ENGINEERING

Introduction

Principles of inclusive curriculum design

Anticipatory
Flexible
Accountable
Collaborative
Transparent
Equitable

Generic considerations

— cost and financial considerations;
— embedding student and staff well-being;
— promoting student engagement;
— use of technology to enhance learning;
— responding to different approaches to learning;
— avoiding stereotypes and celebrating diversity;
— making reasonable adjustments.

It is the responsibility of the every member of staff within HE to respond to the requirements of equality legislation. The basic principle that can and should be universally responded to is that it is attitudes, barriers and other forms of discrimination within the system rather than individual characteristics or deficits that are the cause of disadvantage. Employing an inclusive approach is underpinned by the adoption of other principles of inclusive curriculum design, summarised in the adjacent text box and discussed in the introduction section of this guide available at www.heacademy.ac.uk/assets/documents/inclusion/disability/ICD_introduction.pdf

May and Bridger assert, in respect of developing an inclusive culture, "making a shift of such magnitude requires cultural and systemic change at both policy and practice levels" (2010: 2). In essence this change is represented by a shift in focus from responding to the 'needs' of individuals or specific groups of students to an approach that anticipates and plans for the *entitlements* of the evolving student population. Thus the onus is on institutions and subject communities to change and adapt their policies and practice rather than expect this of individual or specific groups of students.

There are many generic considerations of inclusive curriculum design, summarised in the adjacent text box, which are discussed in the introduction section. The focus of this section is on subject-specific considerations for those in those subjects aligned to engineering. Here examples of innovation and effective practice are provided to demonstrate that effective practice for one group can and should be effective practice for all. The examples, resources and ideas included in this and other subject guides have come from the sector. They were obtained directly in response to a general request made to the sector during 2010, from a review of the HEA Subject Centres or from recommendations made by colleagues teaching in the specific subject.

Where there are examples in other subject guides that may be particularly relevant or worth reviewing for further adaptation these are flagged. However, notably inspiration and ideas for curriculum design can come from many sources, therefore reading strategies employed and ideas in other subject areas can be a useful source of new ideas.

Inclusive curriculum design: subject-specific considerations

Tackling isolation through effective induction

A number of factors have resulted in lower retention rates in Engineering than in many other subjects (HESA, 2006, cited in Willis, 2008: 2). Research undertaken by the Engineering Subject Centre found that Engineering students were likely to look to their peers for subject related queries. Willis (2008) reports that providing opportunities for students to build bonds and social networks at an early stage in the first year could improve retention. Willis's report, *Enhancing the first year experience for engineering students*, provides a pre-entry and induction checklist for programmes, which includes questions such as:

— Does the course publicity clearly indicate what students may expect from the course?
— Does your department have a clear induction strategy for students?
— Is there an opportunity for students to take part in a practical activity in week 1? For example, do the students undertake an engineering task?
— Are measures taken to identify whether students from under-represented groups (e.g. women or ethnic minorities) are comfortable in the environment created within the department?
— Are existing students involved in the induction process?

(Willis, 2008: 6)

An inclusive approach would ensure students are inducted in their department and programme as well as providing opportunities for all students to build the necessary relationships with their peers and other departmental or institutional members.

> The *'Design, build, test, float, fly and race - the School of Engineering Sciences Induction Week'* was devised by the University of Southampton in response to large first-year classes taught across a number of programmes and to improve retention. The week

included study skills training, field trips and a group-based, hands-on design, build and test activity such as aerospace students building a balsa wood glider. The purpose was to:

— support students to adapt to the university learning environment;
— cater to different learning approaches;
— enable students to discover their strengths and weaknesses through working with others;
— provide a preview timetable.

The three professional institutions and representatives from Royal Aeronautical Engineering Society, the Institution of Mechanical Engineers and the Royal Institution of Naval Architects supported the week, providing a valuable connection with relevant professionals. The results included a 50% reduction in drop-out rate during the first semester and anecdotal reports of greater student engagement across the participating programmes (Willis and Takeda, 2006).

This type of activity may be familiar to students with experience of the Royal Academy of Engineering awareness and aspiration-raising activities delivered in schools and colleges. Inclusive design can enable students to draw on previous experience as well as become familiar with new and different expectations in higher education.

The *'PROGRESS'* project, which seeks to improve student progression and achievement in Engineering, has produced a range of guide books written by staff in Engineering. The approach is 'pragmatic' and includes case studies from Engineering departments across the UK (PROGRESS, 2003).

See also Languages, Linguistics and Area Studies, Mathematics, and Medicine, Dentistry and Veterinary Medicine (MEDEV) for other projects involving collaboration with secondary schools.

