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How green is my project? Developing a curriculum for environmental education of civil engineers

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Abstract: *Engineers are expected to cover an increasingly wide range of issues within their educational development. Ability to assess the environmental impact of their actions is part of this expansion and so understanding the "environment" is required. Developing a curriculum that is comprehensive from an environmental perspective yet relevant to the interests of engineers, within a limited amount of time, requires judicious selection of topics and appropriate presentation if the students are to be engaged. This case study is further complicated by an internationally diverse cohort of students, many from low-income countries with differing financial, ecological, legal and social contexts. It shows how the course was planned, using theoretical educational models to provide a framework. Wider lessons are presented on curriculum development for interdisciplinary courses.*

Introduction

> "Most of us, when asked to teach a topic, start by thinking about the content. Questions such as 'what do I know that I can tell them?' or 'who are the best authors or references for this subject?' dominate our thinking. This is only natural because we, as academics, trade in understanding, insights, analysis, synthesis and creativity, but our currency is knowledge, information, facts, data."
>
> (Butcher et al 2006)

The development of a new course draws on a variety of sources and expertise. For specialized courses or training in emerging subjects, the amount of teaching material available is limited, may lack authority, relevance or general acceptance and may be untested. A similar situation occurs when teaching is being applied across disciplines, where material developed for one audience may not be directly suitable for students from another discipline. Material may be plentiful, authoritative, accepted and tested but the relevance to the new student group needs assessing. This case study sets out the rationale behind the selection of content for a module on environmental issues specifically for civil engineers and related professionals, who may lack awareness of the core principles that underpin environmental management. This paper is based on a review of literature, discussions with colleagues and students, practical delivery of the new module and critical reflection. It focuses more on the process of developing the course than the final product.

Why educate civil engineers about the environment?

> "Civil engineering helps you understand nature. When you understand nature, you understand a whole lot about how the world works"
>
> Richard Coackley, ICE President 2011

Civil engineering is an interdisciplinary subject. It has been defined as “the Art of working with the great sources of Power in Nature for the use and benefit of society” (Jowitt P. 2004 based on Thomas Tredgold’s 1828 definition of Civil Engineering). Thus nature (the environment) and the needs of society are brought together through the art of civil engineering. Understanding society and nature are fundamental to civil engineering practice. The Engineering Council states that a Chartered Engineer is expected to “undertake engineering activities in a way that contributes to sustainable development” (2008) defining principles of sustainable development as:

1. “Contribute to building a sustainable society, present and future.
2. Apply professional and responsible judgement and take a leadership role.
3. Do more than just comply with legislation and codes.
4. Use resources efficiently and effectively.
5. Seek multiple views to solve sustainability challenges.
6. Manage risk to minimise adverse impact on people or environment.”

(Engineering Council (2009) quoted in Penlington and Steiner 2010)

Penlington and Steiner (2010) recognise different areas within engineering for sustainable development (enviro-centric, techno-centric and socio-centric) all of which need to be integrated, being actively re-grouped, linked and emphasized if the students are not going to be left alone to “make sense of the whole” (OECD (1972) cited by Chettiparamb 2007).

Interdisciplinary approaches

Chettiparamb (2007), in a wide ranging literature review of interdisciplinarity, explores a range of perspectives, noting many categories of disciplines and inter/ multi / pluri/ transdisciplinarity. She quotes Heckhausen’s six types of interdisciplinarity (indiscriminate, pseudo, auxiliary, composite, supplementary and unifying) where supplementary interdisciplinarity

> “… happens when disciplines in the same field develop a partial overlapping in certain subject matters. … However beyond that particular category there might not be a particular overlap. The overlap is seen recognised and established to provide a fuller picture of the subject matter. This type of interdisciplinarity exists in the borderlines of the disciplines.”

(Heckhausen (1972) quoted in Chettiparamb (2007))

Thus if civil engineers are to understand the environment, there is an overlap with disciplines such as ecology.

