

Application of a Generic Curriculum Change Management Process to Motivate and Excite Students

Charles D. McCartan (c.mccartan@qub.ac.uk), Geoff Cunningham,
Fraser J. Buchanan and Marion McAfee

Queen's University Belfast, UK

Abstract: *The School of Mechanical and Aerospace Engineering at Queen's University Belfast is committed to enhancing the quality of student learning. A plan to implement curriculum change around this goal has been formulated and is already several years underway. A specific part of the plan involved instigating a first year introductory module to engage the students in the practice of their engineering discipline. The complicated nature of devising this type of module with regard to objectives, resources, timeframe and the number of students involved meant that a very systematic approach had to be adopted.*

This paper presents the simple but definitive change management process that facilitated in the creation of a first year Introduction to Engineering module. The generic nature of this process is described and its application to other facets of curriculum change is discussed. Within this process the importance of collaboration to establish a forward momentum is emphasised. This enables academic staff to progress as a group and build curriculum development based on their own experiences, expertise and established practice

INTRODUCTION

Engineering education reform is being considered, planned or embraced by many universities around the world. International organisations such as the CDIO Initiative (www.cdio.org) are growing in members. The comprehensive methodology that this initiative has developed for redesigning engineering degree programmes and the philosophy underpinning the need for change in engineering education is described in a book by Crawley *et al* (2007).

Stakeholder feedback is one of the key factors fuelling this endeavour to change the status quo in engineering education; employers want engineering graduates who can hit the ground running – essentially they want proficient engineers. This is only possible with curriculum change that suitably enhances student skills to this avail. Essentially, engineering graduates should understand how to conceive, design, implement and operate the value-added products and systems associated with their discipline – hence CDIO.

However, the recent trends in UK universities would show an apparent precedence of research over teaching and as such it is important to appreciate the future implications for engineering education in the UK, especially with respect to the aforementioned curriculum reform that stakeholders are demanding. Armstrong *et al* (2006) discussed this in detail with regard to SARTOR and UK-SPEC and concluded

that: CDIO can help engineering schools in the UK redress the imbalance caused by an emphasis on research; implementing CDIO does not require a change in direction as it builds on past and current developments; and CDIO can help ensure that engineering education is delivered to the highest standards.

The School of Mechanical and Aerospace Engineering at Queen's University Belfast (QUB) is endeavouring to improve its student learning experience; a curriculum change plan was already being developed when the School became a collaborator in the CDIO initiative in 2003. The School is now well underway in a process of reforming its existing engineering degree programmes, and in the case of its new Product Design and Development (PDD) degree, a programme has been built with the CDIO principle, syllabus, standards and methodology at the core.

As such, the School is now heavily committed to implementing CDIO completely in all its degree programmes. One facet of this was a standard that involved enhancing the quality of student learning through a new first year introductory course; the purpose of such a course being to engage the students in the practice of engineering, to broadly outline the tasks and responsibilities of the profession and to augment their personal and interpersonal skills. Therefore, a curriculum change project was initiated to design, develop and implement a new 'Introduction to Engineering' module for first year mechanical engineering students. This module would be one full module with seventy-two hours of contact time spanning two semesters; the classes would be timetabled as one three-hour session per week for each of the twelve week semesters.

At this time, the School was also participating in the 'Supported Change Programme' (Taylor and Mannis, 2006) pioneered by the UK Centre for Materials Education (UKCME). This Centre is one of the twenty-four Subject Centres that form part of the Higher Education Academy, and provides discipline based support to universities across the UK. Within this programme the UKCME acts as a facilitator to encourage enhancement of the learner experience by supporting curriculum change at a departmental level and to a departmental agenda.

The new 'Introduction to Engineering' project was the perfect basis to begin collaboration with the UKCME, with the Centre being able to provide ongoing support in a variety of ways to ensure sustainable development. This paper describes how the School worked with the UKCME to effectively design and develop a new meaningful introductory course, describing in detail and discussing the benefits of the generic approach adopted.

A SYSTEMATIC APPROACH TO CURRICULUM CHANGE MANAGEMENT

There was a clear appreciation within the School that successfully implementing such a new introductory course for first year students would be a difficult process. The initial strategy adopted was to evaluate the development and implementation of this course through a programme of in depth interviews conducted by staff from the UKCME with all School staff involved in the teaching of first year students. The UKCME staff then analysed the interviews.

