p. i). Underpinning this vision is engineering education—the means by which society recruits and trains engineers at all levels. Moreover, the importance of engineering in addressing some of society's most pressing problems has recently been the subject of much public attention with issues such as the Gulf of Mexico Oil Spillage, the Icelandic Volcano and the consequences of the Earthquakes in Japan making headlines around the world. Within this context, the expectation that engineering will provide innovative and practical solutions to such global problems (IMechE, 2009; RAEng, 2008; Spinks, et al., 2006) means that engineering education has a vital role to play in the future sustainability of society. Yet, in many respects, as a discipline, contemporary engineering education is at something of a tipping point. Subjected to two seemingly diametrically opposed demands—the need to equip students with a broad range of highly technical and focused skills and capabilities, whilst at the same time preparing them for work by enabling them to develop personal, interpersonal and other 'transferable' skills (Lucena, et al., 2008; RAEng, 2007), the demands on University level Engineering Programmes are unparalleled. Adding to this pressure is the fact that the profession in the UK is facing unprecedented shortages—with fewer young people than ever before selecting to enter what is often a misunderstood and undervalued career (RAEng, 2007). Indeed, many Engineering Programmes are not only struggling to recruit young people, but are also facing significant levels of student attrition, with 'student drop-out / failure' being a major issue across the UK (DIUS, 2008; RAEng, 2008; NSF, 2009). Another challenge faced by both Engineering and Engineering Education, is that as a discipline, the profession is generally perceived to be one in which inequities and inequalities in gender, social class and ethnicity are the 'norm' (Gill, et al., 2008; NSF, 2009; RAEng, 2010). From the public's perspective, such stereotypical images are reinforced when considering the 'outwardly visible' demographic characteristics of the Engineering Profession, which, when viewed by non-Engineers, appears to be dominated by white, middle-class, middle-aged or older males. From an educational perspective such 'stereotypical' images and perceptions can be off-putting for young people. The result is that many potential 'future engineers' simply do not consider the possibility that Engineering could make a viable and exciting career choice. Additionally, the fact that the traditional pre-requisite subjects of Mathematics and Science are increasingly 'out of favour' amongst today's young people, who often perceive them to be too difficult or lacking in relevance (Jones, et al., 2000; Dickens & Arlett, 2009), means that only a few possess the basic qualifications necessary to study engineering at Bachelors level.

Within this challenging environment, the future for Engineering and Engineering Education in the UK is at best challenging and at worse non-existent. Moreover, predictions indicate that the situation will worsen over the next twenty to thirty years as fewer young people will select to study engineering. This means that, unless urgent action is taken to redress the balance, the UK will face significant shortages of future engineering talent over the forthcoming decades (IMechE, 2009; Spinks, et al., 2006).

CDIO: THE WAY FORWARD?

In addition to the issues facing Engineering Education, the Higher Education (HE) Sector in the UK as a whole is facing unprecedented levels of funding cuts. At the same time the Sector finds itself subjected to ever increasing employer and government expectations in that it is expected to 'produce' large numbers of highly qualified, flexible and employable 'work-ready' graduates. Within this context, the School of Engineering and Applied Science at Aston University, took an innovative and proactive decision to introduce a relatively new method of Engineering Education, that of CDIO (Crawley, 2002), across its first year curriculum for all Mechanical Engineering and Design students.