She recognises some of the reasons for and against an interdisciplinary approach, with single disciplines being regarded as a way of institutionalising the creation, rigour, quality control and dissemination of knowledge but being protectionist, resistant to change, restricting the range of information regarded as relevant, preventing access and sharing a language (“awful jargon” according to Leitch 2005 quoted by Chettiparamb 2007). Interdisciplinary approaches also have strengths and weaknesses, having developed in response to various drivers, including

> “the need for professional training. Even if a person is an ‘expert’ within the university, once outside the university, s/he had to be the person to connect other things. Thus having to engage in the day-to-day affairs of concrete practice created a demand for interdisciplinarity (OECD 1972, quoted by Chettiparamb 2007)

Chettiparamb quotes Klein (1996), noting that “interdisciplinary work … requires active triangulation of depth, breath and synthesis” where depth is “competence in pertinent disciplinary, professional and interdisciplinary approaches.” This is recognised by Robinson and MacGregor (2011) as

> “There is clearly a delicate balance needed in an interdisciplinary subject between providing too broad and shallow a coverage, and too much detail of particular subject areas, particularly as students will have a wide and differing range of interests and aspirations, and feel they will need to be prepared in different ways depending on what career path they wish to follow.”

Synthesis is an “interdisciplinary outcome rather than mastering a body of knowledge”, as students gain cogitative skills in balancing the different disciplinary discourses (Chettiparamb citing Haynes 2002). Within the discipline of civil engineering,

> “The case has been argued for mainstreaming an appreciation of sustainable development into engineering education and training, and with it, the inculcation of an appropriate habit of mind, attitudes, systems skills and domains of knowledge to enable the engineers of the future

> to better contribute to society… advocating a more process/ issues-based approach to engineering education in which the student's mind becomes a fire to be kindled, rather than a vessel to be filled by additional curriculum content in narrow subject-specific disciplines.
>
> (Jowitt P. 2004)

This characteristic is mentioned by other authors, with approaches to learning being "active, participatory and reflexive … problem and enquiry-based learning ... group work and peer review" (McEwen 2011), recognising

> "the importance of moving away from traditional teaching and learning to more interactive and participatory modes so that the pedagogy employed harmonizes with sustainability precepts and principles and is more engaging for students"
>
> (Kagawa et al 2006 quoted by McEwen 2011)

Chettiparamb notes the people involved, with Anbar (1973, cited in Klein 1985), proposing a "bridge scientist" attends to problems of language (translating the perspective of one discipline to the perspective of another) or concentrating on paradigmatic conflicts between disciplines, either because they are curious about other disciplines, are being forced out of a declining subject area, are generalists with superficial training in one or more disciplines or are reluctant managers of an interdisciplinary group.

Curriculum development

The "how" and the "why" of teaching across disciplines has been discussed extensively for well over a decade (e.g. Thom 1998). However there is less guidance on "what" to teach, apart from the general indication of the need for critical thinking and interdisciplinary content. Thom (ibid) gives two examples of modules that introduce environmental principles to engineering undergraduates and Penlington and Steiner (2010) list some teaching resources.

A systems approach to learning

Learning can be modelled as a system, with inputs, actions and outcomes (Romiszowski, 1981). The inputs include the students and their current skills, knowledge and attitudes, the course content and the course delivery. After the activities, the actual outcomes and success of the course can be measured. If the desired outcomes are not met, the inputs can be adjusted.

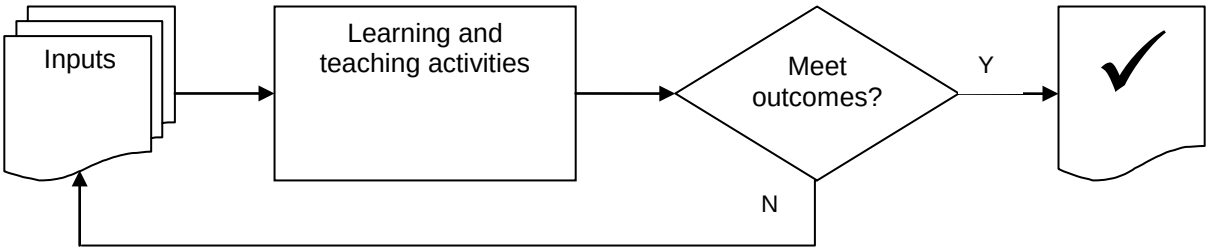

Figure 1: A simplified model of learning

To construct a course, the inputs can be broken down further, so the decisions required are (with this author's emphasis):

1. "What are the needs in relation to the product of the training programme?
2. What are the aims and objectives?
3. <u>What content should be included?</u>
4. <u>How should the content be organized?</u>
5. What educational strategies should be adopted?
6. What teaching methods should be used?
7. How should assessment be carried out?
8. How should details of the curriculum be communicated?
9. What educational environment or climate should be fostered?
10. How should the process be managed?"

