

The London Engineering Project – A Higher Education Institution Model

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Abstract

Engineering courses are under pressure to change due to a range of factors including: the demands of industry, student feedback and the government's Widening Participation (WP) agenda. Courses and departments must adapt in order to attract and retain a broader range of students. This paper presents a generic model for the adaptation of engineering curriculum to embrace this need for change; it is presented in a diverse and innovative manner which can fit any institution. The model is based upon research conducted as part of the London Engineering Project (LEP), a project designed to widen participation of under represented groups in engineering and is promoted here as a theoretical model of best practice for initiating the development of engineering curriculum by providing a holistic view of the perception of engineering throughout the institution. It shows how the progression of a series of interlinked strategies is required to ensure the embedding of a diverse and innovative engineering curriculum without the loss of technical content.

Introduction

The paper has been divided into three sections: the first looks at some of the problems within engineering education in Higher Education Institutions (HEIs), the second reviews the problems encountered when considering the implementation of change within an HEI, the third details the London Engineering Project, highlights national problems surrounding engineering today and presents the resulting generic model for change within an HEI engineering department.

Issues in engineering in HEIs

Over the last decade, many reports discussing the major issues around engineering in particular: education, cultural diversity, gender awareness and employability / key skills within HEIs have been produced (for references see Table 1). Often the problem faced by an HEI is that a large amount of information is published surrounding the challenges of teaching an expanding curriculum to a more diverse audience and relatively little is published on methods to practically address these challenges. Other key barriers include: not all issues are relevant to all HEIs, the sheer volume of materials published make them difficult to summarise and assess, with the materials often being specific to an institution as a whole rather than to an academic subject. Plus, perhaps more controversially the development of 'best practice' teaching methods are not commonly cited as a means of rapid career progression for academic staff when compared with 'classical' research. Through out this project an extensive literature review was undertaken in order to understand all the key issues faced by HEI engineering departments as highlighted by these reports. These key issues have been summarised in Table 1 including the main references associated with each issue.

Table 1: A summary of the key engineering HEI issues

	Issue	Detail	References
1	Student Recruitment	There is an issue around general lack of recruitment onto engineering degrees.	Wilson, 2000; Connor, 2001; SEMTA, 2003; Spinks, 2006.
		Lack of recruitment from all cultural and socio-economic groups, plus a low recruitment of female students and adult learners.	The Sutton Trust, 2005; DFES, 2005.
2	Student Retention	Retention on the course once at the HEI.	HESA, 2005.
		Retention in Engineering upon graduation.	ETB, 2005.
3	Student Skills base	Employers requiring a broader range of generic skills than students presently obtain.	Spinks, 2006
4	Inclusive Courses	Analysis of engineering courses has highlighted the need for expansion beyond standard 'hard' engineering knowledge and more inclusion of practical and societal implications of technology.	Xiang-Yun Du, 2006; Prendergast, 2007; Nafalski, 2002.
5	Student Satisfaction	Studies have highlighted that students (of all cultures, backgrounds and genders) regarded the engineering subjects as dull, unappealing, uncreative and uninspiring.	Cronin, 1999; Prendergast, 2007; Read, 2007; Sagebiel, 2006.
6	Student Experience	Studies suggest that the 'SET white middle class masculine culture' is affecting in a negative way the experience of many of the students within the HEIs, adversely affecting confidence and career aspirations.	Cronin, 1999; Prendergast, 2007; Seymour, 1997.
7	Employer Engagement	Several reports have highlighted the fact that employers feel that students leave HEIs lacking in many of the generic skills that they require and in addition to this there has been the suggestion that greater engagement is needed with employers to enable a distinct interface between the HEI which provides education and the employer who provides training.	Spinks, 2006; The Times Higher, 2007; ETB, 2006.
8	Students Mathematical ability	Concerns have been raised over several years about the decline in the mathematical standard of incoming engineering graduates and the effect this is having on both the recruitment and retention of good engineering students.	Lea, 2002; Bowen, 2003.
9	Academic career progression	Pedagogical research within engineering is yet to be recognised as a strong career path and as a result engineering academics are often short on time to complete such projects. But research has shown that the support of senior management deeply enhances the chances of success of a pedagogical project.	Arlett, 2007; Alexander, 1998; Hannan, 2002; Cabinet Office, 2000.