Defined as '*an innovative framework for producing the next generation of engineers'* CDIO is based on '*... a commonly shared premise that engineering graduates should be able to: Conceive – Design – Implement – Operate complex value-added engineering systems in a modern team based engineering environment to create systems and products'* (CDIO, 2011). In the case of Aston University, CDIO provides an ideal medium by which it can offer a programme that is practically relevant whilst being academically grounded. In promoting the concept to students, the University website points to research into the effectiveness of CDIO and notes... *"... the essence of you becoming an engineer or designer is not only dependent on you developing technical knowledge but also being able to combine this with practical engineering skills, social awareness, team and project management abilities, and competencies in many other fields to solve engineering problems"* (Aston University, 2011). CDIO has been introduced as a core component of the curriculum for Mechanical Engineering and Design students. Reflective of the external and internal challenges faced by Engineering Education today, the Aston approach to CDIO has been developed in a 'bottom-up' manner aimed at meeting the academic learning needs of students, whilst fulfilling employer and governmental expectations in terms of employability. The curriculum has been purposefully designed to offer economically viable and relevant practical activities that are theoretically grounded in appropriate academic content. One day per week is dedicated to the delivery of the module, which is taught in a purposefully designed CDIO laboratory. Outside, of this time, students are expected to spend a further 14 hours on CDIO related activities (including theoretical and practical based learning). Other, more traditional subjects supplement the curriculum, with both groups participating in formal learning appropriate to their discipline.

A frequent comment students make about their learning on engineering programmes is that they find it difficult to determine how the different modules they study 'fit together.' In some cases, this can lead to students deciding to leave the programme of study. By developing a capstone CDIO module, the motivation is to provide the students with a coherent learning experience that enables them to view their study in a more holistic and interconnected way. In addition, benefits are realised from allowing both engineers and designers to work side by side, with each appreciating the others field. The learning outcomes derived for the capstone module take account of these overarching objectives as well as addressing the need to develop some basic engineering / design skills and understanding in the newly arrived students.

The module itself comprises a series of practically focused activities that allow the students to explore basic engineering / design ideas working in small groups of around 6 people. The initial projects are intended to be completed in the weekly session, but in the second half of the module the projects take place over multiple weeks. The projects explore aspects of statics, dynamics, energy generation, sustainability, mathematics, and design, all within an environment that promotes creativity and teamwork.

Working alongside the module team, two independent researchers[1] have been employed to record and analyse the overall pedagogic and practical value that CDIO adds to the student learning experience. Additionally, the researchers have used the opportunity to identify and critically analyse staff development needs in respect of problem based learning approaches in general, and CDIO in particular. This research is now discussed in some depth.

THE RESEARCH STUDY

Commencing July 2010, the two researchers have ‘shadowed’ the teaching team, attending programme planning and development activities during the summer break, before going on to attend CDIO lectures, as non-participant observers. Utilising an Action Research Design (Norton, 2009), and adopting mixed methodological research approaches, the researchers have captured the views of students and teachers, critically recording and analyzing the Programme in ‘real-time.’ The work discussed in this chapter represents the first stage of a longitudinal study, which is aimed at critically evaluating the CDIO Programme as it is rolled out across the four years of the Undergraduate Programme in Mechanical Engineering and Design. In this respect, the research is unique in that it represents a contemporaneous analysis of the issues and changes as they take place, rather than providing a retrospective analysis, as is often the case in engineering education research.

The first stage of the research involved non-participant observations of two staff meetings during the summer of 2010. Additionally, non-participant observations were conducted during the first four CDIO sessions which ran during October 2010. Following this, observations were conducted on a fortnightly basis through to December 2010. During the second semester, observations were conducted on three different occasions. Bearing in mind the ‘engineering’ focus of the observations, it was decided that the lead researcher was the best person to undertake this part of the work. The reason for this was that as an engineer, he is familiar with the language, content, and context of the sessions—and so could concentrate on the pedagogy and research without being distracted.

In addition to the observations, a quantitative survey was administered to all of the students in week 5 of the first semester. The survey aimed to capture their initial views of CDIO as a learning approach. A total of 65 students completed the first survey, representing 65% of the sample. The quantitative data was analysed and the results fed directly back to the teaching team—with the aim of providing sufficient information to enable them to gauge the success of the approach and deal with any issues arising.

Building on the findings of the observations and initial survey, a second, qualitative survey was administered at the end of the second Semester in April 2011. Comprising ten ‘open’ questions, all of the students were surveyed. A total of 73 responses were received (73% of the sample).