(Harden 1986)

These are the inputs provided by the teacher. The perspective of students with their existing skills, knowledge and attitudes can be different from the teachers. Whereas teachers may view the process chronologically (setting objectives, running teaching activities then assessment), the students focus on the assessment, which is supported by the learning, (Stefani 2009), thus setting the outcomes and assessments should be early stages of the process (figure 2).

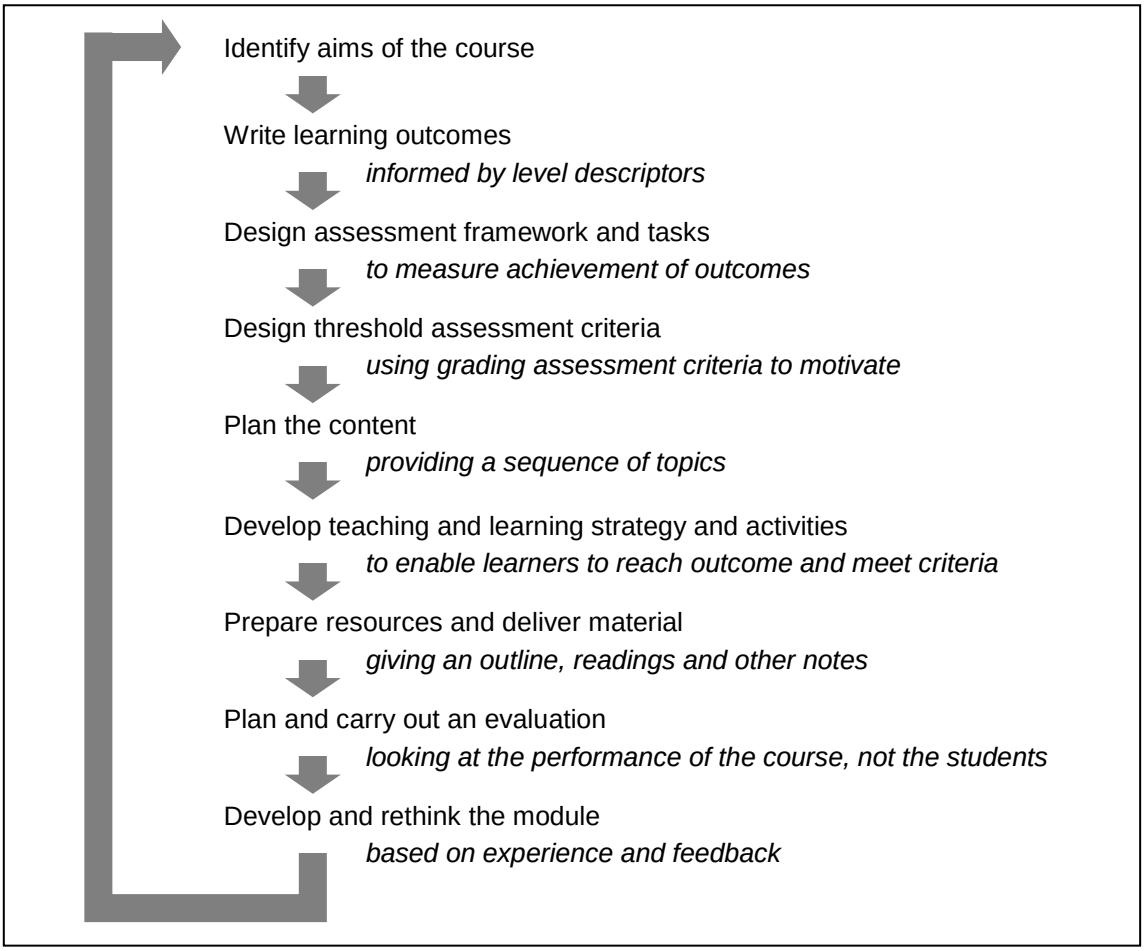

Figure 2: Learning Outcomes process at module level (based on BCU, 2011 and Stephani 2008)

The outputs can be defined by learning outcomes, objectives, competencies or goals, or alternatively specified by the inputs, with a syllabus setting out the content. Biggs (quoted in Stefani 2009) emphasized the need to align these activities, with learning and assessment synchronized using learning outcomes to summarize course content and indicate assessment but the criteria for selecting specific outcomes are not so clear.

