Seeing Beyond Silos: Transdisciplinary Approaches to Education as a Means of Addressing Sustainability Issues

Edmond P. Byrne and Gerard Mullally

Abstract

Sustainability is a normative topic framed by disciplinary perspectives. This can be problematic as the tools that are used and applied to meta-problems and 'grand challenges' associated with societal (un)sustainability, and which may result in proposed 'sustainable solutions', are framed through the lens of the 'object world' disciplinarian. Traditional engineering education and practice has tended to frame problems in narrow techno-economic terms, often neglecting broader social, environmental, ethical and political issues; or what might be termed the social complexities of problems (Bucciarelli 2008; Mulder et al. 2012). This reductionist approach has sought to close down risk and uncertainty through deterministic modelling and design, resulting in frameworks/models which provide an air of misplaced confidence but which are incapable of accounting for (or recognising) unknowability, and can thus lead to behaviour which ironically, results in increased fragility, rather than promoting increased robustness or resilience. Researchers in the social sciences and humanities are inherently more comfortable and adept with dealing with complexity, uncertainty and unknowability. This paper is posited in this context, whereby chemical engineering and sociology students taking respective disciplinary sustainability/environmental modules were brought together to work on a common assignment dealing with some aspect of sustainability. This paper reflects on this collaborative exercise, including the experiences of the students themselves, alongside some challenges and successes. It concludes that

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W. Leal Filho and S. Nesbit (eds.), *New Developments in Engineering Education for Sustainable Development*, World Sustainability Series,
DOI 10.1007/978-3-319-32933-8_3

transdisciplinary approaches to learning are not just desirable in addressing wicked and meta-problems when addressing challenges of (un)sustainability, but represent a *sine qua non* for building the social capacity in confronting these issues.

Keywords
Education · Transdisciplinarity · Complexity · Sociology · Engineering

1 Introduction

> Literary intellectuals at one pole—at the other scientists, between the two a gulf of mutual incomprehension—sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding. They have a curious distorted image of each other. Their attitudes are so different that, even on the level of emotion, they can't find much common ground. It is all destructive. Much of it rests on misinterpretations which are dangerous.
> (Snow 1965)

It has been widely contended that any successful address of the 'grand challenges' that are posed by contemporary and modern society associated with its unsustainability, not only needs a global perspective, but a holistic non-reductive type of knowledge that can only emerge through a transdisciplinary approach (Max-Neef 2005; Hirsch et al. 2006; Nicolescu 2012; Lang et al. 2012). The 'object world' view of the disciplinarian expert (Bucciarelli 2008), built upon the dominant Cartesian paradigm of modernity not only represents the root causes of an unsustainable societal construct, but is also, by implication, wholly inadequate in addressing either the symptoms (e.g. climate change, and crises around energy, food, water, economic inequality and financial) or the root causes of these problems.

Moreover, the siloisation of the academy—whereby universities, as drivers of knowledge and understanding, merely seek to learn 'more and more about less and less' amid increasingly specialized and ghettoised silos of knowledge, only serves to further embed such a paradigm of reduction and separation (Morin 2008), resulting in an educated global population (and elite) who are neither able to either fully comprehend nor adequately deal with emerging crises. The result is engineers who are incapable of seeing the broader ethical context of their work (nor of seeing the rationale for developing such an awareness), including the absence of envisioning a normative or political dimension to their work. To the engineer who holds this limited self-perception, acting as a technological 'gun for hire' therefore, every object is a potential nail to this hammer, and every problem can thus potentially be reduced to a closed problem with a technological 'solution'.