Mathematics for Engineering students

Engineering students are increasingly recruited from more diverse backgrounds that may mean they are perceived as less well prepared for Engineering programmes. In particular, changes in A-level Mathematics and the expanding number of students entering Engineering without A-level Mathematics means that departments need to review their programmes to ensure students can access the curriculum and use their strengths and previous experiences. Involving students in this process can help

staff to become familiar with what experiences students have of using mathematics in subjects other than Engineering and what they bring that may assist with future curriculum design that embeds skill development in mathematics.

Following a recommendation by the Engineering Council UK diagnostic testing in mathematics has been introduced at pre-entry and induction stage on many Engineering programmes (LTSN Maths TEAM Project, undated). To avoid a deficit-based response whereby 'remedial' support is put in place for students deemed not to have the required knowledge, skills and experience, sufficient flexibility should be built into the mainstream Engineering curriculum to enable all students to acquire and hone the required skills.

> HELM – Helping Engineers Learn Mathematics website aims to enhance the mathematical education of Engineering undergraduates by providing a range of flexible learning resources, and drive student learning via a computer-based assessment regime. The website includes 50 workbooks covering basic engineering mathematics and statistics. The workbooks are student focused utilising engineering applications of mathematics. There is a large bank of online formative assessment tests students can work through. (HELM, 2005: www.lboro.ac.uk/research/helm/).

The Bioscience, Economics, and Mathematics subject guides provide examples of how to respond to students with diverse mathematical backgrounds.

Increasing access to laboratory and practical work

Laboratory and practical work comprise a significant proportion of contact time for Engineering students and around 20–30% of marks awarded are for laboratory- and practice-based assessment. Davis contends, "the application of theory in a practical setting remains an expected and fundamental part of the engineering curriculum" (2008: 3). Enabling all students to have access to the learning outcomes associated with practical work should be a central aspect of an inclusive Engineering curriculum. Undertaking laboratory-based work can present barriers for some students due to the fixed time and location required. While the assessment of laboratory work can be onerous for students and staff, Davis suggests this can be streamlined using a range of strategies:

— feedback sheets: structured around the report format; containing list of common errors, with ticks against the errors made;
— model reports: giving out examples of good work for

students to compare;
— peer and self-assessment: students marking their own or another student's work;
— students select which laboratory session to report on (e.g. only two out of four to be written up);
— sampling of reports by staff (e.g. students have to write reports for all laboratory classes but only two out of four will be marked) (2008: 15).

An inclusive approach will utilise a range of assessment methods that will assess the learning process as well as the 'product' of laboratory work. This may include direct observation, reflection, planning and time management (Davis, 2008: 16). Alternative assessment approaches that can replace or augment laboratory-based work include:

— 'hands-off' practical work, for example designing a procedure, responding to a 'real world' case study from industry, analysing and reporting on raw data, role-play scenarios;
— computer-assisted laboratory work such as simulation packages;
— virtual laboratory work such as ReLOAD (real labs operated at distance), which was devised by the University of Leeds to allow online remote access experiments in dynamics and control (Davis, 2008: 17–20).

The Bioscience, Materials, and Medicine, Dentistry and Veterinary Medicine (MEDEV) subject guides provide examples that could be adapted for enhancing students' experience of laboratory and practical work.

Developing intercultural competence and understanding

Many strategies developed in response to the diverse educational, linguistic and cultural backgrounds of international Engineering students can be of benefit to all students.

Strategies that can be adopted to aid intercultural competence and make the curriculum more inclusive include:

— identifying subject-specific terminology and specialist language and providing glossaries and background reading;
— responding to cultural expectations about student participation;
— devising ground rules for different situations such as seminars and group work;
— staff joining groups to model active participation self-directed projects;
— sharing common difficulties and strategies for overcoming them;
— explaining the rationale and benefits of self-directed projects (Bond and Scudamore, 2010).

In addition to the design considerations that influence the learning experience, the content of 'real problems to be solved' can convey a greater appreciation of the alternative solutions to engineering problems. For instance, requiring solutions to use resources only available in certain situations can encourage all students to recognise their cultural and working context. UNESCO (undated) regards engineering as helping to eradicate poverty and contribute to sustainable social and economic development; in recent years the UNESCO website (www.unesco.org/new/en/unesco/) has included competitions or projects that can provide the basis for intercultural competence for Engineering students.

Responding to different learning approaches using technology

In part motivated by the inaccessibility of traditional podcasts for deaf students, Glasgow Caledonian University investigated the effectiveness of audio capture and integration with other resources to support student revision and review of classroom learning.

Students found the linkage of audio content, PowerPoint slides and other material such as tutorial solutions helpful. Video was also found to be beneficial in some circumstances such as when gesture was important. Other benefits included:

— presenters were particularly focused on 'performance' with the result they communicated clearly;
— speech capture and transcription can provide alternative formats for students to use (Stewart and McKee, undated).