STUDY FINDINGS

The Observations

The overall aim of undertaking observations, which were conducted on a non-participatory, overt basis, was to enable the research team to gain a first-hand insight into the issues from the perspectives of the staff introducing CDIO. In order to deal with issues of reliability, the social scientist in the team developed the observational framework which was grounded in pedagogical research and utilised an ethnographic approach. The observational data was analysed by both researchers utilising a Grounded Theory approach (Strauss & Corbin, 1990). Four distinct concepts were identified in the analysis of the observational data: people: pedagogy: process: and product.

The first concept 'people' reflected staff concerns about the practicalities of offering a 'resource / teaching' intensive programme such as CDIO. Such concerns were realised once the programme began, with 'high' demands on staff, both physically and mentally, being observed. CDIO is not an easy option for staff as it is very much 'student focused'—the stress of actively teaching for nine hours in one day was evident. Additionally, one of the issues identified during the observations related to the difficulties of 'large group' teaching. A purpose built but basic CDIO laboratory is used for the sessions. Whilst this provides a good environment for practical activities (albeit a little cramped), it was noted that the 'instructional' part of the sessions (using PowerPoint slides / lecturing) was somewhat difficult as the acoustics in the room were not ideal.

The second concept 'pedagogy' reflects the challenges of balancing engineering content and context with active learning and student focused teaching practice. The decision to base the curriculum around CDIO was taken relatively late in the previous academic year. Amongst the staff, a sense of excitement and novelty was witnessed in the initial planning stages of the programme. However, later in the year, during the observations of the programme delivery, it was evident that some of the staff found the fast pace of CDIO, and the expectation that the programme would be consistently innovative, somewhat challenging. It was observed that time pressures often focused staff minds on content and the method of student engagement became almost secondary. Another pedagogical issue related to assessment and feedback. In keeping with the spirit of CDIO, the programme lectures introduced a range of formative and summative assessment—including the use of learner response systems (plippers), and the keeping of individual logs. The 'instant' feedback, via the use of 'plippers' was observed to be a great success—keeping the students (and staff) engaged. However, other methods of assessment including project based summative assessment and the keeping of individual 'logs' appeared to be less of a success. Difficulties in providing individual feedback to such a large group were observed, with some students seemingly not able to link 'generic' group feedback to their own work. However, observations of the final task 'project presentations' showed high levels of commitment on behalf of the students and staff, although perhaps predictably, some difficulties with 'group work' were witnessed (with some students apparently 'free-riding,' as well as issues around group dynamics more generally).

The observations of the 'process' of CDIO clearly identified the value of breaking learning into the four distinctive stages of *Conceive, Design, Implement* and *Operate.* The students were seen to take to this method of learning very well, and from an engineering perspective, each stage was seen to be both distinctive yet at the same time integral to students' learning. Theoretical content was observed to be important to each practical stage.

The final concept 'product' was observed to encapsulate three different factors associated with the delivery of CDIO: resources, technology and production. Possibly the most distinctive aspect of the Aston approach to CDIO is that it has been offered at a time of economic austerity. To put it simply, the programme has been 'run on a shoe-string.' This has meant that in undertaking the projects, the students have had to obtain their materials from 'recyclable and recycled' sources. In doing this, the students were observed to rise to the challenge—the majority appearing to find it 'fun' and 'exciting.' The emphasis on 'recycling' naturally appealed to the students but also enabled them to learn about the basics of engineering in a very practical, problem solving way. This did not detract from the academic quality of the programme in any way. The second issue observed related to the technology used for the programme delivery. The 'plippers' occasionally did not work, resulting in frustration for the students and additional stress for the staff. It also became clear

Figure 1. Student perceptions of the usefulness of previous learning experiences (%)