HEIs and change

HEIs are not commonly viewed as institutions that are appreciative of change nor do the systems and processes within them generally support innovative and rapid change. Many change projects fail and the most commonly cited reason is the neglect of the human dimensions of change. This neglect often centres on a lack of insight into why people are unhappy with organisational change, a poor appreciation of the process of change and a limited knowledge of the tools and techniques that are available to help. (Johnson (2002), Krotter, (1979), Balogun, (1999)) There are many different approaches to change within HEIs, the two most cited are the 'structural approach' which uses a hard project management approach to change with the second approach being 'people orientated' and focusing in much more on the softer, people side of change. Research has shown that when trying to make improvements in HEIs, gaining the commitment and trust of those affected by the change is paramount to its success and if the human dimension of change is ignored problems may occur such as:

- Strong emotions can halt progress (fear, anger etc)
- People become defensive or deny there is a problem, blame others.
- Complaints and scepticism become the norm.
- Increased absenteeism and people leaving the organisation.
- Fall in morale.
- Conflict spirals out of control.
- People do not do as they say they will.

When successful change initiatives are examined the most common factor appears to be that they use a combination of the 'structural' and 'people orientated' approach, some of the reasons for this are illustrated in Table 2.

Table 2: Approaches to Improvement (UCL (2008))

'Structural'	'People Orientated'	'Combination'
Change is enforced often top down	Change is desired often bottom up	Change is desired both bottom up and top down plus strategically supported top down
Change is a step process	Outcomes not predetermined	Set direction – but flexible
Initiated and pushed top down	Change is driven bottom up	Top down support for bottom up change
Objectives set in advance and inflexible	No end point	Objectives need to be set – but flexible and reviewed frequently
Goes wrong due to poor planning and project control	Goes wrong due to people issues	Planning is important but commitment of people is vital

As with all change, that instigated within an HEI should not happen in an uncontrolled way and requires a structured approach to ensure success. Many texts and research papers have been published on the 'management of change' (Johnson (2002), Kotter, (1979), Balogun, (1999) UCL (2008)) and there is a general

consensus that there are a key set of activities that are essential for the effective implementation of change:

- Ensure the change had an understandable and sound reasoning behind it. Change for change sake is not often well received or supported.
- Enlist the support and involvement of key people.
- Create a good simple plan of action with clearly defined objectives and small and achievable chunks.
- Support the plan with upper management behaviour.
- Recognise what needs to happen to support the change (training, workshops, diversion of funds etc.).
- Recognise milestones in the project.
- Communicate constantly.

The London Engineering Project

In 2000, the Department for Education and Employment (DFEE), (Wilson, 2000) predicted a 2% increase in the demand for engineers in the period 1998 – 2009: this would translate into approximately 370,000 new jobs. The report also highlighted that engineers were vital to the economy and essential to enable the UK to meet key global and environmental challenges. A further report by Hodgson (Hodgson, 2004) predicted a shortfall of engineers in the UK in the region of 100,000 by 2010. This current and very real shortage of graduate engineers is having a direct effect on productivity, creativity and hence profitability of UK companies (Spinks, 2006).

Several reasons have been cited for this shortfall of graduate engineers: issues surrounding the problem of recruitment to engineering degree programs, in particular the mathematical standards of students and the lack of suitable careers advice (Lea, 2002 and Bowen, 2003), less than half of those graduating with an engineering degree actually take up engineering as a career option (ETB, 2005), the age profile of the profession is such that many of these new positions are to replace existing engineering professionals and graduates do not have enough experience for such openings (SEMTA, 2004). It has been predicted that by 2011 only 20% of the workforce will be white, able-bodied men under the age of 45, the traditional source of engineers, with reports showing that HEIs are not always successful in recruiting students from both genders, all cultural and socio-economic groups within society, (The Sutton Trust, 2005 and UKRC, 2005). Many employers are indicating that the graduates that are being produced by HEIs do not have the required generic skills that companies need (Spinks, 2006) and often once the students have arrived at an HEI the experience that they encounter does not live up to the expectations that they have had developed often resulting in a high drop out rate (Cronin, 1999 and Booth, 2007).

After reviewing such reports on the position of engineering in UK, HEIs and schools are engaging in discussions with many of the key groups providing support and promotion for Science Technology Engineering and Mathematics (STEM) across the UK, The Royal Academy of Engineering developed a proposal for a 'National Engineering Programme'. This programme was designed and written to build on present best practice work and to bring together active groups of people, its key aim was to increase and widen participation in engineering across the UK whilst promoting engineering as a sound career option. The proposal was that this would be achieved through a partnership of regional schools, universities, STEM organisations and industry in selected neighbourhoods around the UK that had low participation rates in HE using engineering as a vehicle to widen participation. This proposal was submitted to the Higher Education Funding Council for England (HEFCE) in 2005

and it was at this point the need for a pilot project of activity was highlighted and the London Engineering Project (LEP) was formed.

