Developments in the curriculum of Environmental Building at the University of Plymouth

Paul Murray, Pieter de Wilde, Steve Goodhew, Susan Turpin-Brooks, Peter Holgate, Steve Donohoe and Michael Riley
Environmental Building Group, School of Engineering, University of Plymouth
(contact email: paul.murray@plymouth.ac.uk)

Abstract

The Environmental Building Group at the University of Plymouth educates students towards accredited degrees in Building Surveying and the Environment, Environmental Construction Surveying and Construction Management and the Environment; close links are in place with the local School of Architecture. The group has been active in this field for 10 years, and has pioneered the theme of environmental building surveying. Teaching efforts have led to national recognition in the form of a National Teaching Fellowship and membership of the Centre of Excellence in Teaching and Learning focused on Education for Sustainable Development (CETL-ESD).

This paper reflects on the strengths and weaknesses in the current curriculum, contributing to an upcoming course review evaluation in 2008. It aims to position the teaching at the University of Plymouth within a changing practice, where sustainability has become a mainstream concern. The paper will review the changes taking place in each of the major disciplines taught on the programme: surveying, building technology, renovation, law/finance, and project management. For each of these disciplines, the paper will discuss initiatives that are planned to keep the curriculum at the leading edge of the environmental building / sustainability field. The paper concludes with an overall analysis of the programme, taking a look beyond individual fields and assessing the overall content of the curriculum.

Keywords: Sustainability, curriculum, SWOT-analysis, future trends

1. Introduction to the Environmental Building Programme at the University of Plymouth

1.1 Programme Structure

The Environmental Building Group at the University of Plymouth offers students a range of courses that help them to prepare for a career in the fields of Building Surveying and the Environment, Environmental Construction Surveying and Construction Management and the Environment. These are offered at different levels: a foundation pathway course, BSc (Hons),
MRes, MSc and PhD. The courses are all accredited by the relevant professional bodies, including CIOB (the Chartered Institute of Building) and RICS (Royal Institution of Chartered Surveyors). The programme is part of the School of Engineering, which provides excellent links with related areas of study like Civil Engineering and Mechanical/Marine Engineering. The programme also has close ties with the School of Architecture at Plymouth, with some shared modules and courses.

The programme is strongly related to professional practice in the building industry. Students on the undergraduate track are encouraged to spend a year on placement to gain experience and prepare for their career. While the programme offers all Higher Education Levels that students might undertake, there is a continuous influx of students entering academia at all levels after a period of working in practice. Furthermore, the programme has close ties with practitioners who provide guest lectures and take part in student assessment panels. The intricate interrelation between the courses and the building industry is graphically represented in figure 1.

![Diagram: Interaction between Environmental Building Programme and the building industry at the University of Plymouth](image)

*Figure 1: Interaction between Environmental Building Programme and the building industry at the University of Plymouth*

The programme has a history that dates back to 1996, and has pioneered the theme of environmental building. Past graduates are sought-after by the industry, and have found their way to positions in the core disciplines but also into other areas like building control, development and historic building preservation.

The Plymouth programme has a strong track record in terms of pedagogical quality. In 1998 the programme was awarded the second highest aggregate grading (23 points out of 24) for teaching excellence in England by the Quality Assurance Agency. This was followed in 2000 by the award of £325000 from the UK government to transfer teaching excellence in flexible learning
to other universities. In 2004 a prestigious National Teaching Fellowship was awarded to the then Head of Building Programmes for educational excellence and in 2007 the University of Plymouth received a Green Gown Award from the Higher Education Environmental Partnership Improvement organization for the contribution the Environmental Building Programme made to Education for Sustainability. The Environmental Building Teaching Team were also key contributors to the successful bid to set up a £4.5 million government funded Centre of Excellence in Teaching and Learning focused on Education for Sustainable Development (CETL-ESD). The fruits of these developments have been presented to national and international audiences over the last seven years, see for instance [1], [2], [3].

