# Embedding Sustainability across the Built Environment Curriculum and Beyond

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## Abstract

This study will outline progress of an ongoing Teaching and Learning Engineering Innovation project in the Department of Building and Civil Engineering at the Galway-Mayo Institute of Technology, which has employed incremental diffusion approaches to embed sustainability as a core threshold concept across all degree programmes. Phase 1 involved undertaking a curriculum review of all programmes in the Department to identify opportunities to embed sustainability in programme and curriculum design, particularly focusing on constructively aligning learning outcomes, graduate attributes and competences to pedagogy and assessment strategies. This was followed by the design and piloting of a questionnaire survey, which was disseminated to all students within the department to identify pro-environmental attitudes, self-reported behaviours, social and moral norms etc. A reciprocal learning framework encompassing curriculum and pedagogical experimentation, ongoing collaborative industry research on resource efficiency and the circular economy, the 'living lab' campus and other initiatives associated with the Green Campus programme is under development in phase 2. This paper will present findings from a selection of experimental interventions tested in phase 1 with students on the B.Sc. in Construction Management and the B.Sc. in Quantity Surveying and Construction Economics where complexity, 'wickedness', reflexivity, personal and professional identities and possible futures were debated and discussed. This is informing the development of an educational framework to facilitate a transition within the Department to move from learning ABOUT sustainability (accommodative) using narrow 'bolt-on' discipline-specific approaches to learning FOR sustainability (reformative) where the campus operations, curriculum and institute policy begin to be reconceptualised to capacity-building learning AS sustainability (transformative) (Sterling et al., 2013) through experiential learning communities of practice that aim to bring about whole institutional change.

## 1 Introduction

The role of education as a catalyst towards re-imagining and creating conditions for possible sustainable futures has received considerable attention over the past two decades, with the United Nations Educational, Scientific and Cultural Organization (UNESCO) declaring 2005 to 2014 as the International Decade of Education for Sustainable Development (DESD). This initiative defined Education for Sustainable Development (ESD) as 'a vision of education that seeks to balance human and economic well-being with cultural traditions and respect for the Earth's natural resources' using inter- and transdisciplinary lifelong learning approaches. In Ireland, this decade of 'action' largely passed the Higher Education sector by, with the exception of pockets of good work, most notably by Dublin City University[1] (DCU), University College Cork[2] (UCC),

[1] DCU were a project partner on a funded Tempus RUCAS (Re-orientating University Curricula to Address Sustainability) project, which involved 11 universities within the EU and Middle East.

[2] In 2007, UCC students instigated a pilot Green Campus programme, with the help of An Taisce, which would see the university become the first in the world to be awarded a Green Flag from the Foundation for Environmental Education. In 2016, UCC published its Sustainability Strategy, which is student-led, research-informed and practice-focused. In 2018, UCC became the first university in Europe to be awarded a Gold Star from the Association for the Advancement of Sustainability in Higher Education.

Galway-Mayo Institute of Technology (Mayo[3] and Letterfrack campuses) and other Green Campus Programme participants. The national framework for sustainable development in Ireland, *Our Sustainable Future* (DoECLG, 2012) did refer to 'sustainable education', recommending a focus on: environmental issues (climate change, disaster risk reduction, biodiversity, environmental protection, natural resource management, urban decay, water security); socio-economic issues (economic growth, poverty, food prices, child labour, social exclusion, justice, debt-security, human rights, health, gender equity, cultural diversity, production and consumption patterns, corporate responsibility, population growth, migration); and political issues (citizenship; peace; ethics; human rights; democracy and governance).