Meanwhile as engineers get on with the business of (literally) constructing society, as ordained by their business or political masters, social scientists broadly content themselves with exploring the nature of reality, as (co-)constructed and mediated by humans, the interactions between human agents themselves, and at

times between humans and the rest of their environment. The tools of their trade enable them to theorize, critique, deconstruct and reconstruct at will. But while they understand the recursive nature of iterative complex systems, these tools are not typically applied to the real techno-economic society that engineers and scientists help co-construct, and which is overseen by economists, policy makers and politicians. Indeed the dominant societal paradigm of reduction and separation is largely ambivalent, if not antagonistic to either the ideas or implications of a paradigm of emergent complexity. Meanwhile disciplinary silos remain firmly in situ while all only see value from within their own disciplinary silos. The upshot is that the potential for meaningful progress in the wake of emerging crises through transdisciplinary integration and insight is lost among practitioners who not only cannot speak the same language, but who in many cases are incapable of even recognising the existence of any other. This of course represents a very broad brush characterisation and simplification of the nature of the problem, but we would argue that it represents a useful and necessary caricature to help highlight the problem and ultimately provoke change. 'We need a kind of thinking that relinks that which is disjointed and compartmentalized, that respects diversity as it recognises unity, and that tries to discern interdependencies' (Morin 1999; cited in Hofkirchner 2009, p. 7).

2 Background and Rationale

Given the above assessment, and the common recognition that the only rational and intellectually honest way to address emerging societal crises associated with unsustainability was through transdisciplinary approaches, the authors concluded that this could largely only be meaningfully progressed through practical intervention. A key intervention point presents at the stage of professional and formative education. If C.P. Snow's chasm between the humanities and the sciences can ever hope to be breached, then contact at the critical stage of educational formation may be necessary whereby disciplinarians can at close quarters both see and appreciate the 'object world' views of the other and hence hopefully, find the space and opportunities to develop useful emergent 'complex thought' (Morin 2008) around issues of sustainability. One cannot reasonably hope to expect disciplinary practitioners, educated exclusively in hermitically sealed silos within a 'multiversity' setting, to spontaneously develop the required understandings, skills and competences to work productively together in tackling larger wicked problems at some unspecified later stage of their respective careers or lives if they are not exposed to each other during the formative years of disciplinary education. There is also a very powerful subliminal message being spun when the two groups come together; the conferred legitimacy that two academics, working together in trust, can confer on transdisciplinary work, undertaken within an ethos of openness, vulnerability and absolute good faith, sends a very strong message of affirmation to students and

future graduates. Not only is working with sociology/humanities or engineering/science graduates a useful and interesting means to addressing complex and difficult issues, it is, the implicit message tells them, an absolute requirement. The other must not only be accepted, but necessarily embraced.

Of course, in order to get to this point in the first place, the two academics needed to build up trust in each other in addition to having shared understanding. While both had worked across the 'divide' with others in the past, the development of such trust, to enable a successful collaboration of this nature, could only emerge through a number of earlier interactions. For example, the authors worked closely together in organising a 'Sustainability and Modern Society Seminar Series' at their local university (UCC 2012), and together with another colleague, geographer Colin Sage, developed a transdisciplinary research initiative entitled 'Sustainability in Society', from 2011 (UCC 2011). The latter resulted in a transdisciplinary conference ('Trans-disciplinary conversations on transitions to sustainability') in 2013 (UCC 2013), and emerging from that, a subsequent book (Byrne et al. 2016). The authors have also collaborated in transdisciplinary related research leading to a number of publications (e.g. Byrne et al. 2013; Mullally and Byrne 2014; Byrne and Mullally 2014).

This provided both a context and platform from which to develop a joint collaborative exercise between students of a chemical engineering module (PE3011 Sustainability in Process Engineering) and a sociology module (SC3029 Sociology of the Environment) initially on a pilot basis, from academic year 2013-2014. The rest of this paper will provide details as well as reflections on this exercise.

3 Assignment Description

Students from two modules which ran concurrently were brought together for a joint assignment during 2014 by the authors of this paper. The modules involved were PE3011 Sustainability in Process Engineering (taken by students in the third year of their four year Bachelor of Engineering degree, as well as a number of visiting students, mainly from Germany and Brazil) and a sociology module SC3029 Sociology of the Environment (taken by third year students of the Bachelor of Arts degree, majoring in Sociology and other humanities subjects, including a number of visiting students, mainly from USA). While the devised assignment was compulsory for the engineering students and comprised 15 % of the assessment grade for the assignment, it represented a voluntary component of the module for the sociology students. Thus there was a smaller take-up among the SC3029 students, who were in a minority.