It was soon evident that the interviews had generated a wealth of material. They identified ideas and aspects of good practice already in place on which the future development of the introductory course could build. This analysis was then shared with the participating teaching staff and represented a powerful resource for influencing change. Crucially, a set of tools - summaries of staff perceptions -

emerged which could be used to inform and shape the development process. A summary of the outcomes and tools which emerged is presented in this section.

It is important to point out here that to design and implement an introductory course that would fulfil the CDIO objectives and succeed in engaging the students in the practice of their engineering discipline would, by definition, be a resource intensive task; the experience of CDIO colleagues in Liverpool University (Murphy *et al*, 2006) had shown this to be the case.

However, the interviews identified three clear areas that assisted in the development of the new introductory course and defined the ensuing change management process:

- Departmental Strengths
- Issues relating to course development
- Indication of a possible way forward

Departmental Strengths

Several key assets were recognised within the School and amongst the staff that provided a sound rationale and impetus for the proposed curriculum development. These were acknowledged as strengths that already existed, but it was important to highlight them in order to ensure confidence in the proposed plan for the new introductory course. These strengths are described in the rest of this subsection and summarised in a two part list as follows:

School

1. The School was dedicated to improving its student learning experience.
2. The School was committed to a structured curriculum change plan (CDIO implementation).
3. There was already a sequence of curriculum change in place.
4. There was strong support from the Head of Department.
5. The School had already considered the issues relating to resources and facilities.
6. Stakeholder survey data existed to guide the planning and development of the introductory course.
7. The school had identified specific 'gaps' in the students' learning experiences.
8. There was appreciation of other resources and practices relevant to such an introductory course that were already prevalent at other CDIO collaborating universities

Staff

1. The relevant staff had taken ownership of the new introductory course.
2. The relevant staff acknowledged the objectives of the proposed introductory course.
3. There was a general agreement on the course structure.
4. Certain staff members already possessed the necessary expertise and experience to implement the introductory course.

There was strong support from the Head of School for the realisation of the new introductory course as the School had already committed to a structured curriculum change process as part of their CDIO implementation plan. The interviews showed that the staff involved in first year teaching within the School had clearly accepted the need for curriculum change and were keen to proceed with the development of the new introductory course.

These staff members were confident that the right approach was in place in that this plan for the introductory course was not perceived as being a 'one-off' effort, but instead was part of a bigger picture of curriculum change. They also knew that the School had already investigated the resources, facilities and logistics necessary to support a high quality learning experience for the students involved in the new introductory course.

However, it was recognised that to succeed in producing an introductory course that would properly enhance the student learning experience and meet the objectives described by the CDIO Standard for such a course, that a major commitment would be required. Also, it was essential to fully understand the expected learning outcomes from the outset.

Again, the UKCME interviews with the relevant staff from the School produced excellent corroborative agreement in relation to these expected learning outcomes for the new course. Altogether, the teaching staff identified seven objectives that they thought were essential to the new course and these are shown in order of priority in table 1 below. These formed the framework for the design and development of the course. It is important to note that the top priority was to motivate and excite the students for their chosen profession. This would therefore be the guiding axiom for everything that followed regarding the planning and development of the new course.

Table 1. Seven Learning Objectives for the Introductory Course
in Order of Decreasing Importance

Level of Importance	Objectives of the Introductory Course
1 (most important)	Motivate and excite students.
2	Demonstrate the relevance of the engineering and materials science covered in Stage 1, and show that it can be applied to real-world problems. (Students frequently don't see the point of various topics they are being taught).
3	Introduce students to Mechanical and Manufacturing Engineering, and clarify their understanding of the nature of engineering and what engineers do.
4	Improve students' understanding of both fundamental engineering and engineering science concepts.
5	Provide practical engineering experience to compensate for the fact that, unlike in the past, current students seldom have practical experience (work at cars, repairing appliances, generally taking things apart, etc).
6	Begin the process of developing professional skills: computing, report writing, information retrieval, presentation skills, team working, etc.
7 (least important)	Bridge the gap between school and university, by ensuring that students can cope with the change in learning methods, the need for personal organisation, the problems of balancing paid work with academic work, etc.

In addition, the interviews also identified valuable resources that already existed within the School in relation to expertise and experience in organising and delivering

learning activities that were highly relevant to any future introductory course. There was evidence of practice and content from other first year modules that valued and promoted active and collaborative learning experiences.