I have previously found the following learning approach…	Very Useful	Useful	Neutral	Not Useful
Work-Sheets	**9**	**39**	**39**	**13**
Projects	**29**	**59**	**12**	**0**
Problem-Solving	**35**	**62**	**3**	**0**
Making Things	**43**	**45**	**9**	**3**
Designing Things	**35**	**57**	**5**	**3**
Drawing Things	**29**	**43**	**23**	**5**
Planning Things	**29**	**54**	**14**	**3**
Working on a Computer	**18**	**49**	**22**	**11**
Formal lessons with less than 5 other students	**21**	**26**	**39**	**14**
Formal lessons with between 6-19 other students	**23**	**34**	**40**	**3**
Formal lessons with 21 or more other students	**8**	**20**	**40**	**32**
Group Work	**32**	**49**	**11**	**8**
Working in Pairs	**17**	**51**	**24**	**8**
Working Alone	**17**	**49**	**20**	**14**
Private Tuition	**14**	**18**	**51**	**17**

that voice amplification technology was necessary when addressing a large group of students for a sustained period. Finally, the issue of 'production' is a key part of CDIO, given that all of the learning was project based. In each of the sessions the students made something 'real' and then tested it. This was observed to be a successful and engaging way of learning. It provided the students with the means by which they were able to actively test theories; indeed, they were observed discussing different choices, theories, and concepts in their groups. However, on the negative side, different levels of commitment were observed with some students contributing far more than others in the production of the final product.

Quantitative Survey

The purpose of administering a survey in the early stage of the students' academic careers was to enable the researchers to gain an insight into their previous learning experiences so that the programme leaders could adapt their approach accordingly. The initial survey was also developed as a 'benchmarking' tool upon which the longitudinal study could be based.

In the initial survey Likert Scales were used to gain a breadth of opinion and insight. Questions were focused into 4 distinctive categories:

1. Previous learning experiences
2. Expectations of the university learning environment
3. Expectations of the 'added value' of university
4. Perceptions of the first few weeks of participating in CDIO

Students' Previous Learning Experiences

Students were asked to indicate how useful they found previous learning approaches in preparing them for the university learning environment.

This part of the survey was kept deliberately minimalistic, and took into account the fact that

Figure 2. Students' expectations of the university learning environment (%)

I expected to participate in the following learning activities at university…	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Presenting work to a group	**16**	**59**	**17**	**8**	**0**
Role-Play	**3**	**32**	**26**	**33**	**6**
Experiments	**32**	**60**	**8**	**0**	**0**
Team / Group work	**45**	**37**	**9**	**9**	**0**
Reading by myself	**17**	**52**	**25**	**6**	**0**
'Long' essay type assignments (2500 words +)	**8**	**22**	**29**	**35**	**6**

over 80% of the students had entered university straight from school. The answers are summarised in Figure 1.

Figure 1 shows that 'problem solving' was the students' previous preferred learning approach, with 'designing things' and 'making things' also scoring highly. Additionally, 'problem-solving' and 'planning' were identified by over 80% of the group as useful learning approaches. Such 'practical' learning preferences are perhaps not surprising given the discipline choice of the sample group—all of whom have selected to study engineering or design at university. The least favoured learning approach was 'formal lessons with 21 or more students.' Indeed, all three questions relating to 'formal lessons' were not rated particularly highly. Likewise, 'private tuition' did not score highly, although since almost a third of the group indicated that they found private tuition useful or very useful, it does give some indication of the lengths some students (and their parents) go to in preparing for university.

The answers relating to classroom size reflect the fact that the majority of the students previously attended typical 'State' schools, wherein up until the age of 16 years, classes of more than 30 students are common-place. However, in the UK, private tuition is relatively rare, generally only available for those able to afford it (usually middle class, university educated parents). That just under a third of the sample had received private tuition was not reflective of the overall social class demographic of the sample (the majority of whom are from 'working class' backgrounds).