Given the potential for wide divergence and framings among the respective cohorts, it was decided that the assignment would be as general as possible. The initial and primary aim of the project was to get the engineering students and the sociology students to come together and to engage around a common theme of sustainability. It was thus decided to divide the joint class into groups, each

comprising of three or four students, mixed between engineering and sociology students and also between local and international students. The class as a whole included 27 from PE3011 and 7 from SC3029 from which nine groups were formed.

3.1 Assignment Content

Given the diverse nature of the students involved and the aims of the assignment, the specification was purposefully left quite open ended. Essentially groups were asked to pick any aspect in relation to 'sustainability' and then to research, reflect upon and engage with it, both collectively and individually. The ultimate hope was that through a creative fusion of disciplinary 'object world' views, approached in an open spirit of enquiry, that both a broader context for some chosen aspect(s) of sustainability might emerge (driven by the sociologists perhaps?), alongside also some pragmatic pointers for intervention (driven by the engineers?). The potential also existed for a 'car crash' situation where conflicting frames and 'object worlds' would lead only to confusion and antagonism. However, we were willing to accept this as an outcome of this piece of 'low stakes' experimental classroom research. Nothing ventured, nothing gained! The following therefore represents part of the assignment specification given to students:

> Any aspect may be chosen by the group that relates to 'sustainability' to research and then reflect upon. The group reflection is open ended and can be directed as you best see fit. For example you might like to consider what this aspect or topic means (to yourselves or to society), how it has the potential to change the way we/you do things, consider how it can or might be achieved, what are its potential consequences, difficulties or problematic issues, why or how it is so powerful a concept, and so on.

Output comprised two parts. The first part (attracting two thirds of the available marks) involved a short group presentation to peers and lecturers on the module on the chosen sustainability related topic/aspect, followed by a group discussion plus questions and answers. The second part (attracting the remaining one third) involved a 400–600 word personal reflection on the exercise, including how the student felt the trans-disciplinary nature of the assignment worked out (or didn't) in terms of for example, the learning opportunities and challenges it presented.

The groups met formally once a week for five consecutive weeks ahead of the presentations, with the lecturers present for feedback on their work. To get some ideas flowing and to incorporate a degree of commonality (as each of the groups were concurrently taking their perspective modules separately), a video was shown over the first two weeks. The video focussed on conceptions of progress, whereby it reflected on (un)sustainability in our contemporary world, in each of economic, social and ecological domains.

4 Student Output

The mixed groups worked very well together, with no apparent 'car crash' situations emerging. A wide range of topics were chosen to analyse, though three groups chose to look at issues around consumption. Meanwhile, just one group chose a topic which could clearly be related to technology, perhaps reflecting the nature of the groups, though of course all could have both technological and engineering implications. Table 1 displays the topics chosen by the respective groups.

4.1 Group Presentations

The group presentations were the first time that the lecturers saw how or to what extent the project succeeded in terms of the students from disparate backgrounds working together to produce authentic, emergent and novel ideas and proposals. By and large, it was a great success: each of the groups provided well researched, thoughtful and thought provoking presentations which displayed a strong level of engagement. Lively discussion followed the presentations among the presenters and the lecturers and their peers. While there wasn't always a coherent narrative, or in a few cases an altogether consistent one, it was clear that the students engaged very well and in good faith, particularly given their different backgrounds. This was reflected in some of the lecturers' comments on the grading sheets which included ones such as '*Interesting presentation—some good points though not always perhaps consistent'* to *'Interesting take on food though apparently opposing views. Lacked any overview framework to map out perspectives*.' Other presentations did display more coherence however, and attracted comments such as '*A nice angle on Fairtrade chocolate. Nice analysis/critique. Coherent and well presented.*' All seemed to enjoy the experience, though the sociologists generally appeared less confident at the thought of presentation by Powerpoint (the ubiquitous mode

Table 1 Groups and topics chosen

Group	Chosen 'sustainability' related topic
A	Globalisation versus localisation
B	Consumerism—products, resources, environmental and social
C	Chocolate bars and sustainable consumption
D	Habits and their meaning for sustainable development
E	Consumerism
F	Biomimicry
G	Unforeseen and unintended consequences of sustainable development
H	Sustainability in food consumption
I	Sustainability and Ethics

chosen) than the engineers, they being more comfortable with text and verbal expression than the more visual (graphic and diagram) oriented engineers.