More importantly, the interviews provided certain staff members, who had already employed new activities to enhance student learning in their modules, with the opportunity to articulate and discuss their specific experiences. Insights into the time taken, the sequencing of the learning experiences, the resource issues and the obstacles and benefits to learning, all helped enlighten the development and implementation of the new course. This also supplemented the published information (Murphy *et al*, 2006, Young *et al*, 2005, Gustafsson *et al*, 2002) and communicated experiences from CDIO collaborators who had embarked on similar projects and successfully implemented introductory courses in their respective engineering programmes.

As part of its CDIO implementation plan the School had already engaged in systematically collecting evidence relevant to this initiative through stakeholder surveys (alumni, students and staff) and data collection in relation to workspaces. Therefore, specific evidence had been obtained from these activities that provided credible data to guide the planning and development of the introductory course. For example, it was clearly understood that there were limitations with the available workspaces and this would obviously put constraints on the planning of the course. In fact, significant thought had already been given as to how the existing workspaces could be used more effectively to meet student learning needs.

Finally, as part of the internal teaching review mechanism within the School, gaps had been identified in the students' learning experiences. A specific deficiency related to the improvement of oral communication skills and clearly had implications for the development of the introductory course.

Issues Relating to Course Development

From the interviews there was a general consensus regarding the context for the evolution of the introductory course; the two key focus areas would be the course content and the students. The content would have to provide experiences relevant to the engineering discipline and profession to help prepare the students for the modern workplace where employers expect 'ready-made' engineers who can 'hit the ground running'. In addition, consideration of the diversity of student intake would influence the course development even further.

The interviews revealed a general agreement on the main learning objectives relating to the content of the course and these are described above in table 1 in order of importance as rated by the staff involved. Information was also uncovered that summarised the perceptions concerning the students' learning culture and how the introductory course could help develop a more mature approach to learning synonymous with a third level education. Table 2 summarises these potential enhancements in the characteristics of the students' learning culture.

Consensus from the interviews identified several specific areas with attainable goals that would guide the development and planning of the new course:

- Course Content
- Workspaces
- Ownership
- Assessment

- Evaluation

Table 2. Perceived Changes in the Characteristics of the Learning Culture for the Introductory Course

From	To
Learning as individuals	Learning with others
Competition (between students)	Collaboration (between students)
'Pupil' at school being told / spoon-fed	Adult learner challenged / stretched
Strong drive to get the right answer, with mode of assessment operating to promote this	Opportunities to make and learn from mistakes, with mode of assessment operating to reward this
Curriculum content that is compartmentalised	Curriculum content that is integrated
Artificially contrived practical exercises (recipe-book approach)	'Real-life' situations
Theory dominating learning	Theory 'by stealth'
Theory perceived as a chore to learn, and so abandoned when problem-solving	Theory is trusted, and so is seen as a necessary tool in problem-solving (as a short-cut to problem-solving)
Students are diffident	Students taking responsibility and caring about outcomes
Mind-set orientated in the present	Mind-set future orientated
Problem-seeking	Problem-solving

Course Content

The course content would focus on active and collaborative learning experiences which would also promote integration with the other first year courses through application and understanding and help improve the overall first year experience for the students.

Involving all the relevant staff in the planning process would be critical in achieving this, no matter what their involvement in the final outcome. In trying to achieve such an integrated course, consideration would have to be given to the development of the individual elements within the introductory course and how they could be effectively transposed from the other first year courses to successfully meet the learning needs of the students. It was also understood that the timing of these individual elements within the introductory course would be essential in order to ensure proper integration with the other courses and to achieve the intended learning outcomes.

This meant that the content of the introductory course would have to be very well structured. It would have to be based around activities which promoted hands-on, active and collaborative learning. The interviews identified several examples of such activities that were already taking place in other first year courses in the School. It was acknowledged that with further staff collaboration, these could form the starting point for developing activities for inclusion in the introductory course. A key aspect of this was that all such incorporated activity required the potential to develop communication skills, team working skills, problem solving skills and the capacity to reflect on learning and achievement.

Workspaces

In trying to design and develop any new course, one of the biggest resource constraints will be the available workspaces; they can especially restrict the intended skills development possibilities. Fortunately, an investigation and survey of workspaces had already been performed by the School in conjunction with other

CDIO collaborating institutions (Young *et al*, 2005). This provided the necessary information on the workspace prerequisites necessary to accommodate the emerging introductory course.