Stefani (in Fry et al. 2009) expands a model of curriculum development proposed by Cowan and Harding (1986) (figure 3). This starts with “assessment” (rather than bolting this on at the end), which influences the learning which in turn results in teaching. “Decisions” are a key stage, based on evaluation of the course (not the assessment of students). All these stages are centred on the “aims” and are set within wider constraints and resources. This is a dynamic model, with the aims being adjusted based on decisions resulting from the evaluation.

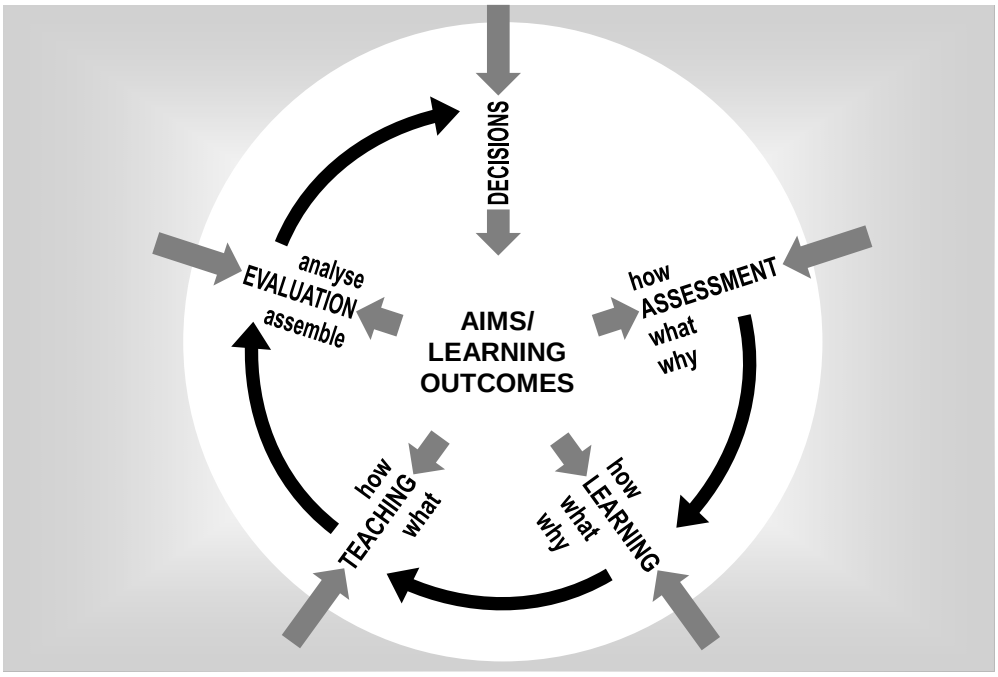

Figure 3: "Logical" model of curriculum development (Cowan and Harding 1986)

Developing course material

The freedom to vary inputs and outputs will depend on the context, constraints and resources. At undergraduate level, the cohort of students is normally well defined and reasonably uniform. Adult learners are more likely to have a wide range of existing skills, knowledge and attitudes. At undergraduate level the outcomes are externally defined (e.g. Subject Benchmark Statements), so the lecturer has reasonably fixed boundaries. Professional bodies have accreditation criteria required for a professional as well as an academic qualification. These various standards address the first three of Harden's Ten Questions listed above, leaving the teacher to plan the detail of delivery, starting - and finishing with the learning outcomes.

At specialist, post-graduate level many of these regulations give freedom to the lecturer to vary inputs and outputs (within reason) but this reduces the guidance available with respect to course content, in terms of both breadth and depth. Some restrictions will apply, such as limits to resources and the knowledge, motivation and interests of the lecturer. Freedom brings an extra dimension to the development of the course but increases uncertainty in selecting the correct learning outcomes.

What to teach?

Dunn et al (1985, quoted in Dent and Harden 2009) identified a range of approaches to identify curriculum needs, namely:

- asking "wise men" [sic] – senior teachers and senior practitioners – to reach a consensus;
- consultation with the stakeholders – including non-specialists;
- looking at errors and mistakes in existing practice;
- examining case studies of good and bad (professional) practice;
- undertaking task analysis, where components of the professional's job are studied; or
- analysing good performance to identify areas that are worth passing on.