Following on from this, one notable achievement was the publication of a *National Strategy on Education for Sustainable Development (ESD) 2014-2020* by the Department of Education and Skills in 2014[4]. The objective of this strategy was to '*ensure that education…equips leaners with the relevant knowledge, the key dispositions and skills and the values that will motivate and empower them throughout their lives to become informed citizens who take action for a more sustainable future*.' Higher education was identified as a priority action area where '*disciplinary silos, a lack of specific ESD content and concerns about the preparedness of lecturers to facilitate the type of participatory learning that is required for effective ESD*' were identified when attempting to take a whole institution approach (Department of Education and Skills, 2014). Subsequent international initiatives such as the UNESO (2014) *Roadmap for Implementing the Global Action Programme on ESD* and the *Education for Sustainable Development Goals (SDGs) Strategy* (UNESCO, 2017) have continued to inform holistic and transformational ESD approaches in the higher education sector. Interestingly, the recently published *Higher Education System Performance Framework 2018-2020* (HEA, 2018) and the *Sustainable Development Goals National Implementation Plan 2018-2020* (DCCAE, 2018) specifically refer to ESD under the evolving policy context, future challenges and focus sections. The most recent policy development has been the publication of the *Climate Action Plan* in 2019 (Government of Ireland, 2019), which again has highlighted the role of higher education in the (so-called) 'Just Transition' and in the provision of courses and modules related to agriculture, land use and climate change. Several construction-related actions mainly focusing on reducing energy use, decarbonising the building stock, the greater use of lower-carbon building material alternatives and upskilling industry stakeholders in deep retrofit were also listed in the *Climate Action Plan*, which in turn should inform curriculum development in higher education.

This paper will outline progress to date of an ongoing Teaching and Learning Engineering Innovation project in the Department of Building and Civil Engineering at the Galway-Mayo Institute of Technology, particularly focusing on some example experimental learning interventions employed in two final-year modules on the B.Sc. in Construction Management and the B.Sc. in Quantity Surveying and Construction Economics.

## 2 The Challenges facing the Construction Sector and the Role of Higher Education

The built environment, on a global scale, is on track to double building-related carbon emissions by 2050 (World Green Building Council, 2019), with steel and cement production jointly responsible for approximately 15-20% of global generated emissions (UN Environment, 2019). Global resource use is also predicted to double by 2030 (UN Environment, 2017), which aligns with the population projection of eleven billion plus by the end of the twenty-first century (UN Environment, 2019). Recent estimates (2017) suggest that buildings' construction and operations account for 36% of global final energy

[3] The GMIT Mayo campus was the first Institute of Technology in the world to be awarded the status of Green Campus by The Foundation for Environmental Education (FEE) and An Taisce in 2011 and GMIT Letterfrack was awarded an Green Campus Flag by An Taisce in 2014 and 2019.
[4] The National Strategy is currently under review.

use and 39% of energy-related carbon dioxide ($CO_2$) emissions. In the EU, more than 50% of all extracted materials (approximately three billion tonnes) and 30% of all our water consumption is related to the construction and use of buildings, with over 800 million tonnes of construction and demolition waste (CDW) produced each year (including soil), which represents two tonnes generated for each European citizen. In Ireland, there has been a clear correlation between construction output and CDW production, with estimates of 17.8 million tonnes (Mt) in 2007 (EPA, 2009) dropping to just over 3Mt in 2014 (EPA, 2018), mirroring the dramatic economic growth and subsequent sharp decline over that period. Preliminary data from the EPA in 2016 suggests that CDW production is on the rise again in Ireland as construction output improves. This clearly demonstrates the enormous challenges facing the construction sector in the coming years particularly relating to higher energy costs; climate change mitigation and adaptation; a rapidly growing world population; the depletion of natural resources; the level of toxicity in a building's lifecycle; increasing air and water pollution; growing levels of waste as well as local and global societal issues such as poverty, war, famine etc. (Kibert and Grosskopf, 2008 cited in Hayles and Holdsworth, 2008). Traditionally, the sector has viewed environmental management as an extra cost burden in a highly competitive industry, with supply chain stakeholders reluctant to undertake actions voluntarily for fear of losing competitiveness; this can be especially true amongst SMEs. So, what role can higher education play in rethinking the built environment sector to imagine a future that will move beyond just doing less harm to the environment towards one which has net positive environmental benefits. Societally and within the built environment sector, this will mean a move away from unsustainable drivers such as anthropocentrism, resource extraction, consumerism, human population growth and wealth generation orientated towards short-term profits (Lozano-Garcia et al., 2008) to embracing integrated systems approaches such as the: deconstruction of buildings and the use of reusable components and recycled materials within a circular economy; employment of passive or energy positive design with appropriate renewable technologies and excellent indoor environmental air quality; and natural ecosystem integration including optimised hydrological cycles (Graham, 2000; Kibert and Grosskopf, 2008), to name but a few. This will require a transformative and interdisciplinary integration of knowledge, insights, skills and practices from divergent disciplines to generate the radical or disruptive strategies or technologies that will shift systems of production, provision and consumption and open up new possibilities (Metzger and Zare, 1999). The complexity of these issues require a new form of thinking grounded in environmental literacy described by Orr (1992 cited in Hayles and Holdsworth, 2008) as:

'*…the knowledge necessary to comprehend inter-relatedness; an attitude of care and stewardship; and the practical competence to act on the basis of knowledge and feeling*.'

Orr (1992 cited in Hayles and Holdsworth, 2008)

Barth et al. (2007) and Filho (2009) highlight the potential role that higher education can play in implementing sustainable development by providing a link between knowledge generation and knowledge transfer through societal and industrial outreach and engagement and the education of potential future decision-makers. Interestingly, efforts to embed sustainability into the built environment curriculum seems to have had mixed results. Wang (2009) suggests that it is widely accepted that sustainability should be incorporated into engineering education, but Jung et al. (2019) found that environmental concern and sustainable consumer behaviour scores were significantly less for built environment students in the US who had completed a course in 'Green Building and Sustainable Construction' that those who had not. In contrast, Bielefeld (2011) found that first-year students who completed an environmental engineering module (as opposed to a civil engineering module) had greater knowledge and more positive attitudes towards sustainability. In addition, there was strong evidence that students considered sustainability in subsequent course assignments, even when not specifically asked to do so. Murray and Cotgrave (2007) suggested that sustainability literacy was a future paradigm for construction education and that it was readily achievable within existing courses and modules. To support the embedding of sustainability literacy as a core competency in construction-related courses, Cotgrave and Kokkarinen (2010) developed a framework focusing on

learning outcomes and the holistic integration of project-based approaches across the selected programmes, which when tested (Cotgrave and Kokkarinen, 2011) found that participating students believed it was important to inform clients of the environmental impact of proposed works and to build in an environmentally-friendly way. This was further supported by students' reflective feedback on their experience and understanding, which highlighted a perceived improvement in attitudes towards sustainability (Kokkarinen and Cotgrave, 2013).

## 3 Project Overview and Methodology

In 2018, the School of Engineering in GMIT invited academic staff to submit proposals under a Teaching and Learning Innovation initiative open call focusing on any aspect of academic practice. The author successful applied for funding for a three-year project entitled 'Embedding Sustainability across the Built Environment Curriculum and Beyond'. The main aim of the project is to: develop an educational framework to facilitate a transition from learning ABOUT sustainability (accommodative) using narrow 'bolt-on' discipline-specific approaches to learning FOR sustainability (reformative) where the campus operations, curriculum and institute policy begin to be reconceptualised to capacity-building learning AS sustainability (transformative) (Sterling, 2013) through experiential learning communities of practice to bring about whole institutional change. This proposal is employing an incremental diffusion approach with Phase 1 initially focusing on the two undergraduate programmes in the Department of Building and Civil Engineering. Phase 2 will seek to engage more broadly with the suite of programmes in the Department of Building and Civil Engineering by working with staff who have already expressed an interest in piloting the interventions on different modules in Years 1 to 4. It is envisaged that other snapshot pilots will also be carried out in other disciplines facilitated through the Education for Sustainability[5] elective module on the M.A. in Teaching and Learning Programme and the Green Campus initiative[6]. Phase 3 intends to share the lessons learned, evidence-based practice and reusable learning resources across all disciplines using organisational learning and educational open-source principles to demonstrate how to move from just from learning about sustainability to actively engaging in sustainable education itself. The project is utilising Rusinko's (2010) generic matrix for the integration of sustainability into higher education (Figure 3.1) The four quadrants provide different options for integration into existing or new curricula i.e. using either existing courses and structures (quadrants I and III) or developing new courses and structures (quadrants II and IV). Previous work has demonstrated multiple examples of using each of the four approaches i.e. Rameriz (2006), Svanstrom et al., (2012), Stubbs and Cocklin (2008), Blizzard et al. (2011) in Quadrant I; Buchan et al. (2007), Stubbs and Schapper (2011), Down (2006), Barth and Rieckmann (2012) in Quadrant II; Hayles and Holdsworth (2008). Hopkinson and James (2010), Wilmot (2009) in Quadrant III; and Rusinko (2010), Ferrer-Balas et al. (2008), Savelyeva and McKenna (2011), Dobson and Tomkinson (2012), Barth et al. (2007) Menoni (2006), Mieg (2006), Muhar et al. (2006), Stauffacher et al. (2006) in Quadrant IV.