4.2 Individual Reflective Reports

The individual reflective reports provided students with an opportunity to reflect on the assignment. It thus provided some excellent insights on how the students engaged with the topic and each other. It also offered students the opportunity to elucidate on personal perspectives to a greater extent than was possible or evident in the group presentation. The result of this was twofold: (1) It provided evidence of some strong student engagement and learning during the assignment, producing some valuable insights and enhanced self-awareness, and (2) it showed that the students found the opportunity to engage with students of other disciplines to be an overwhelmingly positive and intellectually stimulating and rewarding experience. This was reiterated by the lack of any negative comments. A selection of relevant comments from the reflective reports demonstrates this (Table 2).

5 Student Feedback

Formal anonymous student feedback was also elicited on the assignment itself. Students were invited to respond to five questions (outlined below) which related to the learning outcomes of the PE3011 module as a whole and were asked to tick a respective box (Fig. 1). They were also asked some follow on questions (Table 3). 29 responses were received (including 24 PE3011 students) representing an 83 % response rate.

The five questions asked (labelled 1–5 respectively in Fig. 1) were as follows: To what extent did this assignment help you:

1. develop new and deeper understandings you'd previously overlooked or help broaden your perspectives?
2. think more critically?
3. enhance your level of understanding around sustainability/sustainable development?
4. better prepare you for the nature of your future career?
5. Overall, how do you think the exercise worked?

Figure 1 displays the collated responses to these questions. Given the small numbers involved and the lack of significant differences between (PE3011 and SC3029) responses, no differentiation is made between disciplinary groups. It is clear that there is strong agreement with all of the questions posed, with over three quarters indicating an 'above average' or 'excellent' response, with the sole exception that a smaller majority of students were less likely to believe the exercise would help them to significantly better prepare for their future careers.

Table 2 Some student reflective report comments

Comment	Context
"*I think that the disciplines of sociology and engineering work very well together and found the whole experience very educational. It helped to broaden my own ideas on sustainability and helped me look at the issue from angles that I would not have necessarily considered before*."	Irish female sociology student (Group H)
"*I thoroughly enjoyed the interaction and working process of the assignment with a completely different discipline to that of chemical engineering. While different viewpoints were certainly brought up, I found that both disciplines complimented one another nicely. I found this assignment a valuable experience to my future work career not only from a sustainability perspective, but also the perspective gained from working with sociologists, i.e. a different discipline*."	Irish male engineering student (Group F)
"*In my opinion there are two interesting issues about the concept of sustainable consumption that became apparent during the presentations. Firstly, many of the other groups who challenged the issue of (un-)sustainable consumption put a strong emphasis on its environmentally destructive implications. This critique of present-day consumption is very appropriate but it is somehow one-sided as it does not challenge the dilemma that rising levels of consumption fail to deliver an improved level of human well-being in western societies. I think that focusing on the environmental impacts and finding solutions to mitigate them, reflects to some extent the engineer's approach, whereas challenging the underlying concept as such, without the necessity to find an alternative, the sociologists approach*."	German male sociology student (Group I)
The concept of social and collective consciousness, suggested by the sociology student in our group was a very insightful and original slant on our whole presentation. Coming from an engineering and technical background, I felt as though this was a completely innovative and fresh approach to addressing the problem of unsustainability. By creating a consciousness or awareness which is held by all of society we can really begin to recognise problems and in our case recognise the habits that are keeping us from developing a sustainable future.	Irish female engineering student (Group D)
"*I want to leave college with a well-rounded education in my discipline of "Environmental Studies". That's why I was so excited to be a part of this assignment that blended the social and technical disciplinarians. It took two completely different brain types and perspectives and proved how valuable both were in tackling the world problems that we currently face. After our group had decided on the topic, the engineers returned with a detailed outline of the inner workings of the living machine and the economical advantages. I, on the other hand, had not even thought of looking into the details of the design but remained excited about the bigger theme of modeling technology after nature. It was automatically clear that we were coming at the assignment from completely different angles*."	US female sociology (environmental studies major) student (Group F)
"*When it came to writing this personal reflection based on the group project undertaken by PE3011 and SC3029 students, it struck me how much I had learned about the topic we had chosen and, more importantly, a different way of thinking. As engineers, we sometimes suffer from narrow mindedness; things are black or white, right or wrong. Working with the sociologists opened my eyes to the fact that this seemingly logical way of thinking is not always the best*."	Irish male engineering student (Group A)