This list does not mention students' existing knowledge or motives for study; McEwen (2011) recommends that students should be seen as partners in course design and delivery. Dunn's list also assumes that what is done in professional practice is the state of the art, neglecting the role of "new" knowledge stemming from research. Kordi et al (2005) used the first two approaches to establish the learning outcomes for a specialised course in sports medicine, but this approach does rely on a single discipline to engage with. With interdisciplinary areas, there are two or more disciplines to consult, resulting in gaps, overlaps and a need to negotiate and prioritise.

Content can be categorised in different ways (box 1) but these two sets of four categories are not synonymous, **precursor** material may be **essential** and some **supportive** material **should** be included.

Box 1: Categories of content

Qualities of content:

- **Mainstream**; directly contributing to the one or more planned learning outcomes. Actual selection can be on familiarity, enjoyment, resource availability, research related or influenced by the other categories;
- **Precursor**; core material that is required before other material can be presented, so relates to the sequence of teaching;
- **Opportunistic**; core material that also provides additional insights. Some students will be able to take the significance to a further stage; and
- **Supportive**; the use of case studies or real life examples to illustrate core material but learning the specific "facts" in the case study are not a required outcome.

Quantities of content:

- **Essential** material (perhaps delivered directly);
- Material that **should** be covered (perhaps though reading or other directed activities). These first two categories should provide enough material to allow the average student to reach a reasonable standard in the time allocated;
- Material that **could** be covered; and
- Material that is **nice** to know.

Butcher et al (2006) adapting earlier work by Harden (1986)

Environmental assessment for engineers - a case study

The literature review provided a theoretical discussion on the process if not much guidance on the practical aspects of selecting content for a course. It was clear that "the environment" was an issue for engineers, but specific topics were not suggested. The background of these generic models and classifications of course development provided a framework and reference points for the final course to be analysed and critiqued.

The context

In addition to theoretical and external guidance, there are also local constraints and boundaries. Institutional culture influences what is taught (Stefani 2009), so the course under discussion was constrained by the context of the institution and the students. The Water, Engineering and Development Centre (WEDC) focuses on the delivery of infrastructure services, such as water and sanitation, to people in low - and middle – income countries. It has a history of producing practical answers rather than discussing theoretical approaches; most of the teaching staff have a background of working for NGOs or consultants. This emphasis on "research that matters" is part of Loughborough University's wider culture, which has strong history of "learning through doing" and many links with industry.

Within this institutional climate and the remit of the Centre, the subjects have been addressed from a multidisciplinary perspective for a couple of decades. The balance between separate disciplines varies depending on the subject being taught. For example, a module on wastewater treatment is mainly technical, but includes economic, institutional and environment aspects. Teaching on gender will address technical and economic as well as social responses.

The WEDC MSc programme in Water and Environmental Management started in 1980. The importance of environmental issues has grown over this time, with the original subject matter being a series of ad hoc (scientific) topics on pollution, climate change and other impacts, according to the lecturer's interest and experience. The module evolved as topics and staff changed but in 2010, in response to student feedback and staff comments, the module was reviewed and revised. The availability of staff was not considered, as colleagues from other departments or bought in teachers were available.

The students

The starting point for the course was the student perspective - what they already knew and what they would need in the future. Broadly, the students were from engineering or science backgrounds, but

with a variety of other experiences, especially for the mature students who had been working in overseas development for a number of years. The students were not destined for a career as “pure” environmentalists but would have a general role, coordinating projects (which would include an environmental assessment), designing infrastructure (which could have adverse impacts) or responding to adverse impacts on the environment by others (such as pollution). This corresponds with Anbar’s “bridging” role between disciplines.

The students were from high and low-income countries. Whilst the MSc focuses on low-income countries and many students will be working in such a context, some will work in industrialized nations and need to be aware of the range of issues that may be encountered. This meant that a wide variety of environmental contexts (e.g. different habitats), problems (e.g. different sorts of pollution) and solutions (including legislative approaches) needed to be addressed.

Developing the content

The process of course development was based on searching the mainstream environmental literature, prioritising these according to the relevance and interest to engineers and identifying underlying themes to provide a narrative thread to the course. Priorities were based on discussions with staff, students and teaching centre staff, piloting some of the changes within the existing module and using reflection and feedback. The detail of the course is not discussed here, but several aspects are used as illustrations of the wider process, again using literature to provide some foundation.