The integration of sustainability can be situated in one quadrant or in multiple quadrants simultaneously. Lozano et al. (2006) does recommend an incremental approach where the initiative can be trialled and tested and if 'successful' can expand throughout the department or school. An example of this would be when working within quadrant I, which would cause the least disturbance to the existing structure as it would involve the integration of sustainability themes or case studies into existing modules while remaining consistent with module descriptors, content and learning outcomes. The move to quadrant II to develop a dedicated stand-alone module within an existing course has been met with some criticism. Sterling (2004) calls this process 'bolting-on' while Rusinko (2010) points out that this approach may isolate sustainability if it is not incorporated into the core curricula (Shriberg, 2002, Stubbs and Schapper, 2011). This would fit in with the existing

[5] The 'Education for Sustainability' elective module was developed by the author to offer a structured CPD option to staff in GMIT as part of a suite of module on the M.A. in Teaching and Learning.
[6] The author is also the GMIT Dublin Road Green Campus Chairperson.

mechanistic model of higher education that divides understanding into separate boxes (Segalas et al., 2012). Quadrants III and IV have a cross-disciplinary focus with quadrant III focusing on common core modules across disciplines. Quadrant IV is the most challenging with its cross-disciplinary (two or more disciplines) or transdisciplinary approach (including industry stakeholders and citizens). It is clear that a new pedagogical approach is required to encourage 'deep learning' (Warburton, 2003) and 'transformative change' (Sipos et al., 2008) to address the complexity that is inherent in sustainability.