2. Curriculum development drivers

To stay at the forefront of the discipline the Environmental Building Programme at Plymouth needs to adapt to a constantly changing context. Over the 10 years that the programme has existed, important developments have taken place in the construction industry as well as in education. New technology and information sources have become available; the students starting their education today are different from those of 1996, and the industry has different expectancies of the skill and knowledge base they will be bring into practice. In general the building industry is increasingly aware that the environment and factors related to sustainability have become a major issue. Buildings have a huge impact on the environment in terms of energy use, waste, pollution and habitat destruction. As a consequence, there is a strong demand for graduates that have a background in the environmental aspects of construction. The programme at Plymouth is benefitting from this demand. Yet at the same time it also means that these is an increased offer of similarly oriented programmes from other Universities, and that the unique selling point that set the courses apart when they were launched in the 1990s needs to be reviewed. The changes in industrial practice are rapid, as exemplified by the ambition of the British government to require all newly-built homes to be carbon neutral at a time horizon of 2017. Such changes require the development of a strategic vision to maintain the programme at the cutting edge of ‘environmental building’.

The overall aim of this paper is to provide a position paper that evaluates the context of teaching environmental building at undergraduate, postgraduate and research level, identifying relevant changes and underpinning a vision for future development of the programme.

3. Changes within the major subjects of the programme

The main subjects that are taught within the programme are building surveying, building technology and building science, renovation and refurbishment, law and finance, process management, and land and environmental surveying. These disciplines are taught by a wide range of approaches, which involve student-centred learning [4], traditional lectures, workshops, laboratory experiments, site visits, design project work, and management games.

The following sections discuss the developments per subject, reflecting on changes that are apparent in industry, the implications of these changes for teaching the subject at the different
course levels, and developing a view of required changes in the learning and teaching of the subject area.

### 3.1 Building surveying

The Building Surveying discipline traditionally centres on an understanding of the physical and functional performance of built assets. The central knowledge and skills of the building surveyor relate to building pathology - which involves a deep understanding of building decay mechanisms, analysing building condition and managing remedial works programmes. The discipline is overseen externally by the professional body, the Royal Institution of Chartered Surveyors which maintains standards educationally and professionally. In 2006 the RICS published new guidance on qualifying competencies for newly Chartered Building surveyors [5]; which as can be seen from Table 1 includes sustainability as a mandatory competency.

**Table 1 RICS compulsory competencies for Building Surveyors (RICS 2006, p7)**

<table>
<thead>
<tr>
<th>Core competencies for Building Surveyors</th>
<th>Mandatory competencies particularly relevant to Building Surveyors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building pathology</td>
<td>Sustainability</td>
</tr>
<tr>
<td>Construction technology and environmental science</td>
<td>Conflict avoidance</td>
</tr>
<tr>
<td>Contract Administration</td>
<td>Health and Safety</td>
</tr>
<tr>
<td>Inspection</td>
<td></td>
</tr>
<tr>
<td>Design and Specification</td>
<td></td>
</tr>
<tr>
<td>Legal/regulatory compliance</td>
<td></td>
</tr>
</tbody>
</table>

As Table 1 demonstrates, building surveying as a professional discipline embraces a wide range of subjects associated generally with construction and the built environment. The inclusion of a compulsory sustainability competency however, is particularly pertinent development for the Environmental Building Programme as it sets a clear directional steer on educators to engage building surveying students with what is fast becoming a central professional theme. The RICS definition of what constitutes sustainability competency includes the ability to demonstrate how and why sustainability seeks to balance environmental, economic and social objectives at global, local and national levels in a built environment context, as well the ability to demonstrate and apply sustainability to practical and professional situations [5]. Efforts are also being made in teaching Building Surveying at Plymouth to integrate emerging themes such as flood risk assessment and remediation measures within the curriculum in response to the climate change agenda.
3.2 Building technology and building science

The subject area of building technology covers different aspects: it is involved with the systems and components that are used to construct buildings, the assembly and maintenance of the built environment, and last but not least with building science as a prime tool to understand how buildings and their (sub)systems function and perform.