Students' Expectations of the University Learning Environment

Students were asked to indicate their level of agreement in respect of the types of learning approaches they expected to experience at university. Their responses are given in Figure 2.

That the students' least expected 'essay type' assignments possibly reflects typical pre-university education whereby 'long' essays are not generally part of the curriculum (particularly in the sciences). It was not unexpected that the majority did not anticipate being asked to participate in 'role-play,' an approach increasingly being explored in engineering education. The large number of students who indicated that they expected to be involved in 'experiments' and 'team/group work' reflects the 'active' and 'project based' nature of engineering.

It should be noted that in the UK, engineering does not generally feature on the pre-university school curriculum (Clark & Andrews, 2010). Whilst there are a small number of school-based 'engineering clubs,' many of which offer children and young people the opportunity to take part in national 'engineering' competitions (see for ex-

Figure 3. Students expectations of the "added value" of university (%)

I expect university to…	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Improve my problem-solving skills	**52**	**45**	**1**	**2**	**0**
Teach me about real world problems	**64**	**34**	**2**	**0**	**0**
Improve my employment prospects	**62**	**32**	**6**	**0**	**0**
Provide me with the skills employers want	**52**	**42**	**5**	**1**	**0**

ample, Bloodhound, 2011), engineering remains mostly absent from the typical school curriculum. A recent attempt to change this has been the introduction of the 'Engineering Diploma' (IET, 2009). It is, however, too early to gauge the impact that the Diploma has had on pre-university education, or whether it is beginning to change young peoples' perceptions of the discipline. Reflective of the current school education system, the vast majority of the sample did not have any previous exposure to engineering education. The exception to this was two of the sample who are sponsored by the Forces to do their Degree. Both full time service men, these two students had previously trained to 'technician level' and are a real asset in the classroom. All of the other students however, were more or less completely new to the discipline, with their previous exposure being limited to participation in competitions, or to familial linkages (usually fathers, grandfathers, brothers, or uncles who are engineers). The lack of exposure to engineering at an early stage in the education system is a global challenge. In the UK there is a growing discussion as to how this can be remedied and at what age children can be most effectively engaged and how (IMechE, 2010).

Students' Expectations of the "Added Value" of University

Students were asked to indicate their level of agreement with regards to their expectations of how university would prepare them for employment:

Figure 3 shows that the students' have high expectations of their programme in respect of employability and preparing them for the 'world of work.' Given the rising costs of higher education and the increasing demands put onto students to think about employment, this is not surprising.

Students' Perceptions of the First Few Weeks of Participating in CDIO

The final part of the survey looked specifically at the students' perceptions of participating in CDIO. The results are shown in Figure 4. Even at this early stage the value of CDIO in helping students' link engineering practice to theory and theory to practice was apparent. Likewise, its value in promoting team working, independent thinking and problem solving were all indicated in the survey. Perhaps not surprising, the majority of the students indicated that the CDIO approach was not quite what they expected—although just under half did say they preferred it to formal lectures.

Qualitative Survey

The questions in the 'open' survey were asked in such a way so as to give students the opportunity to give their views without being influenced by their lecturers or by the researchers. The questions focused on the students' perceptions of CDIO as a learning approach and covered all aspects of the learning experience. Most of the responses took the format of a single sentence.

Figure 4. Students perceptions of CDIO (%)

CDIO …	Strongly Agree	Agree	Disagree	Strongly Disagree	Unsure
Is an interesting way of learning	**38**	**54**	**0**	**0**	**8**
Enables me to see the links between practical engineering and theory	**27**	**55**	**3**	**0**	**15**
Enables me to see the links between engineering theory and practice	**30**	**59**	**2**	**0**	**9**
Is my preferred way of learning	**22**	**27**	**8**	**2**	**41**
Is not what I expected at University	**17**	**61**	**11**	**0**	**11**
Is less preferable than formal lectures	**0**	**11**	**42**	**24**	**23**
Has helped me think independently	**12**	**47**	**14**	**2**	**25**
Has helped improve my team-working skills	**47**	**42**	**5**	**0**	**6**
Has helped improve my problem solving skills	**28**	**59**	**2**	**0**	**11**
Is more enjoyable that formal lectures	**50**	**41**	**3**	**0**	**6**
Sessions enable me to fully participate as a team member	**48**	**49**	**0**	**0**	**3**

This survey captured the student perception towards the end of their first year of study at university.