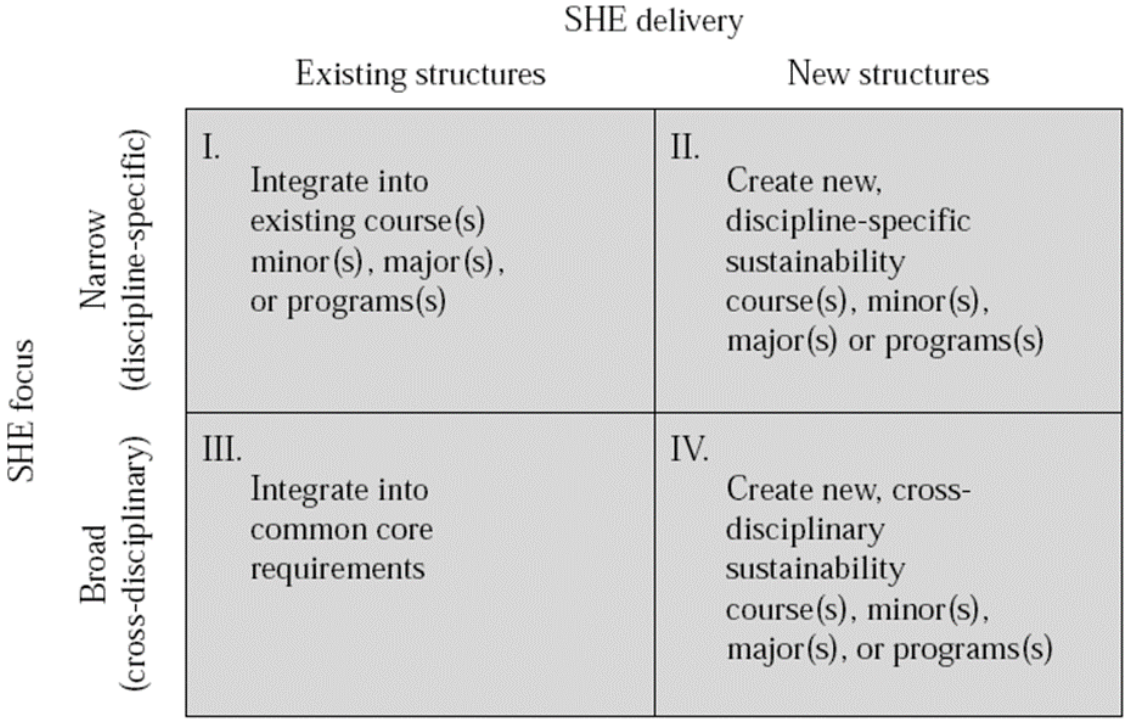


**Figure 3.1 Rusinko's (2010) generic matrix for the integration of sustainability into higher education**

## 4 Embedding Sustainability into the Built Environment Curriculum

The Department of Building and Civil Engineering has four Level 8 undergraduate programmes in Architectural Technology, Civil Engineering, Construction Management and Quantity Surveying and Construction Economics and an industry focused two-year part-time Level 8 Higher Diploma in Engineering in Building Information Modelling (BIM). An initial review of the programmes[7] found that different iterations of 'sustainability' (energy, waste, water, carbon etc.), are already embedded into some existing modules, particularly those related to construction technology, building design and performance. A stand-alone 10-credit elective module, 'Environmental Management in Construction' is also available to all students in Year 2. In Year 4 of the Construction Management programme, there is a dedicated 10-credit module on 'Resource Efficiency Strategies for the Construction Sector' and sustainability is a core theme in the final-year module, 'Integrated Project' on the B.Sc. in Quantity Surveying and Construction Economics. It is these two final-year modules that are currently forming the testbed for a range of learning interventions. This paper will focus on the use of STEEP analysis, journal clubs and back-casting as experimental learning interventions within a Quadrant I framework.

[7] A detailed curriculum and pedagogical review is currently ongoing as part of a programme review process in the Institute during the 2020 academic year.

### *4.1 Overview of STEEP analysis, journal clubs and back-casting*

Social, Technological, Environmental, Economic and Political (STEEP) analysis[8] has been used widely in several construction and sustainability-related foresight studies as it provides a methodology to examine drivers and trends that may influence or impact the unit or theme under investigation. For example, the UK Department of Business, Innovation and Skills (2008) used STEEP to frame how the UK built environment could evolve towards a more secure, sustainable low carbon sector that still meets individual and societal needs and economic requirements by 2050. The STEEP approach was also used in a New Zealand study by BRANZ entitled *Building the Future–Four Visions of the New Zealand Built Environment in 2025* (Bates and Kane, 2009), which highlighted the key forces in both the local environment and macro environment.

