

Engineering for Employability: A transition into CDIO

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Abstract

This paper draws upon the findings of a three year study which tracks an institutions journey of CDIO. In focusing on the student perspective the findings discuss students' prior learning experiences and their expectations of university. The study considers students' early perceptions of CDIO; emergent findings suggest that whilst CDIO is not really what students expect when they first arrive at university, most prefer it to 'traditional lectures'. Indeed the majority indicate that they believe the approach enhances their employability and provides a more engaging learning experience. The conclusion argues that with its focus on problem-based learning and team-working, CDIO has changed the face of the 1st year experience for mechanical engineering and designed students within the university and that in doing so it has enhanced transition and ultimately promoted student success.

Keywords: Problem Based Learning, CDIO, Active Learning, Employability.

1. Introduction

This aim of this paper is to provide a brief introduction into the emergent findings of a longitudinal engineering education research project the purpose of which is to map, critique and evaluate the introduction and subsequent development of a problem-based learning approach in a UK School of Engineering and Applied Science. Focusing specifically on CDIO the study has followed the introduction of CDIO in the School right from the onset, looking closely at student expectations and experiences. Bringing together three years' data this paper discusses students' perspectives of their first term in university, whereupon they suddenly find themselves immersed in a completely 'alien' learning approach – that of CDIO. Perhaps the most important finding of the study is that from the students' perspectives, one of the main benefits of problem-based learning is that it is built upon an ethos of 'real-life' learning. By being given the opportunity to work on 'real' problems CDIO quickly engenders a sense of identity, enabling first year students to begin to 'feel like engineers' right from the onset. In doing so it promotes a sense of loyalty and pride in the discipline across the cohort.

2. Background & Context

The requirement for undergraduate engineering education to provide industry with 'work-ready' engineering graduates able to 'hit the ground running', in possession of the necessary high level practical skills and theoretical knowledge required by an exceptionally diverse sector (Lucena et al, 2008), means that engineering programmes find themselves facing unprecedented pedagogical challenges. Contextualised by the wider economic situation in which higher education finds itself having to 'cut-back' financially, such challenges mean that engineering schools need to provide a curriculum that balances academic and theoretical rigour with the practical training demanded by industry. The question of how to do this within a limited budget is one that many engineering schools are facing, and one that is further complicated by widely held stereotypical beliefs that as a profession engineering is dominated by inequalities in gender, social class, and ethnicity (Gill et al, 2008; RAEng, 2010). The image and reputation of 'degree-level' engineering as being suitable for white, middleclass, males only is reflected difficulties experienced by many engineering schools in attracting suitably qualified young people onto undergraduate engineering programmes; an issue which in itself is further compounded by problems with student attrition as many students enroll onto engineering programmes only to 'drop-out' during the first year (DIUS, 2008; RAEng 2008).

Whilst many engineering schools struggle to attract, and then keep, young people onto undergraduate programmes, warnings that unless quickly matters improve then the UK will face unprecedented shortages of engineers in the near future (Spinks et. el, 2006) means that something needs to be done urgently. Indeed, without action there is the danger that, in the UK at least, engineering education may soon find itself struggling to survive. This makes the need to both look at the curriculum and at how engineering programmes can 'make employable graduates' of vital importance.

Set against this background, in 2010, colleagues at Aston University took the decision to dramatically alter the undergraduate syllabus in Mechanical Engineering and Product Design by introducing problem-based learning in the form of CDIO across the first year curriculum (for further details see CDIO, 2013; Crawley, 2002). The main reasons for introducing such a major change reflected a desire by academic colleagues and managers alike to provide an academically relevant and industrially attractive curriculum that would provide students with high level work-ready skills whilst making sure they continued to learn the relevant

empirical underpinning of the discipline. Concurrently with the introduction of CDIO, engineering education researchers were employed to track and record the experiences of both staff and students as the changes were put into place and ‘rolled out’.

3. Methodological Approach

Starting with the research question "How effective is CDIO as a learning and teaching approach in Mechanical Engineering and Design Education?" an Action Research Design based upon a mixed methodological approach was put into place to enable the researchers to follow the programme development and delivery right from the onset. Whilst the researchers have utilised a number of different tools in the course of the study including semi-structured interviews, overt non-participatory observations, focus groups and surveys, this paper draws upon the quantitative part of the study only.