(continued)

Table 2 (continued)

Comment	Context
"*The work that the three Engineering students produced gelled really well with the Sociology that I brought to the group. Initially I had not expected everyone in all the groups to get along very well, but both the Engineering and the Sociology students were all very welcoming to each other. Individually the two subjects are two quite different disciplines that I had originally thought would hold no value for one another, but I was quite surprised and happy also, to see that a lot of insight can be gained from blending the two subjects into one. In my own opinion, bringing an Engineering perspective to the Sociology of the Environment module, sheds a new and interesting light on the problems that society is confronted with, and offers a different catalogue of conceivable solutions to these problems*."	Irish female sociology student (Group D)
"*Although areas of conflict may be an issue in trans-disciplinary subjects, this was not the case in our group. We worked as a group and agreed on what problems arose in the consumption and possible solutions that could be implemented in the future*."	Irish male eng. student (Group H)
"*Overall I really enjoyed this assignment as it was different to others encountered throughout the year. I also enjoyed working with students from another discipline; I felt that it challenged me as well as encouraging me to take on a different perspective*."	Irish female eng. student (Group C)
"*I thoroughly enjoyed this assignment. It was a great way to hear perspectives from an engineering point of view and to brainstorm what we can do together to make the world a more sustainable place. I was in awe at how much I learned from the engineers about ways they could contribute to sustainability. As a social work major and an activist, my favorite part of this assignment was coming up with ideas as to how we can alter our society to combat these environmental and social injustices. I have realized that we need engineers on our side. Activists can educate people extensively; but if the products are not made well, then the process is futile. We need engineers to create products that last. How can we slow down consumerism if there is planned obsolescence? When products are designed to fail, we waste more materials and natural resources*."	US female sociology (social work major) student (Group E)
"*As a group we had slightly different views regarding the topic. The sociology student had done a lot of work in the field of globalisation and felt that future technologies would allow this regime to prosper. Contrary to this my two engineering colleagues and I felt that the overuse of natural resources and over consumption of goods and services, as a result of globalisation, was not sustainable. We accepted each other's points of view but ultimately we could not come to a decision as to which regime was the best. Working with people other than engineers, on an assignment, was a new experience for me and I got to see the topic from a different perspective. Working with a variety of people is a big part of engineering so I feel that this particular exercise will be beneficial in the future, when considering stakeholders in certain projects*."	Irish male engineering student (Group A)