Linzer (1987) and Thompson (2006) provide a detailed historical overview on the background of journal clubs from its initial conception by Sir William Osler as a way of distributing unaffordable periodicals (Rich, 2006) to its extensive use as an educational tool in the fields of medicine, surgery (Horneff et al., 2010), psychiatry (Swift, 2004), nursing (St. Pierre, 2005; Rich, 2006), pharmacy (Clements and Trompeter, 2011), obstetrics and gynaecology, paediatrics and geriatric social service (Linzer, 1987). Although journal clubs have been predominantly used in medical and healthcare education, there is huge potential in their application as a pedagogical tool across all disciplines. Newswander and Borrego (2009) detail their use in the engineering field as a key ingredient in the cultivation of a community of practice at graduate level. A review of previous research (Hammick, 1995; Burnstein et al., 1996; Klapper, 2001; Dirschi et al., 2003; Hall, 2006; Golde, 2007; Walker et al., 2008) identified the following benefits: encourages criticism and creativity; facilitates familiarity with current literature; builds confidence in presentation skills; practical discussion of publication standards; learning from 'experts'; and peer mentoring and teaching.

A popular scenario methodology employed by the Dublin Institute of Technology (DIT) Futures Academy (Ratcliffe, 2000; Ratcliffe and Sirr, 2003; Ratcliffe and Krawczyk (2004, 2011) and others (Lovin, 1976 and 1977; Robinson, 1982 and 2003; Carlsson-Kanyama et al., 2003; Quist, 2007; Phdungsilp, 2011) has been the back-casting approach. Back-casting has emerged from normative forecasting (Jantsch, 1967) and *La Prospective* (Godet, 2000) methodologies. The aim is to provide a counterpoint to forecasting approaches that are projective in nature using trend extrapolation and historical data. Instead, back-casting starts with an image of the future and then traces its origins and development path back to the present. The future desirable or undesirable image(s) is particularly useful when applied to complex problems where dominant trends exist requiring a major change (Dreborg, 1996). The time horizon and scope of the back-casting approach should allow for the development of radical alternative options (Quist, 2007).

### *4.2 Use within the curriculum*

Traditionally, when covering definitions of sustainability in the modules listed, the following Brundtland statement was put forward as the most widely accepted definition of sustainability.

'*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*.'

Brundtland (1987)

The author realised that a more in-depth analysis was required into the sustainable development concept so that students may begin to understand the complexity involved and to address the competencies required (anticipatory/foresighted

[8] Is often also referred to as PEST (Politics, Environment, Social and Technology) or PESTLE (Politics, Economics, Social, Technology, Legal and Environmental).

thinking, systematic/critical thinking) to address the interdependency of sustainability issues. It was decided to use the STEEP analysis approach as it is consistently used in foresight and scenario planning work in combination with a Journal Club, where relevant journal papers were reviewed each week. This new learning intervention consisted of the following steps:

Week 1 – Prior to the start of class, each student was asked to complete the Green Campus survey, which explores pro-environmental attitudes, knowledge, self-reported behaviours, social and moral norms, perceived behavioural control and behavioural intentions[9]. At the start of class, each student was asked to write down on a post-it, a set of five keywords related to their understanding of sustainability. The post-it's were collected and displayed on the whiteboard for later discussion. Students were then asked to purchase (in groups of 2) a newspaper each (Irish Times, The Irish Independent or The Guardian) and bring it back to class. Each group was directed to select articles that they thought could be categorised as covering general social, technological, environment, economical and political issues of the day. These articles were cut out and posted to the walls under the five headings. Each group was asked to explain their selection and why they placed their articles in the different categories. A discussion was facilitated to highlight the interrelationships between the five themes and their relationship to sustainability as they understand it i.e. as outlined in the keywords on the post-its. At the end of class, each student was asked to select two articles from any newspaper during the subsequent week that addressed a sustainability and a construction sector issue.

Week 2 – Each student posted their selected articles on the walls under the STEEP headings, 'defending' their selection. The facilitated discussion again focused on the interrelationships between the themes but focused more specifically on the role of the construction sector in relation to sustainability. In addition, the concept of the Journal Club was introduced to the students, by disseminating a peer-reviewed journal paper that reviewed definitions of sustainability[10] with instructions on how to 'deconstruct' the paper into manageable sections i.e. abstract, conclusions, methodology, references etc. At the end of class, each student received the STEEP assignment brief[11], which required the selection of five peer-reviewed journal papers related to the five individual STEEP headings and the construction sector i.e. 'corporate social responsibility within the construction sector' would align with the Social heading, 'waste prevention on site' would align with the Environmental heading etc. Each student had to produce a short literature review summarising these papers and exploring the interrelationships between them. For week 3, each student had to select one peer-reviewed journal paper on any one of the five STEEP headings, summarise it and submit it to Moodle for feedback in class.