In drawing upon three years survey findings, the paper considers the issues around students’ transition into university. Using 5-point Likert (Agreement) scales to collate and analyse data regarding students’ previous learning experiences, their expectations of study at university, and their perceptions of CDIO at the end of the first term in their first year of study the paper provides a unique insight into some of the issues impacting students’ experiences.

The response rate over the three year period varied from 42% in year one, to 51% in year two and 43% in year 3. The gender split of the three year period was 18% females and 82% males. Around 60% of each cohort was from a BME (Black and Minority Ethnic) background. On average 15% of each cohort were international students (non-EU).

4. Findings

The first part of the survey examined students’ previous experiences using different learning approaches. This was particularly important as in redeveloping the curriculum colleagues had identified a need to gain some understanding of students’ ontological and epistemological ‘starting points’. Put simply, the differences in learning approaches and styles between high school and university means that it is important for academic colleagues understand where students are "coming from" when developing the new problem-based curriculum. This enabled the curriculum to be adapted in such a way so as to maximise student learning.

Looking at the collated data, the most frequently experienced approach was ‘problem solving’ with ‘project work’ and ‘making things’ also proving popular. The approach to which the least amount of students had been exposed was ‘worksheets’. Figure 1 below shows the percentage of students in each cohort who indicated that they had experienced the different types of approaches.

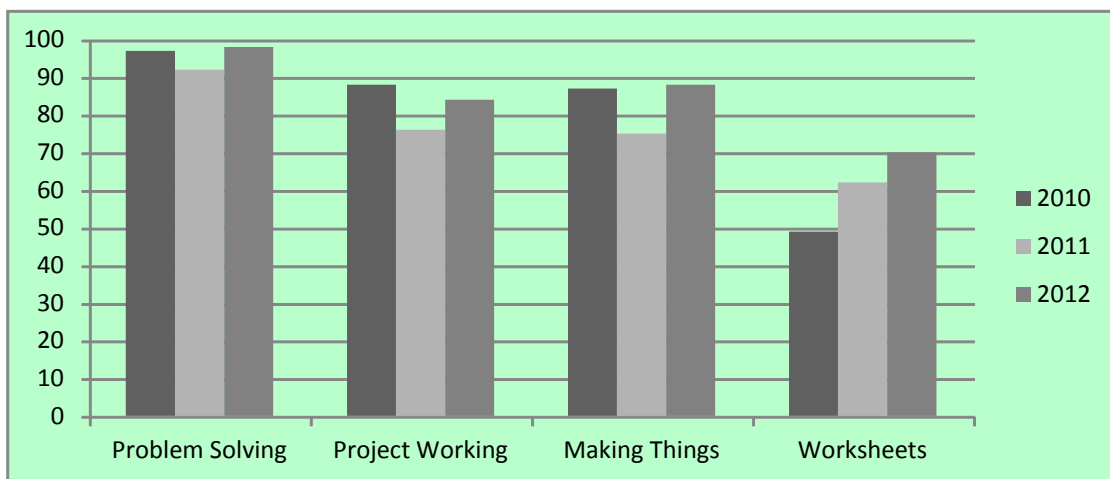


Figure 1: Percentage of students in each cohort who agreed they enjoyed each learning approach (Per Cohort)

In addition to looking at the students’ experiences with regards to learning approaches, the survey also considered the students’ previous learning environments. Across all three years the most commonly identified learning environment was that of working in groups with 80% of the students indicating they had some experience of group-work. The least experienced learning environment comprised classes of 20+ which was experienced by 26% of the overall sample. Figure 2 below shows the aggregated data relating to the students’ exposure to different learning environments.