This has resulted in 18 months of activity based in thirty London schools and three key HEIs: London South Bank University (LSBU), University College London (UCL) and the University of Sussex. The activity in schools has been designed to raise awareness of engineering and has included initiatives such as e-mentoring, workshops and guest lectures, all based around and supportive of existing activities delivered by partner organisations. The activity in HEIs has been designed to ensure inclusive and exciting engineering courses that produce graduates who fulfil employer requirements and who have had the student experience they anticipated and deserve. The HEI activity fell into three key areas: the development of new and more inclusive degree programs (Sussex), deeper employer engagement with the development of employer led foundation degrees (LSBU) and the adaptation of existing degree materials to be more diverse and supportive of a widening student base (UCL). Many of these individual activities have been published and their success documented (Pendergast & Read (2007), Read & Hanson (2008), Read & Worjick (2007) and Read & Greig (2008)) but latter stages of the LEP are to develop strategies and methods that will allow initiatives developed in the pilot to be rolled out across the UK. With this in mind the final section of this paper looks at taking the issues of engineering education, the problems of instigating sustainable change with in an HEI and using lessons from the successful pilot initiatives to develop the beginnings of a generic frame work of how engineering curriculum could be changed within an HEI.

A generic framework for change

A consensual view on why change is needed

The data relating to the need for more engineers in the future and on problems in recruiting students to engineering degrees today point to a need for change. But individual engineering departments must come to their own decisions on how these needs affect them and to what degree and in which direction they need to change. A key consideration is the local ability to accommodate a change in the size of the student population in a department: not all universities are recruiting universities. Some have limitations placed on them which mean that they must behave as selecting universities.

Departmental engagement

What can be seen from previous sections is that any change within an HEI has to be supported from the top down and welcomed from the bottom up. To achieve this all involved in the change must understand why change is necessary to the survival of engineering. This can be presented in any number of formats such as staff away days, management meetings, staff reviews etc. and the most appropriate method for individual institutions should be selected. Activities that have proved successful in the LEP pilot have included bringing in respected external speakers from places such as the Higher Education Academy Engineering Subject Centre or the Royal Academy to facilitate departmental discussions about engineering education. Other successful activities have involved the use of employee advisory boards that have been in a position to highlight to universities the skills that their students are lacking and why a change in engineering education is needed.

Departmental review

Once departmental engagement has been achieved and that staff understand the need for change, the next stage of any framework must involve benchmarking of the institution as a whole and the engineering department within that institution. At this stage of development some areas identified as important for an institutional review are:

Area to review	Explanation
Institutional strategies and departmental strategies for the future	Any initiatives must work in harmony with and support these strategies.
The profile of the engineering degrees with in a department.	Are they very traditional degrees, is there room in the portfolio for some less traditionally based programs.
Staff profile.	Age profile, gender profile, industrial experience.
Working environment of the students and staff.	State of laboratories, up to date equipment, ladies toilets, equipment in lecture theatres, equipment available for students to borrow, areas for students to conduce group projects, areas for staff and students to meet.
Independent student focus groups.	Have students been approached by someone independent to the institution to air their issues? - as often they are afraid to give a detailed opinion to an 'insider'.
Results.	League tables, student satisfaction surveys, unofficial websites.
HESA data.	Recruitment, student profile, final destination, retention, socio-economic back ground.
Employer feed back.	Develop, facilitate and listen to an employer advisory group – about course content, student skills up and coming issues.

Course / module review

Once institutional and departmental needs and commitments to changes have been established the third stage of the framework can be implemented; that is to identify areas of the engineering curriculum within an institution that could be enhanced. This could be achieved by the bench marking of the actual engineering degrees and modules on offer by the institution. At this stage of development some areas identified as important for an academic review are:

Content in relation to

- Diversity
- Ethnic inclusion
- Gender awareness
- Transition skills
- Practical skills
- Ethics
- Environmental issues
- Recent case studies
- Enterprise / entrepreneurship skills
- Innovation / creativity

A complete review could also include use of Tables 1 and 2, the Higher Education Engineering Subject Centre's (HEAEngSc) audits on first year experience, employability, key skills, entrepreneurship and enterprise and the RAEng's engineering ethics curriculum map (HEAEngSc (2005), RAEng, (2007))

Best Practice review

One key area of activity that is often missed out of such a framework is the review of already established best practice. Often best practice takes the form of hidden gems, buried deep within an individual course specification. This is where dissemination bodies such as the Engineering Subject Centre add particular value through their work in capturing and featuring best practice in engineering teaching and learning.

Planning and mapping

This section of the framework concentrates on the development, planning, implementation and dissemination of institution specific initiatives. What should have been achieved up to this point is:

- A consensual view on why change is needed and on what change is needed
- Departmental commitment to change.
- Benchmarking of the Department and courses within the department and an acknowledgment of areas requiring improvement.
- A review of best practice in these areas.