Week 3 – a random sample of students were asked to identify what journal paper they selected and why, which facilitated a discussion on the literature review process i.e. use of library databases versus other sources i.e. Google, Google Scholar, Research-Gate, Academic.edu etc. General feedback was provided on all submissions focusing on paper selection, structure and layout of the report, referencing, academic writing and plagiarism. For week 4, each student had to select two more journal papers and submit a summary within the report structure before next week's class.

Week 4 – general feedback was provided on all submissions with a specific focus on plagiarism[12], referencing and academic writing. In-class activities focusing on these aspects were also carried out to highlight their importance including a self

[9] Elements of this survey will be completed by the students at the end of the year to determine any change in their attitudes and self-reported behaviours.
[10] Glavic and Lukman (2007) Review of sustainability terms and their definitions, *Journal of Cleaner Production*, V15, 1875-1885.
[11] The assignment is usually worth 10%. The assignment involved producing a 1500 (min.) to 2000 (max.) word paper considering the STEEP implications on sustainability in the construction sector.
[12] All submissions are scanned using a plagiarism software embedded into Moodle.

review exercise where student 'marked' through own work using the assessment rubric[13]. For week 5, each student had to submit a full draft of the report covering five selected journal papers before next week's class.

Week 5 – a peer review exercise was carried out where students 'marked' each other's final draft using the assessment rubric. General feedback was also provided by the lecturer to all students. The final assignment was submitted in week 6.

Week 6 – submission of final assignment to Moodle.

Week 8 – as part of the feedback process, each student was asked to self-review their final assignment in-class using the assessment rubric. If the student's mark came within 1% of the lecturer's mark, the submission would receive the higher mark. After each student marked their own assignment, the lecturer's individual feedback forms were disseminated so that they could compare both marks and feedback.

Week 9 – students were asked to provide some reflective comments anonymously on the STEEP assignment and use of the Journal Club.

Some example qualitative responses in relation to the STEEP assignment included:

'*I found the assignment difficult to comprehend at first as I have never heard of a STEEP analysis and found it hard to relate the analysis to the construction industry. When I was researching papers on STEEP, I found it hard to find any examples of where it was used in construction so I decided to break the search down into the different sections. In the end I learned how STEEP analysis can be used when determining if a project is viable*.'

'*I thought it was very helpful for preparing for my dissertation because I had never done research with journal papers before*.'

'*Good, challenging, educational, great use of research*.'

'*I found the STEEP approach assignment good as we got used to using the library search engine, we also learned to use the Harvard referencing system, and also it prepared us for our literature review for our dissertation*.'

'*Found it a more suitable way for learning about sustainability in the construction sector rather than looking at a PowerPoint presentation or lecture notes. Found the STEEP analysis a good model for researching the topic*.'

The feedback seems to indicate a positive response to the exercises in that it challenged the student, who in turn had to engage in research-orientated activities i.e. use of appropriate search engines, referencing, literature review etc. It is noted however that the responses are more focused on research competences and skills than exploring sustainability-related insights, which highlights a limitation in reflection and feedback tool in that it is too general and would benefit from a more structured approach. This trend is continued in qualitative comments made in relation to the Journal Club:

'*The journal club paper module I found the most useful as it introduced us to the papers and online resources that are available. We also learned how to read the papers and analyse them*.'

'*Most of the papers were long and difficult to read*.'

'*Again a good way for practicing for dissertation work. I found some of the papers a bit hard to read*.'

[13] The rubric consisted of the following headings: cover and contents page; appropriate sections; clear and correct referencing; correct font and spacing; merging of referenced material throughout the text; correct spelling, use of paragraphs and grammar; appropriate summary pulling together all the elements of a STEEP analysis; references page with correct referencing.