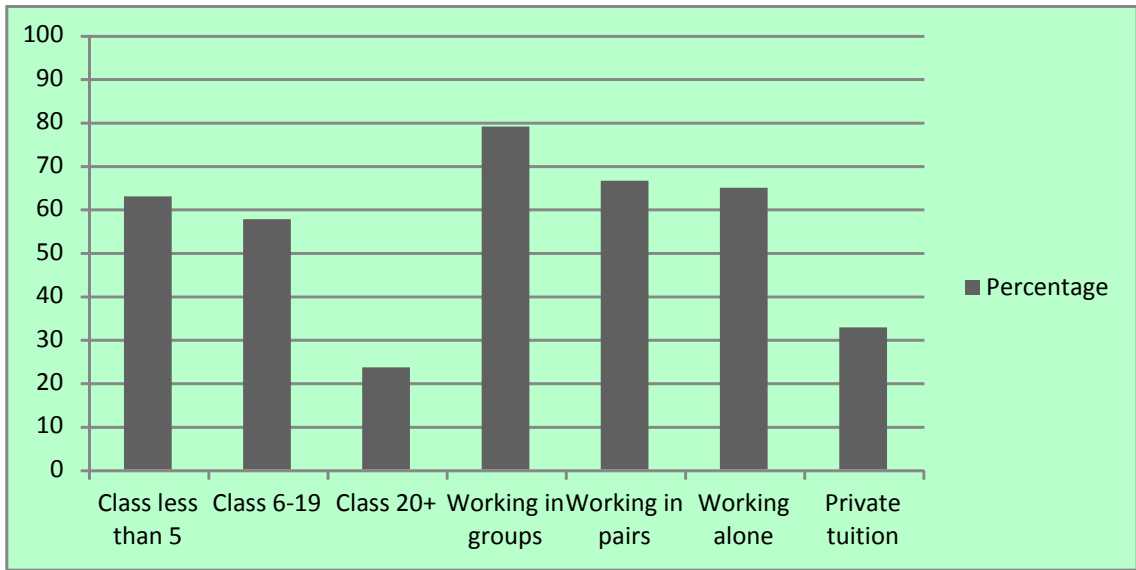


Figure 2: Students' previous exposure to different learning environments

The next set of questions focused on students' expectations of how they would learn in university. Figure 3 below shows that the majority of the sample expected to be working in teams and to be involved in 'experiments' and 'model making'. Whilst just under two-thirds expected to find themselves required to 'read' as part of learning at university; additionally, less than a third expected to be involved in role-play and only a quarter thought they would be required to write essays.

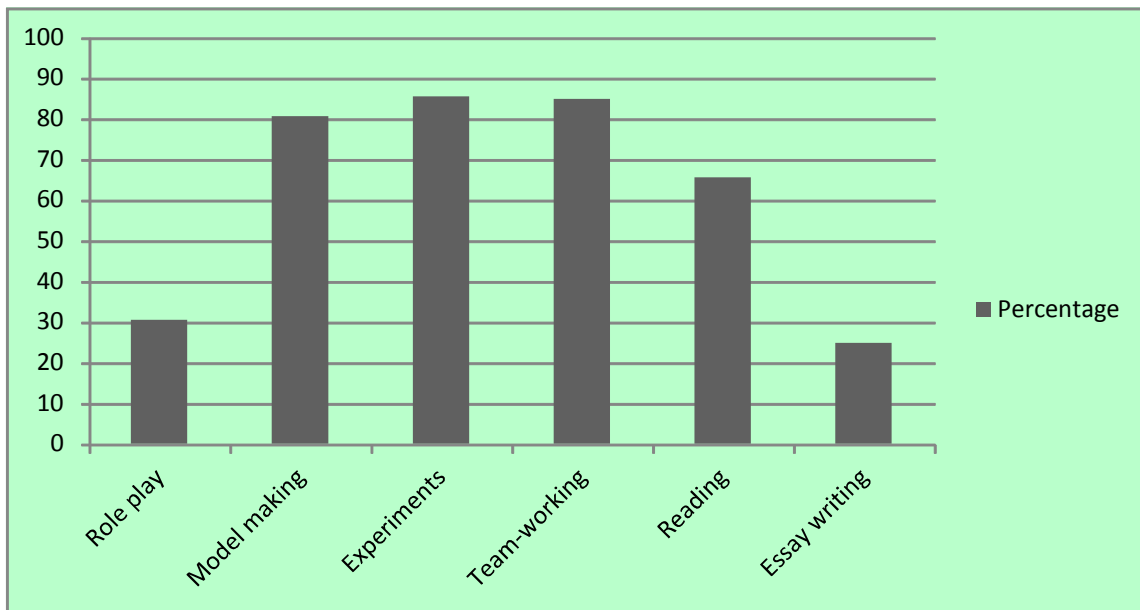


Figure 3: Students' expectations of how they would learn at university

The next part of the survey examined the students' perceptions of their first term at university learning using the CDIO approach. This data is displayed disaggregated across the three years to give some indication of the students' changing perceptions year-by-year as the concept of CDIO developed and changed within the university.

In addition to considering students affective perceptions of CDIO the survey also sought to gain some insight into how they perceived CDIO would equip them with transferable skills and in doing so promote their employability. Again this data has been disaggregated to give some indication of the students changing perceptions year-by-year.