The area of building systems and components is subject to rapid change in response to the increasing awareness of environmental problems. Structural systems made of in-situ and precast concrete, structural steel, timber and, mainly for domestic buildings, bricks continue to dominate the industry. Yet even these basic commodities start feeling the impact of high global demand and an increased scarcity of resources, leading to innovation and novel products in the field. Infill and cladding technology is evolving rapidly. Many large and representative buildings now employ active/intelligent/double facades, and increasingly integrate solar technologies and daylighting systems in the building shell. In terms of infill and partition walls industrialised, open systems are replacing traditional stud and sheet partitions. Some innovative buildings even experiment with the integration of phase-change materials in for instance gypsum board. New HVAC technology like micro-CHP units, small scale wind turbines, photochromatic glazing and heat pumps are quickly becoming commonplace in the industry. Interest in environmental friendly materials like cob, strawbale and timber from renewable sources is at an all time high. Within buildings, developments in ICT technology have large impacts, from the ICT connections provided for the occupants to the use of the same technologies for building operation/control and facilities management.

Assembly and maintenance are fast-developing under both economic and environmental pressure. With the decrease of skilled labour and continuous needs to make the construction process ‘lean’ there are continuous efforts to make the process more efficient and increasing quality of the end product. This coincides with the drive to reduce waste, both in terms of unwanted by-products as well as waste in productivity of construction equipment and staff. At the same time facilities management aims to guarantee reliability, maintainability, usability, and serviceability. Furthermore, there is an increased interest in looking at the whole building life cycle, bringing in interest in producibility and disposability and taking a cradle-to-cradle view.

The area of building science as an enabling discipline is relatively unaffected by the increased interest in environmental issues: the underlying physical principles like heat and moisture transfer, (day)lighting and acoustics remain the same, and have been the subject of physical research for a number of decades. Some progress is being made by developing new computer programs to evaluate different performance aspects, especially regarding air flow in buildings by means of CFD modelling and regarding daylighting. At the same time increased computational power allows a more holistic performance of processes, for instance combining lighting and thermal issues.

The impact of these developments on teaching in the Environmental Building Programme has different aspects. On the one hand, there is a continuous need to provide a strong scientific basis
that allows students to understand and appraise novel systems, techniques and processes. At the same time there is a need to regularly update both the course content and lecturers experience with novel systems, ensuring the students are aware of the latest options available.

### 3.3 Renovation and refurbishment

Interest in the effective ‘use’ of buildings in the UK has undoubtedly been influenced by the increased ‘customer’ focus within the construction and property sectors within the last ten years, driven by the Egan Report and subsequent industry initiatives (M4i and Constructing Excellence). Coupled with this, the enabling technology within facilities management and maintenance, has ensured that the performance of buildings is mapped more accurately (e.g. BEMS and thermal imaging) and indeed related back to ‘user needs’ through various tools such as Post-occupancy Evaluation [6]. With this growing area of knowledge, more robust decisions about renovation and refurbishment can be made.

To be of most use in business, students need to appreciate the connectivity between science, technology and sustainability or performance assessments (leading to effective changes for buildings. Involvement with the CETL-ESD (see section 1) has enabled the Plymouth Environmental Building students to access real projects and hence gain appreciation of this holistic view in their undertaking of feasibility and refurbishment projects. Such student assignments have recently included final year students evaluating sustainability tools and thermal upgrading options for use on campus building projects, with feedback from this influencing some decisions by the University Estates Department (e.g. fenestration). Additionally, second year understanding of sustainability in this applied context has been achieved through sharing of information and views via a ‘Sustainability Forum’.