Aims

The aim of the module set the direction, stating:

> “The aim of this module is for participants to develop a broad understanding of both the needs for and the mechanisms of environmental assessment and management, with emphasis on aquatic environments, in low- and middle-income countries. “
>
> (Loughborough University 2011)

The low- and middle-income country focus is clear and the emphasis on aquatic environments demonstrates that it is part of a wider programme based on water management, but the detail is open to interpretation.

In Dunn et al.’s list, a starting point for selecting material is to ask “wise men” (and women) or a range of stakeholders. This would be good for an environmental assessment course for environmentalists, but environmental assessment for *engineers* is not so straightforward. Allan (2001) notes that:

> “Interdisciplinarity is a demanding ‘non-discipline’ and especially difficult because anyone adopting the approach is at risk of attracting the very sharp and even destructive analysis of elements of their argument by scientists with more specific disciplinary expertise in a particular episteme. Unfortunately, while there are referees in scientific ‘disciplinary’ games, albeit narrow, often biased and much questioned, there are no referees at all in ‘interdisciplinary’ games. Yet firms, governments and other entities which get things done have to address problems which are inherently interdisciplinary. Their ‘referees’ are market performances and political success, whether sanctioned by democratic process or not.”

The range of topics that could be included was wide; the challenge was to balance the breadth of material with enough detail to make it practical whilst being demanding enough at a postgraduate level. Introductory textbooks that covered the whole range of issues were general and too shallow. More specific texts were available, but went into too much detail for a three-week course or only looked at one context (e.g. environmental regulations in the EU). What is essential for environmentalists may only be “nice to know” for engineers and the opposite can also be true (figure 4).

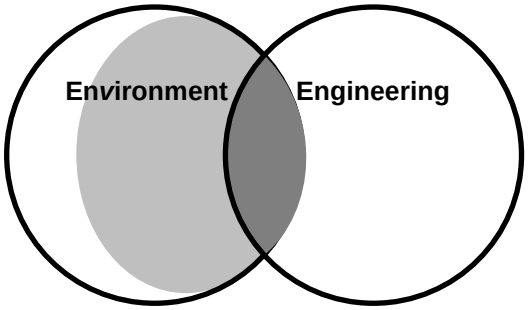

Figure 4: Subject boundaries

Starting from the basics

Robinson and MacGregor (2011) consider the role of precursor material;

> "… where modules are taught by specialist departments these can be very challenging if they are not pitched at an introductory level for students new to the discipline, or are not specifically tailored to sustainability students."

They noted that introductory material was not seen as being relevant until later in the course. Lev Vygotshy (Thompson 2001) promoted the idea of a "Zone of Proximal Learning", where learners move from what they know to what they do not yet know. Too wide a zone and this threshold becomes increasingly difficult to cross. Thus the precursors bridge to the essential content, but have to start from where the students' abilities and interests currently are. By relating some environmental concepts to known engineering or science concepts, the route to constructing new knowledge can be facilitated. Thompson notes that, with adults, personal relevance of content, involvement of the learner in the process of learning and deeper understanding of underlying concepts form a favourable intersection between a constructivist approach to learning and some adult learning principles.

American educational psychologist Jerome Bruner proposed that learning activities build on what the students already know, allowing them to construct their own knowledge, but that this process is not necessarily linear (GTC 2006). He proposed that curricula should start with an intuitive introduction to basic ideas, but these should be re-visited repeatedly until the student fully understands them – a "spiral curriculum". Successive stages can move from "learning by doing" through learning using images to learning by words and numbers, as the underlying principles become accepted and understood. On a postgraduate course the students may have extensive existing knowledge, but this can vary widely, depending on their individual experiences to date.

Some basic environmental topics such as evolution, cell biology or climate change were omitted, as they were not directly relevant to later engineering topics. However some basic environmental concepts are precursors to other topics (shaded light grey in figure 4). Brunner not only advocated a spiral curriculum, he also emphasized the need to introduce structure, patterns and fundamental principles at an early stage, so that the learner can begin to arrange their own learning and build on strong foundations (GTC 2006). The specialized language used by environmentalists had to be introduced so students could access some concepts (Felley and Reed 1997). An example of this is the construction of an understanding of the mainstream concept of the biotic index (where surveying the biodiversity in a river can indicate water quality). Certain species will be expected to be in pristine rivers, based on the concept of habitats, which in turn is founded on the concepts of food chains, ecosystems, cycles (water, nitrogen), succession, biomes and system dynamics (precursor topics), illustrated by reference to particular species (supportive content), which are named using taxonomy many of which would be new to engineers but not complex for environmentalists.