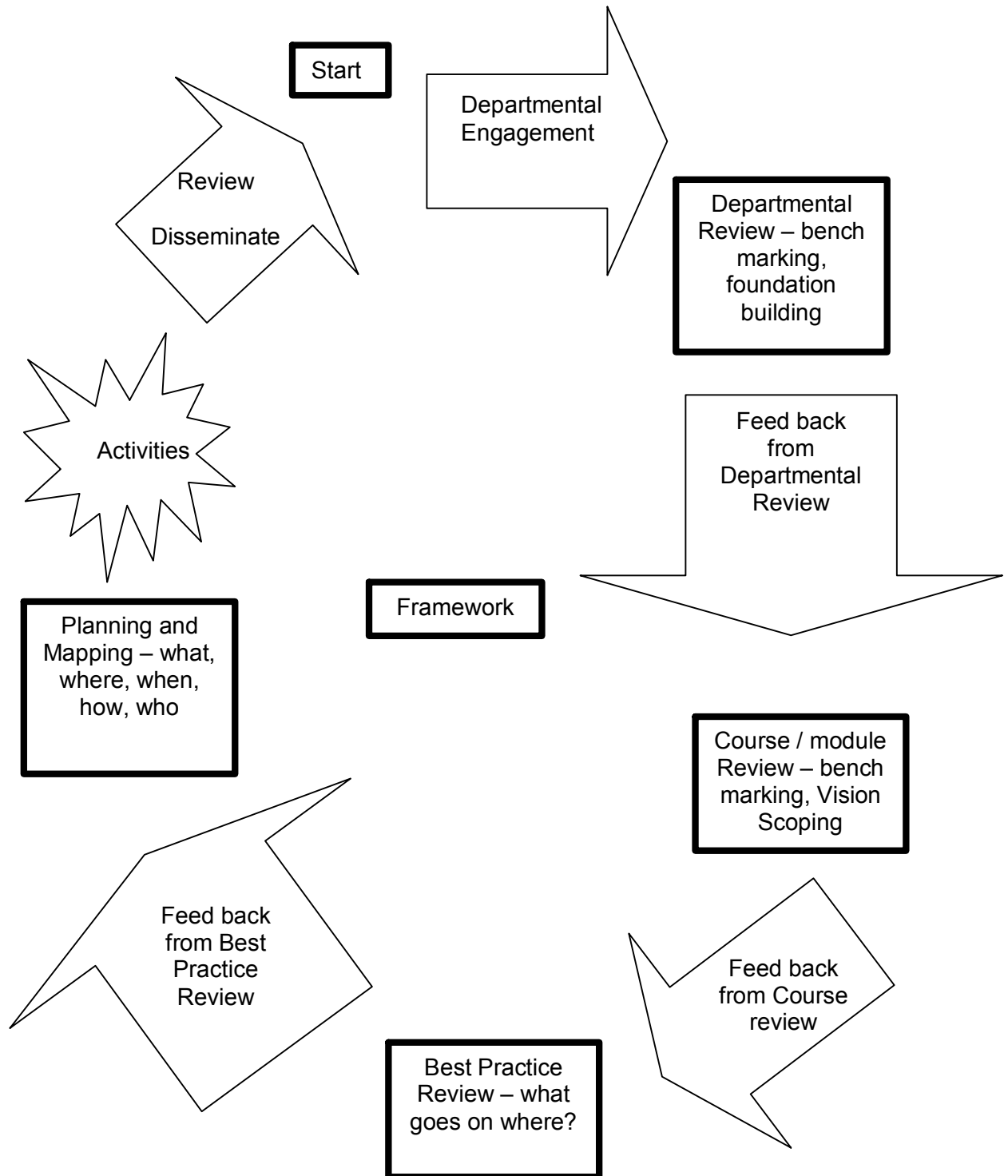
There are a variety of ways that this planning and mapping could take place including departmental brain storming sessions facilitated by an external education innovator, through to individual members of staff developing initiatives to support the required change, but whatever option is chosen, this mapping and planning should include a time plan, full costing, academic commitments and deliverables.

Dissemination

Not all interventions to engineering curriculum will be successful and those that are will need revising and reviewing on a regular basis. For this to take place interventions need to be evaluated, published and disseminated, one method that was used to achieve this in the LEP was to use the case studies and journal supported by the HEAEngSc and to present projects at educational conferences at both a national and international level (Pendergast & Read (2007), Read & Hanson (2008), Read & Worjick (2007) and Read & Greig (2008)). This also achieves a broadening of the best practice available for review in the earlier stages of the framework.

These six stages in the generic frame work have been summaries in the form of Diagram 1 that includes lines of communication which was highlighted as key to the continuing sustainability and success of change.

Diagram 1: Generic Frame work



Conclusions

- There is a clear need for change in engineering departments if we are to attract and retain more and diverse engineering undergraduates.
- The change process is a difficult process.
- Some university departments are successfully implementing and managing change.
- Whilst rigid change processes are unlikely to work in an academic environment, a framework had been identified for departments to adapt and adopt for their own particular needs.

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