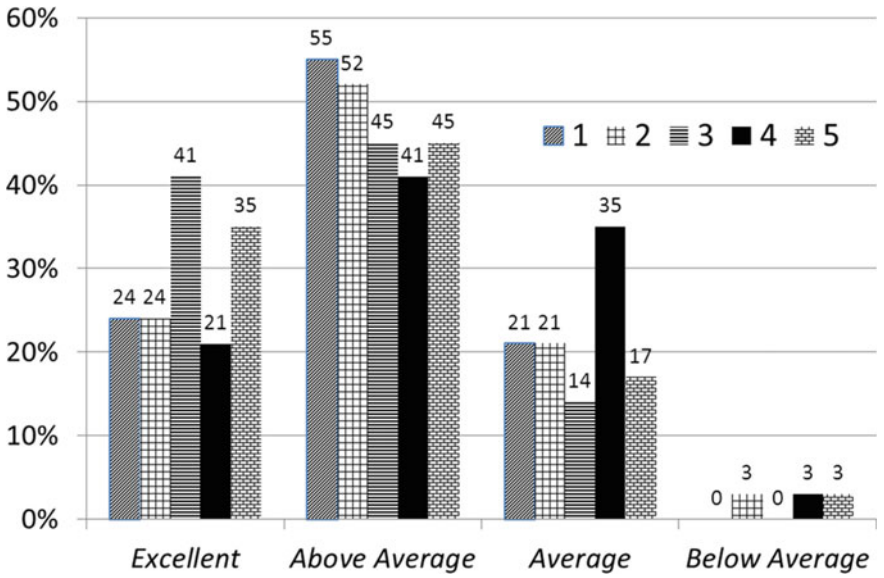

Fig. 1 Collated student feedback on transdisciplinary sustainability assignment

Table 3 Qualitative student feedback—selected comments

1. What are the key learning points *or* insights *or* rewarding aspects that you've taken away from undertaking this joint assignment?	Student background
"*It was an exercise for critical thinking, which was very enriching*."	PE3011
"*Learned that sustainability relates to everything, and should always be critically considered when undertaking any project*."	PE3011
"*I learned that group work from working within multiple disciplines, provides a much wider perspective on a given topic, and I found that this type of teamwork is very effective*".	PE3011
"*I really liked working with someone who came from a different faculty and has a different viewpoint on sustainability*." "*The best part of this assignment is how to work with people with different points of view*".	PE3011
"*I really enjoyed working with the engineers because they had great ideas about how to make products last. It was a good opportunity to hear their perspectives*."	SC3029
2. From a trans-disciplinary or international perspective or both, what aspect(s) of the assignment did you find most challenging?	Student background
"*Initially I found that working with sociology students was quite difficult as we came from very different backgrounds*."	PE3011
"*It was difficult to make a decision on what topic to cover as our viewpoints were a bit different*."	PE3011
"*There was so much to say and discuss. We had great fun discussing sustainability. Working in groups was beneficial because we got to teach each other*."	SC3029

6 Reflection

The assignment worked very well, in fact it exceeded our expectations in that there were no significant disciplinary 'language' problems, but on the contrary there was a willingness to learn and explore in a collaborative manner and in good faith by all parties. We would like to think that this was aided by a similar spirit on behalf of the authors, as we engaged on this experimental mission with an attitude of transdisciplinary openness, underpinned by trust built up over the past few years. This we would hope, engendered a sense of legitimacy among our respective students with respect to the assignment, helping to peel away any cynicism, or the potential for Snow's '*hostility and dislike, but most of all lack of understanding*' across a '*gulf of mutual incomprehension*' (Snow 1965). Thus we will continue with and expand the exercise. For the 2014-15 iteration, the assignment was formalised as part of the assessment for SC3029, while it was also decided that the lecturers would mediate between the groups to help ensure that a range of different facets were chosen (other than consumption), or at that least different aspects could be chosen by different groups.

7 Conclusion

Despite CP Snow's misgivings, there is significant cause for hope. The initial experience of this experimental exercise appears to demonstrate that, despite the rigorous siloisation of our educational system, that this is not a natural or insurmountable problem; where disciplinarians act in good faith and build up necessary trust, there is the possibility of having productive transdisciplinary 'conversations' around significant 'grand challenges' around the contemporary metaproblem of (un)sustainability. This is not to denigrate, nor to suggest a reduced need for disciplinary studies or perspectives; on the contrary, it demonstrates the value and necessity of disciplinary learning and 'object worlds' as pillars from which productive transdisciplinary knowledge can both emerge and be supported. The result can be a dynamic and energetic fusion of thought and action which is not just a nice optional extra, but is in fact nothing less than a necessary requirement if we are to hope to successfully address contemporary crises whose roots reside in unsustainability, while opening up the possibility of genuine human flourishing.

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