### 3.4 Law and finance

To inculcate “green” issues into the Law and Finance subject areas of the construction curricula, the simple addition of extra lectures “added on” to the programme is insufficient. Instead an approach has been developed that aims at “an active, constructive and cumulative process that occurs gradually over a period of time” [7], employing problem based learning [8]. In this context, real life situations and problems in the field of law and finance are gradually introduced to students. For example, the first year syllabus includes a module where estimating is studied. Students are required to calculate unit rates for various construction trades. Traditionally this involved detailed calculations for labour, plant, materials, overheads, and profit for concrete work, bricklaying, roofing etc. The examples used in lectures have been expanded to include recycled and environmentally friendly products as well as traditional products. Later students are introduced to comparative estimating and are asked to investigate cost differences between various construction components such as cost differences between different mixes of concrete etc. Students are introduced to the notion that lowest cost might not be the only important factor in selection and are advised to consider the social and environmental costs of decisions. Students’ comparative estimating is expanded to a position
where not only initial capital costs are considered but costs over the lifetime of a building are included using complex examples and case studies.

In the subject area of law, students study Environmental Law and Regulations as well as traditional legal subjects such as Contract, Tort, Property Law, etc. In the second year of the undergraduate curriculum, students study standard forms of contract and their applicability to project scenarios. Gradually students are introduced to the RIBA Programme of Work. Eventually The BRE guide to Sustainability is superimposed onto the RIBA Programme of work to reflect on how decisions affecting the environment can impact on every stage of a construction project. A problem based learning scenario based upon an actual construction law case is used for the law assignment in the second year undergraduate course. In addition, students are required to give procurement advice as part of their second year and final year projects. Students are also asked to produce budget estimates and life cycle cost reports as part of these projects.

At Masters degree level, students investigate cost modelling in greater depth than their undergraduate colleagues. Postgraduate students are invited to critique a journal paper, for example, Worth et al’s [9] exploration of life cycle costs of four alternative types of roofing systems. The life cycle costs involve a wider scope of calculation than traditionally undertaken and include such factors such as carbon emissions, embodied energy and energy conservation. In the law subject area, Masters degree students consider wider issues of sustainable procurement and explore whether some construction contractual arrangements for the procurement of buildings are more environmentally friendly than others.

3.5 Process management

Process management is the knowledge area that supports the building process, rather than the building product. This is covered in most modules of the programme. The importance and benefits of thinking about the construction process at the very start of the project is being recognised by industry and leads naturally to (recent) innovations in construction, such as partnering, joint ventures, supply chain management and special delivery vehicles. However there is still a real lack of understanding of these ideas in the construction industry and this reinforces the need for all graduates to know the underpinning ideas for these new ways of working.

A theoretical model, underpinning and explaining these newer ways of working needs to be presented to students to ensure that they do not use a cookbook style of learning, and this is provided by systems theory. Theoretical ideas from research in trust, culture and collaboration are needed to enable the new strategies to work. Systems theory can also help understand the more traditional areas such as project management – how and why they fail or succeed for example; it also provides a better explanation of more recent ideas such as lean construction and more sustainable ways of managing the construction process.
The integration of both product and process into one model will become important in the future to enable the client to make fully informed choices from the range of alternatives. We will have to develop new theoretical ideas and ways of teaching these things to both the undergraduate and postgraduate students. It is essential that Plymouth provides its graduates with the ability to cope with future changes in the sector.

### 3.6 Land and environmental surveying

This area of the curriculum includes learning within the fields of level surveying and measurement, the regulation of land use through the Town and Country Planning System, the issues around the effects of change of land use by development which is assessed by environmental impact assessment and the problems caused by previous uses of land which have left it at the risk of being contaminated.

In environmental terms change has taken place towards consideration of the whole sites, not just the buildings. This requires students to consider both the hard and soft landscaping as a means of improving the setting of the building in its surroundings.

The awareness of the need to obtain planning permission for a project has to be extended due to new requirements relating to the granting of permission. These relate to changes, designed to take environmental and sustainability issues into account. This has been done through changes in planning policy as well as the revisions to the Environmental Impact Assessment (EIA) regulations [10, 11] which required EIAs to be carried out for smaller projects than was required by the original regulations and to cover additional issues such the consideration of alternative sites.