Utilising an approach based upon Grounded Theory (Strauss & Corbin, 1990), the qualitative data was analysed by two researchers and four distinctive concepts identified: people: pedagogy: process: and product, thus mirroring the observational analysis discussed earlier. Each of these is now considered in turn.

People

All of the comments in this category related to 'team-working.' The CDIO lectures are planned around group work, with students working in teams of four to six people. The majority of students were very positive about working in a team:

I have found CDIO interesting. So far learning has been strong in areas of team work and leadership. Male: 22 years: Engineering Student

For many students, the opportunity to work in project based teams meant that individuals were able to use their own skills for the benefit of the team. The approach also encouraged independent working outside the CDIO lab:

The most enjoyable part has been working as part of a team for projects—especially the crane project. The whole team had to take advantage of their own skills to help the team. Male: 19 years: Engineering Student

I have enjoyed working as a team. The CDIO approach forces you to find solutions and gain knowledge by research outside of lectures. Female: 19 years: Design Student

There were however, some negative comments from a minority of students. Typical negative comments related to poor group cohesiveness, and a lack of effort from some group members:

CDIO has been irritating at times as I have to contend with other group members either not showing up or not working instead of concentrating on my own progress. Male: 19 years: Engineering Student

Whilst CDIO is interesting and very practical. It is difficult when the people in your group don't put a lot of effort in. Male 19 years: Design Student

On the whole CDIO is pretty good. But it does allow some people to do nothing and still get good grades. Male: 18 years: Engineering Student.

Pedagogy

All of the students made comments in respect of the learning and teaching approach. For most, CDIO was viewed as a positive learning experience with many commenting that CDIO is preferable to 'standard' or 'class based' lectures. Other words repeatedly used by the students to describe their perceptions of the learning approach were: *challenging, interesting, helpful* and *practical.* On the negative side, words such as: *frustrating, long-winded* and *confusing* were used by the minority.

Many of the students' appeared to have mixed views. A typical comment in this area is given by one engineering student, who whilst noting that CDIO is an enjoyable way to learn, also found it somewhat 'hectic.'

CDIO is a very enjoyable way to learn. Much more preferable than standard lectures. However it can be quite hectic and unorganised at times. Male: 21 years: Engineering Student.

On the whole the survey findings suggest that the students were satisfied with the manner in which the sessions were taught and their interactions with their lecturers. There was one notable exception to this, a slightly older student who commented:

My marks in this module have been lower than in other 'lectures / exams.' This is due to the lack of exposure to module staff who have not gauged individual effort or performance. Male: 23 years: Engineering Student.

Whilst another felt the lecturers at times seemed 'confused':

Poorly planned with lecturers seeming confused at times. Several sections have been overly simplistic and restrictive in their approach. Male: 19 years: Design Student

Perhaps the most notable pedagogical outcome of CDIO was that the students felt it enabled them to better understand concepts and to become independent learners:

I like the practical activities. Practical activity: Creating what we talked about. Seeing and better understanding concepts. Learning new terms. Female: 19 years: Engineering Student

I have enjoyed the practical elements of each project. Learning to find things out for ourselves. Male: 20 years: Engineering Student

Process

Many of the students seemed to struggle with the fact that the CDIO module was offered over a complete day—requiring them to be in the classroom for 8 out of 9 hours. Over 60% commented that they felt the sessions were *too long.*

With regards to the processes encapsulated by CDIO, most of the students commented positively about the 'project based' aspect of CDIO. Others made reference to certain aspects of the module with around half identifying the CAD tutorials as particularly helpful.