Setting learning outcomes

Defining "taxonomy" and "the environment" demonstrate contrasting approaches to introducing new concepts to the students. One was short but strongly directed; the other was longer, discursive and left the student to construct their own definitions.

Taxonomy using the binomial system is a basic concept that is introduced to school children studying biology. However engineers may have missed this out if they specialized early in their careers. This could be treated just as knowledge – a series of facts that the students have to learn. A learning outcome could just ask the students to *define* the binomial system, *outline* its history or *describe* the

various levels of kingdoms, families, etc. This is would give them a foundation in the topic, but would not make them better engineers. However asking them to *defend* the need for having such system requires them to make critical judgements rather than just recalling information. They need to know why the binomial system is used and illustrate the need to use names such as *Phragmites austrailis* or *Typha spp* but they do not need the same expertise in species identification as an ecologist. This concept can be made relevant by comparing it to other subject specific nomenclature systems such as the chemical periodic table or geological rock types.

The need to be concise could have led to précising information to fit the time available, leading to a wide but shallow course, cramming in lots of definitions but not getting to any advanced analytical discussions. At MSc level the students are required to discern suitable environmental standards rather than being confined to a single viewpoint. This broad understanding of "the environment" rather recalling a dictionary definition was considered a **threshold concept**, a core idea that enables the student to change the way they picture the subject and move to a higher level (Meyer and Land 2003). A series of environmental perspectives from different points in history, different stages of development, different ecologies and different commentators were presented so that students could compare these views, construct their own models and adapt the concepts to their own situation, as the standards in a high-income country are less applicable in a poor country suffering from chronic pollution and with few resources to address the problem.

Taking an international perspective

A course for UK students planning to work in the UK would be able to look at UK ecology, UK legislation and technical solutions being used in the UK in depth. A course with a global remit could not hope to cover this level of detail for the home nation of each student, so the underlying principles have to be explained in order that they can be applied in any location. Varieties of aquatic habitats are initially complex, so the concept of habitats was introduced using obvious biomes, such as deserts and rainforests. With this concept in place, specific ecosystems could be discussed in more detail with the students being aware that these were only examples from the many possible situations. Knowledge of terrestrial biomes was not required for the module aims but helped introduce a more complex concept, being supportive content (Butcher et al. 2006).

Another of Butcher et al.'s categories was opportunistic material, where core material offers additional insights. For this course grey literature was used in preference to standard textbooks for several reasons. The culture within WEDC is to address practical issues rather than theoretical ones, so examples were drawn from organizations working directly in the area, such as International Union for Conservation of Nature or World Wild Fund for Nature. The material was selected from different countries and from different stages of the environmental assessment process (e.g. the State of the Environment Report for South Africa, the requirements for scoping Environmental Impact Assessments for wastewater treatment plants in Egypt). These examples were opportunistic in that they were easy to source, but needed to be selected and arranged in a manner that demonstrated the mainstream learning across a range of situations without being obscured by the local context.

Feedback

Students complete a feedback form, including positive and negative comments on content, delivery and assessment but only those relating to course content are shown in box 2.

Box 2: Student feedback 2011 and 2012

What did you like about this module?

- Coming from a chemistry background, I was worried that the material would be too advanced and confusing to understand. However, throughout the module I felt that the work was at an appropriate but challenging level. The lecture format of a handout book with class discussions was one that I wasn't used to but I found it very useful. Because we were coming up with ideas, it didn't feel like work!
- A lot of examples have been considered.
- I found the module very useful and practical which is what it needs to be.
- Gained a good all round knowledge of environmental assessment, found it very interesting.
- Content enjoyable to learn
- I also enjoyed the walk and the practical sessions.
- Also good examples were used.
- The inclusion of practical sessions has enhanced my knowledge.
- I loved the module because it was applicable to my country.

- It was very practical and broadened my knowledge.
- Course notes were thorough and allowed thought in lectures rather than note-taking.
- Really makes me engage your critical thinking and helps you get a wider perspective of things. Loved the integrated approach and interlinkages on the topic of environmental assessment. Perfect discussions in class, wish we could have more! Perfect use of examples to help us group the idea.
- Very practical and relevant module for Water and Environmental Management programme. Well presented to us.
- Organisation of module lectures. It was participatory and very practical learning.
- A good idea to do EA process. The lecturer did perfect.
- Tools, practicality,

How could this module best be improved?