To reduce the amount of green field land used for development and to encourage the redevelopment of urban areas the government has introduced a policy of re-using brownfield (i.e. previously developed land). This requires more detailed coverage of this in the curriculum as many of these brownfield sites are contaminated. The pressure to use brownfield and hence possibly contaminated land required this to be covered in the syllabus as developers were going to need to be aware of a whole range of issues - definition of what constitutes 'contaminated land', how to avoid taking an unforeseen responsibility when buying it, and an overview of the investigation and remediation processes.

All of these aspects are becoming increasingly important for setting the context within which the construction of the actual buildings takes place and therefore are of considerable importance in achieving sustainable development.

### 4. New curriculum directions

Sustainability is fast emerging as a central paradigm for construction education as demonstrated by The RICS inclusion of sustainability as a mandatory competency for all types of surveyor [5], the UK government and other professional bodies such as the Chartered Institute of building
and the Royal Institute of British Architects [12]. While the Environmental Building Group has taken structured and active steps both to assess and enhance the sustainability content of the Environmental Building Degree Programme the implications of this new paradigm is that within ten years the curricula of all construction-related programmes will be expected to fully embrace sustainability.

In order to maintain a leading position in this changing context, the Environmental Building Group is reflecting on the long-term changes expected for its discipline of construction. In this future, the group expects a larger emphasis on safety, and the role of industry in the general future of humanity – allowing the human race to cope with a range of pressing issues like climate change, population growth, shortage of fossil fuel, and ecological problems (ecodiversity, acid rain etc). Given the scale of these problems, it seems unlikely that mitigation is going to solve all; it therefore seems paramount that the discipline starts working on resilient technologies, and response to inevitable changes in our environment. Furthermore, the group recognizes two approaches towards a ‘sustainable’ future: 1) gradual change, with a residual gap between what is needed and what is actually achieved, and 2) step change, which requires instant changes in the workings of the industry.

Preparing itself for this future, the Environmental Building Group at Plymouth has put in place a strong base for ensuring the sustainability literacy of our students, by providing them with an understanding of the set of environmental problems faced, as well by handing them the knowledge and skills to contribute to changing the industry. At the same time a new impetus is given to work that aims at helping the industry respond and adapt to change; this work has a strong research component, as this a developing field. Both these efforts align well with gradual change to a sustainable future. On a longer horizon, the team is starting to contemplate the needs of working to step change, and its impact on both the understanding, knowledge and skills this will demand from future staff, students and construction professionals. These views are depicted in figure 2.

In practical terms, the Environmental Building Group recognizes a need to increase the research base if it is to contribute significantly to resilience, responsiveness, and step change. At the same time the compact structure of the group provides a flexible starting point for steering in a novel direction.
5. Conclusions and remarks

The preceding sections underpin the following conclusions and remarks:

- ‘Environmental’ and ‘sustainability’ issues are having an increasing impact on the construction industry, and on the academia that prepare new professionals for a career in this field. Any curriculum needs a regular update, but students in this discipline also need to be made aware that Environmental Building is a rapidly developing field that is facing large changes. Students need to be equipped to take a leading role in guiding the industry into the future.

- Focussing on a developing discipline provides ample opportunity to combine teaching and research, and for growth of the programme. There are good job opportunities for graduates.

- Although the science underlying the curriculum in Environmental Building is quite stable, rapid changes are taking place in the application of these underlying principles in construction practice, building methods, and building systems.

- For the longer term future, the curriculum of the University of Plymouth will prepare for both gradual and step change. To do so, it has identified the subfields of ‘sustainability literacy’ and ‘responsive technologies’ as key enablers for what is to come.

- There remains a need to ensure that students become critical, independent thinkers, and that the programme does not slip towards what is named ‘greenwash’ in industry (a term used to
denounce projects that seem more concerned with an environmentally friendly appearance than with actually addressing the underlying environmental issues).

References