On the negative side, several of the students felt the CDIO sessions were disorganised. Another criticism related to the scarcity of materials:

I feel CDIO is better than lectures. However, materials are scarce... Male: 19 years: Engineering Student.

Whilst some students clearly did not enjoy having to source their learning materials from 're-cycled rubbish':

I didn't like having to 'resource' materials from a skip. Male: 18 years: Design Student.

Product

The opportunity to 'produce' something tangible was, for the majority of students, the mainstay of CDIO. All of them identified one or more of the projects as being particularly enjoyable and useful. When asked what the single most enjoyable part of CDIO was, without exception, all of the students simply referred to one of the Projects—writing, '*The Bridge Project,' 'Crane Building,'* or the '*Egg Project.'*

CONCLUDING REMARKS

Overcoming the Issues and Challenges of Retention using CDIO

The findings from this study suggest that students entering Mechanical Engineering and Design undergraduate programmes prefer 'hands on / problem based' approaches to learning. Additionally, it suggests that students are more comfortable working in small groups than in large lecture classes. Using CDIO allows faculty to capitalize on such preferences, enabling teachers to make the most of students' natural predispositions towards 'practical' learning by providing an active learning environment in which theory can be linked to practice in a realistic and understandable manner. The CDIO learning environment is one in which students are able to explore the various options, it encourages individual learning whilst at the same time enabling students to develop team working and other 'transferable' skills and competencies that are keenly sought by employers. Most positively, the evidence thus far suggests that CDIO has provided the means by which the University has begun to address issues of retention. By providing a positive and exciting learning environment, the 'drop out' rate has decreased from an average of 10% of the cohort for each of the preceding three years (from the academic year 2006/ 07 through to 2009/ 10), to 2% of the cohort so far this year (although the final figure will not be known until after the 1st year Exam Board has sat in July 2011).

It should be noted however, that CDIO is not an 'easy' answer. It is hard work. For staff in particular, the demands of offering such an intense learning experience has at times proved challenging. The wider economic context has also impacted the manner in which CDIO has been developed and administered. The staff has had to use their initiative and imagination to provide interesting and innovative projects with a limited budget. However, in rising to this challenge, all those staff concerned has positively developed their teaching practice. As with any teaching approach, CDIO does not suit all students. It does however seem to favour those with a natural 'leaning' towards engineering and design and has the potential, through varied learning and teaching practice, to engage students favouring any of the different student learning styles. The practical, applied and participatory nature of CDIO means that with staff commitment, student engagement can be high. The challenge for

Aston University is to maintain the impetus in order to encapsulate all three years of the undergraduate curriculum. One area in particular where it is felt further work is required is that of assessment. A variety of approaches were used in the capstone module including practical assessments, learner response system quizzes, presentations, and learning diaries. The effectiveness of each approach and the suitability when assessing the specified learning outcomes is worthy of ongoing consideration. Only time will tell as to how successful the programme has been, and how it has helped address not only issues of retention but also wider concerns relating to employability. The researchers will continue to follow this first cohort and the new cohort starting in October 2011. However, early indicators suggest that, with staff commitment and management support, CDIO can make a real difference to students learning experiences and in doing so positively impact retention.

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KEY TERMS AND DEFINITIONS

Action Research: a cycle of research that identifies a problem, introduces an intervention and then, by way of the subsequent evaluation, leads to a modification of future practice.

CDIO: Conceive, Design, Implement, Operate – an education framework that blends theory and practice.

Project-Based Learning: Learning through engagement with project based activities, often accomplished by way of group working.

Retention: the consideration that, once enrolled, a student remains on their chosen course of study.

ENDNOTE

1 The lead researcher is an engineer with an interest in engineering education research, the other an educational sociologist with an interest in engineering education. Both are independent of the teaching team.