'*The journal club papers provided us with good techniques for reading a paper for our dissertation*.'

'*Good, as it was an introduction into reading journals and understanding the structure, which I found brilliant when it came to preparing to write the dissertation*.'

'*Good idea to become familiarised with the layout of a journal as it will help in future research for projects, and also the construction of reports. However, I found that printing out and reading a new journal every week was both time and money consuming as we were also trying to find and read journals to help us with getting started on our dissertations*.'

Again, these activities proved challenging but provided a cross-module benefit as the work carried out did directly link to the activities they were engaged in the preparation of their dissertation as it encouraged students to engage in critical analysis to assess the validity, usefulness and applicability of previous research (Honey and Baker, 2011).

Towards the end of the module (in week 25), an in-class assignment using the STEEP methodology was applied to four scenarios (Resourceful Regions, Sunshine State, Carbon Creativity and Green Growth) taken from the *UK Powering Our Lives* project. By providing a future vision to the students, it introduced the concept of back-casting[14]. The exercise composed of three parts:

- The class was divided into four groups, who had to work back from the allocated future vision to carry out a STEEP analysis of the perceived influential factors. Each group had to mind-map the drivers highlighting any interrelationships while also identifying areas for further investigation. Each group posted their mind-map and future vision on the wall for comment by the other groups.
- All the comments and ideas proposed were used in the preparation of each group presentation, which detailed what was required to transition towards their allocated future vision using the STEEP framework as a guide. Each group critically evaluated each other's proposals to stimulate dialogue and debate.
- Each student had to prepare a short reflective essay (1500-2000 words) outlining the role of the construction sector in the transition towards any one of the future visions.

Some qualitative feedback on the use of back-casting included:

'*This assignment I found useful as it put all the different areas we learned into a practical scenario from which we had to identify the contributing factor to the scenario*.'

'*The theoretical situation appeared very farfetched, but it did put some elements of the STEEP into practice*.'

'*Good exercise for working in teams. I found that last bit of the exercise difficult because we were finishing off our presentation so didn't get to listen to everyone else's and wasn't able to comment on what they had spoken about. I thought it was a good format as you knew exactly what you were supposed to be doing and how long you had*.'

'*Very challenging*.'

'*I found the STEEP back-casting exercise good as it was a practical exercise and one that we could be faced with in the workplace in years to come*.'

[14] It is recognised that a 'true' back-casting exercise would engage the students in the development of a future vision(s) but it was felt that by allocating an existing future vision developed by an extensive foresight study, it would provide a useful introduction to back-casting and enable the students to apply the STEEP methodology in a different context.

## 5. Discussion and Reflection on STEEP, Back-casting and Journal Club Exercises

The feedback comments reflect an overall positive attitude towards the use of STEEP, back-casting and Journal Clubs as part of the teaching and learning strategy. The exercises did provide space for more dynamic class interaction, where the lecturer acted primarily as a facilitator responding to queries as they arose. The students were proactive in attempting the exercises and assignments utilising the group environment but also leaving room for individual development. There was a limitation in the design of the student critical reflection element due to its unstructured and open format as students tended to focus on their research skills development rather than any related sustainability attitudes, behaviours, skills or competences. This, however, may be a finding in of itself as it did not 'direct' the responses in any way. Lambrechts and Van Petegem (2015) did find that research skills are often mentioned to contribute to the acquisition of competences for sustainable development, albeit usually from a more general perspective. These piloted learning interventions were situated within a more reformative approach i.e. learning FOR sustainability, as they employed a participatory methodology to encourage the active role of the learner in exploring different ways of knowing (Sterling, 2004). Extensive further work is needed to provide a more holistic approach to embedding sustainability across the built environment curriculum. From the initial findings, it is clear that the use of these activities can play a key role in engaging students and support the transition towards a more transformative (learning AS sustainability) learning experience.

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