Ownership

The ownership of the introductory course was an important issue. The staff interviewed unanimously agreed that one academic should have the overall responsibility of course coordinator. As many of the staff as possible should also be involved, with the onus on being visible to the students; this would not only introduce the students to a large number of the staff, but also help emphasise the relevance of the course. Again, CDIO colleagues had also adhered to this paradigm (Murphy *et al*, 2006).

Assessment

The assessment of the introductory course required careful consideration. Feedback from the interviews concluded that the assessment methods chosen should neither be onerous nor time consuming for either the students or the staff involved. This was based on the prime directive that the course was intended to motivate and excite the students, and to help them perceive the relevance of the course. The key aspects of the evaluation would involve: attendance records; retention records; performance data; continual feedback on specific elements of the content; overall module feedback.

Evaluation

A key feature of developing a successful introductory course was to ensure that suitable evaluation was established to ensure that it could be sustained and fulfill its objectives. This is standard practice in the School for all courses, but a more extensive evaluation plan was deemed necessary to ensure that all of the new activities fulfilled their goals and learning objectives.

Indication of a Possible Way Forward

The collaboration with the UKCME enabled them to conclude by outlining a five phase plan for the efficient preparation and development of the new introductory course. These five phases are listed and then individually described below:

- Phase 1 – Review own practice
- Phase 2 – Explore potential
- Phase 3 – Identify practical implications
- Phase 4 – Develop the ‘wrap-around’
- Phase 5 – Establish sequence

Phase 1 – Review own practice

Examine aspects of practice that have evolved in their own subject areas, (or through collaboration with one or two academic staff from other areas), which promote active, collaborative student learning. This study should identify the aims for these activities, the lessons learned from putting them in place, the issues relating to assessment, and crucially, the impact on student learning.

Phase 2 – Explore potential

Explore the potential of each activity as a possible ‘candidate’ for inclusion into the new course, identifying where and how the activity could be modified, incorporating input from other subject areas or disciplines.

Phase 3 – Identify practical implications

Identify the potential implications of incorporating such activities, in terms of resources, facilities and staff time.

Phase 4 – Develop the ‘wrap-around’

Determine what other input would be required to implement the new course regarding preparation, appropriate theory and review, to enable the students to gain fully from understanding each activity.

Phase 5 – Establish sequence

Consider how the activities would be sequenced within the new course to maximise learning potential.

APPLICATION OF THE CURRICUM DEVELOPMENT PLAN

The onus was now on the School to implement each phase of this plan and engage the relevant staff members to further collaborate in developing the new introductory course. This had to be accomplished in five months. A small development committee was established and tasked with implementing the five-phase plan. Although the committee only consisted of six academics, it was important to keep as many of the staff as possible engaged in the process.

The key aspects of Phase 1 had already been identified from the UKCME interviews, so it was simply a case of deciding which specific examples of best practice in active and collaborative learning, already in use within the School, to include in the new course; this was Phase 2.

Most of the practical implications, mentioned in Phase 3, with regard to incorporating these activities into the content of the new course had already been exposed in the interviews.

Phase 4 and Phase 5 proved the most difficult in that these were new areas requiring debate and discussion that had not formed part of the interviews. However, with further staff collaboration it was easily achieved.

It should be noted that in applying the change management plan, the learning objectives and learning culture changes illustrated in tables 1 and 2 respectively provided a crucial resource, as they essentially defined the necessary learning outcomes for the new introductory course.

DISCUSSION

The School of Mechanical and Aerospace Engineering at Queens University Belfast is heavily committed to enhancing the learning experiences of its students through curriculum reform. In one specific case this meant designing, developing and implementing a new introductory course for first year students. The purpose of this course was to engage the students in the practice of engineering through active, collaborative and meaningful learning activities. The School knew that successfully implementing such a change would be a difficult process.

An approach was taken that clearly identified and set out a systematic change management plan. The initial strategy adopted was to engage in a critical appraisal of the new introductory course through an agenda of in-depth interviews conducted

by staff from the UK Centre for Materials Education. These high quality interviews were conducted individually with staff from the School who were involved in the teaching of first year students. It was evident that these staff members were very comfortable with this process and therefore provided a glut of information relating to their teaching; the outcome may have been different without the involvement of an external agency.

These interviews generated a wealth of useful material. They identified ideas, and aspects of good practice already in place, on which the development of the introductory course could build. This information was then shared with all who participated and represented a powerful resource for influencing the planned change. Significantly, the summaries of staff perceptions that emerged from the interviews were used to inform and shape the introductory course development process.