5. Discussion

The data presented in this paper effectively 'tracks' the first three years of CDIO at Aston University. The first two charts examine students' previous learning experiences. The demographic nature of the student body at Aston is such that there are high numbers of non-traditional students with the majority being of a BME background (57%) and from a *working-class* background. The majority of first year students are 18-20 years old and have studied A levels or BTEC prior to university – although in engineering a significant minority are accepted following successful completion of a Foundation Year. Around half of the students are 'local', living at home whilst studying. Figure 1 reveals that a significant majority of all three cohorts had participated in problem-solving, project working and making things in the two years before attending university; with the use of worksheets being the least experienced. The emphasis on 'practical hands-on' learning is perhaps not surprising given that the sample comprised engineering and design students all of whom had studied the prerequisite subjects for each discipline. When considering the data in Figure 1 alongside Figure 3, that the students least expected to find themselves writing essays is perhaps not entirely unexpected and again reflects the practical approach of the courses the students had previously studied and were indeed studying at university. Conversely, although the majority of students had experienced working in groups before university (Figure 2) and had enjoyed participating in practical learning approaches (Figure 1), the data suggests that they did not necessarily believe that CDIO represented an 'ideal learning approach'. Indeed, data in Figure 4 reveals that in 2011 and 2012 less than half of the students indicated that it was their preferred learning approach.

In considering why this might be the case, and in looking at why the students' perceptions of CDIO altered year on year (as shown in Figures 4 and 5) it is important to take into account the wider context. CDIO at Aston was introduced in 2010 with a very limited budget. However, what the programme lacked in financial backing was more than made up for by the enthusiasm and motivation of the teaching team – all of whom were, and still are, dedicated to the approach and determined to make it work. In the first year, the materials and problems were locally sourced, with the emphasis not only being on problem-solving but also encapsulating innovative thinking and resourcefulness. The cohort in this year could not help but be caught up in the 'excitement' of being part of something new. In year two the teaching team changed slightly, with the previous first year teachers moving onto facilitate learning at level five and the first year being taken by a senior researcher and less experienced newly qualified colleague. Concurrently there was a slight dip in students' affective perceptions of CDIO in terms of engagement and

enjoyment, as well as how they perceived it to promote different aspects of employability. In 2012 the students' perceptions changed again with a significant majority indicating that they found CDIO an engaging and more enjoyable learning approach than lectures. Likewise the percentage of students indicating that they believed that CDIO promotes the various aspects of employability also rose in 2012 with improved problem-solving skills, team-working and linking theory to practice being identified as part of CDIO by over 80% of the cohort. This upturn in students' perceptions corresponds with another change in the teaching team, with the original team from 2010 having much more input.

The influence of the teaching team on students' perceptions is not entirely unexpected – as is the fact that the majority of students selecting to come to Aston indicated that during their A levels or previous studies they had enjoyed problem-solving, working on projects and making things. Additionally as CDIO has developed in the university more resources have been dedicated to it – with materials now purchased in 'kit form' to give a more professional grounding.

6. Conclusion

The data given in this paper represents the first three years of what is anticipated will be a longitudinal study. CDIO was launched in 2010 with the intention of providing an approach that both enhanced the student experience and provided industry with work-ready graduates able to 'hit the ground running'. The first cohort of students to have experienced CDIO from the first year of their studies as yet to graduate yet early indications are that this cohort are not only more prepared for work but actually want to enter the discipline when they graduate.

This study is unique in that it has tracked the introduction of CDIO right from the onset. The slight 'dip' in students' perceptions in the second year of the approach is indicative of the expected 'teething problems'. Despite financial restrictions and some cynicism from colleagues, the CDIO teaching team continue to work hard to make a success of the programme. There can be little argument that three years on that this determination is beginning to pay dividends for the students who anecdotally state that CDIO enables them to 'feel' like engineers right from the time they start university. With its focus on problem-based learning and team-working, CDIO has changed the face of the 1st year experience for mechanical engineering and designed students in doing so it has enhanced transition and ultimately promoted student success.

In conclusion, this study is beginning to show that one of the main benefits of problem-based learning in general and CDIO in particular is that in based upon a 'real-life' approach to pedagogy it engenders a sense of identity amongst the students. This sense of identity quickly manifests itself in students who begin to 'feel like engineers' right from the beginning of their university careers. At this stage it is difficult to envisage what the long term outcome of this may be, however, in observing the students a sense of 'pride' in their achievements is evident.

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