- Field work and group work should be encouraged and discussions using case studies.
- The notes had too many things which weren't relevant to the assessment which made it difficult to revise for it.

Lessons learnt

Within the length constraints of a journal paper, some aspects of the process of developing the content for a specialised, interdisciplinary course have been discussed. The breadth of literature studied and personal experience has shown that a prescriptive approach to curriculum development is neither possible nor desirable, as local factors will be influential.

Future challenges

The final comment in box 2 reinforces one of the challenges faced in assembling the content. A large amount of apparently shallow material can obscure the underlying principles. Precursor material is required to bring everybody up to a common understanding and ensure that threshold concepts are understood, but, from a student perspective, it is all "new knowledge" and therefore part of the course. A similar problem occurs with opportunistic and supportive content, when the students focus on the examples and expect to reproduce detail in assessments when this level of recall is not required. Many of the learning outcomes for specific sessions tended to be at the lower end of cognitive complexity and need to be revised.

Guidance on content

In reviewing the literature for this paper and consulting with specialists in the field, practical advice on selecting content for a new course was conspicuous by its absence. The advice on curriculum design assumes that the aim and content of the course is given and the focus moves onto giving this content a structure, through learning outcomes and onto delivery. Dunn et al. (1985, quoted in Dent and Harden 2009) gave suggestions of how this process of material selection can be facilitated, did not include students, although other authors did mention it (e.g. McEwen 2011). One of Dunn's co-authors picks this up later, noting;

> "Students are important players: It is important not to underestimate students' potential input to the curriculum. They are important stakeholders; they can make important contributions to curriculum planning and they can be drivers for change. Collaborative and peer-to-peer learning and students' input to the generation of learning resources can be important and will become increasingly so. When thinking about student-centred and independent learning, it is important to have as the aim directed self-learning rather than self-directed learning. In [*Dron J. (2007) Control and Constraint in E-Learning: Choosing When to Choose. Hershey: Idea Group Publishing] [the author]* made the important point that one of the main challenges for the teacher is to decide at the different stages in students' development how much control students should be given over their own learning."
>
> (Harden 2011)

There are strengths and limitations of involving students in curriculum development, as they are unable to comment on the areas they are not aware of and may ask for more content on areas that they are aware of but that may not be significant. Formal feedback (as in box 2) or reviewing coursework may indicate areas that need more support, but the interactive, discursive style of teaching mentioned above (McEwen 2011) allows a dialogue to develop with the students, enabling

fine tuning of content, providing more depth or additional examples as necessary. Thus delivery does have an active impact on content and the two aspects of curriculum design are not independent.

The lack of practical advice on selecting content can be liberating as well as limiting. Just as there is no “right” answer, there is also no “wrong” answer, just areas to consider. Noting the history of the WEDC MSc programme, the module on Environmental Assessment has evolved over time. The current content is still not ideal, as there are areas that could still be improved, even after the latest re-write, but recognizing that there is need for reflection and improvement is an important lesson in curriculum development. Returning to the system in figure 1, the feedback loop is not an addition to the process, but a core feature to ensure the course was fit for its purpose and will continue so. The feedback should not only relate to the components of the course, such as delivery methods or individual learning outcomes, but also to the overall aims and purpose, as shown in figure 3, with its definite decision stage. Improving teaching techniques or adjusting assessment methods can fine tune the course but regular, formal reflection by the lecturer on course content is necessary to ensure that the aims and content do not drift over time.

Interdisciplinary or core material?

Allan (2001) identified the problem with interdisciplinary subjects, where experts draw up the rules for separate disciplines but the real world requires people to work across these (artificial) boundaries. Dunn’s suggested looking at existing work practice to develop content, which is difficult in newly emerging, specialist areas. However, the interaction between engineers and environment is no longer a fringe subject, especially within the water sector. The current practice of engineering, incorporating environmental issues, contrasts with the current discipline boundaries. The success in selecting content was to look at relevance to the student and their future work not to the (arbitrary?) boundaries of existing academic disciplines. Taking the topics into the core of the discipline rather than viewing them as “other” gave a rationale to their selection and the rejection of topics that did belong elsewhere. Civil engineers use steel without being metallurgists; they can also interact with the environment as civil engineers without conforming to the disciplinary boundaries set by more specific interests.

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