The interviews provided an opportunity for staff to share their insights and expertise in regard to planning the potential way forward for the development of the introductory course; they gave staff a voice and provided a platform for further collaboration in relation to developing the course. Indeed, it gave the staff involved early ownership of the ensuing course and as such, potentially eased the resulting addition to their teaching workload.

This approach of interviewing staff and analyzing the responses took approximately four months and was relatively time consuming. The resource implications for this form of curriculum 'change management' should not be underestimated. Instead it should be appreciated that the relevant development potential that resulted far outweighed the effort expended. It could also be accepted that such a collaborative approach, based on supportive yet critical appraisal, is necessary if sustainable curriculum development is to be achieved.

Although the 'change management process' described was specific to the design, development and implementation of a particular new engineering course, it is feasible to state that this process could be applied generically to most curriculum reform projects to successfully effect curriculum change; and this is a key outcome of this paper.

In total it took nine months to completely plan and prepare the introductory course: four months for the interviews, analysis and preparation of the plan and five months to execute the plan. However, the development and implementation of such a course as the one described in this paper, with all its active and collaborative learning and teaching approaches and their relevant continuous assessment, not to mention the other implications on resources such as workspaces, staff and funding, is probably one of the most difficult forms of curriculum development to successfully accomplish. It is therefore the authors' contention that the change management process used here was invaluable to this end.

The introductory course ran for the first time in 2006/07 and was a success with regard to motivating and exciting the students; based on their performance, attendance and the formative feedback obtained as part of the evaluation process. However, there were certain areas of the content that were flagged for attention and were modified for the second year of the course. The same committee that implemented the curriculum development plan for the course now sits as the evaluation committee. The UKCME involvement has also continued with respect to the sustained evaluation of the course.

CONCLUSION

By using a definitive, but simple, change management process, the School was able to instigate a specific curriculum reform project and implement a new course for first year students.

This process started with an external agency successfully analysing and sharing information from individual, high quality interviews which they performed with the relevant teaching staff from the School. This fostered collaboration, awareness of existing good practice and perceptions amongst these staff members that helped to successfully shape the development process for the planned curriculum change.

The interviews identified three key areas that formed the basis of the change management process: the departmental strengths; the issues relating to the development of the introductory course; and an indication of a possible way forward that included a five phase plan. The process then culminated in the formation of a committee to implement this five phase plan.

The five phase plan was successfully implemented and the new course first ran in 2006/07. The course is now in its second year, having been modified according to its evaluation strategy.

REFERENCES

- Armstrong, P., Cunningham, J., Hermon, P., Kenny, R., McCartan, C. & McNally, T., 2006. The Implications of the CDIO Initiative for Engineering Education in the UK. *Engineering Education Conference. International Conference on Innovation, Good Practice and Research in Engineering Education*. 24 - 26 July 2006, University of Liverpool, Liverpool, England.
- Crawley, E.F., Malmqvist, J., Östlund, S., Brodeur, D.R., 2007. *Rethinking Engineering Education – The CDIO Approach*. Springer, ISBN 978-0-387-38287-6
- Gustafsson, G., Newman, D., Stafström, S. & Wallin, H. P., 2002. First-year introductory courses as a means to develop conceive – design – implement – operate skills in engineering education programmes. *SEFI Annual Conference*, Firenze, Italy, 08-11 September 2002.
- Murphy, M. L., Bullough, T. J., Johnson, M. W., Millard, S. G., Shenton, A. T. and Sutcliffe, C. J., 2006. The Value of Immersive Learning Experiences within an 'Introduction to Engineering' Module. *Second Annual International CDIO Conference*. June 13–14, 2006, Linköping University, Linköping, Sweden.
- Taylor, I. & Mannis A., 2006. Addressing Change in University Departments: A Strategy of Discipline-Based Support'. *Engineering Education Conference. International Conference on Innovation, Good Practice and Research in Engineering Education*. 24 - 26 July 2006, University of Liverpool, Liverpool, England.
- Young, P.W., Malmqvist, J., Hallström, S., Kutteneuler, J., Svensson, T., Cunningham, G., 2005. Design and Development of CDIO Student Workspaces – Lessons Learned. *American Society for Engineering Education Annual Conference & Exposition*. 13/06/05 - 15/06/05 Portland, Oregon, USA.