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Eddie Conlon
Technological University Dublin, edward.conlon@dit.ie

Iacovos Nicolaou
iacovos.nicolaou@mydit.ie

Brian Bowe
Dublin Institute of Technology, brian.bowe@dit.ie

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What Do We Know About EESD and How Do We Know It?

Eddie Conlon[1], Iacovos Nicolaou[1] and Brian Bowe[1]

[1]College of Engineering and Built Environment, Dublin Institute of Technology, Ireland.

edward.conlon@dit.ie

Abstract

Huckle (2004) has argued that critical realism (CR) can provide a philosophical framework for higher education for sustainability. This paper reflects on the process of researching EESD in the Irish context and the usefulness of our approach which used mixed methods and drew on CR as its guiding philosophy. We will argue that aspects of the CR approach: its emphasis on a depth ontology, the search for causal mechanisms, its model of agency/structure relations and its emphasis on the combination of extensive and intensive methods provide tools for exploring EESD as a system. CR requires us to focus on "deeper things" in the examination of the integration of SD in engineering education. This leads to an argument for the requirement for deeper change to facilitate the development of a social model of engineering education which more fully embraces all dimensions of SD.

1 Introduction

Huckle (2004) has argued that Critical Realism (CR) can provide a philosophical framework for higher education for sustainability by providing a philosophy of knowledge "that integrates the natural and social sciences and the humanities...supports critical pedagogy, and continues to regards education as a form of enlightenment linked to a vision of more sustainable futures" (34). His argument is based on the depth ontology of CR and its potential to provide an ontological grounding for interdisciplinary approaches to (SD) and education for sustainable development (EESD). This depth ontology encourages us to look beyond the surface appearance of things to uncover their generative causes. In this paper our focus is on how CR impacts research design and how we used the logic of CR to examine engineering education for sustainable development (EESD) in a limited number of programmes in three institutions in Ireland. Some results of different phases of this work have been reported previously (Nicolaou and Conlon 2012, 2013, 2015, Nicolaou, Conlon and Bowe 2015). In this paper we seek to integrate the findings and provide an account of how our approach was influenced by CR.

2 Critical Realism

CR has emerged as an alternative paradigm in the social sciences to positivism and interpretivism. It combines a realist ontology with an interpretive epistemology. A key feature then of CR is the distinction between the, intransitive (the world which is the object of our knowledge) and transitive (our knowledge about the world) domains. CR argues for the primacy of ontology and also that the nature of what exists cannot be unrelated to how it is studied (Archer 1995). In seeking to explain phenomena CR offers a distinctive approach.It offers a depth ontology: a notion of a stratified reality which includes a distinction between the domain of the real (generative mechanisms), the actual (events) and the empirical (experiences). Structures of objects at the level of the real generate mechanisms that facilitate events. They are not observable but their effects are felt nonetheless. They can be inferred through empirical

investigation and theory construction. Realist explanations consist of connecting experience in the empirical domain with structures and processes in the real domain. This is potentially emancipatory in that it forces us to consider "that certain states of affairs cannot be ameliorated within existing structures" (Collier 1994: 10). They must be changed.

A feature of this depth ontology is the linking of the natural and social worlds. The biological world is emergent from the physical and the social from both. As a consequence social science needs to be combined with natural science to understand how society is embedded in nature, while natural science needs to be combined with social science to understand the form that nature takes in particular social circumstances (Huckle, 2004). While arguing that the social can be studied scientifically critical realists also argue there are differences between the natural and social sciences. Firstly, taking the conduct of experiments as a starting point CR argues that the kind of closure offered by laboratory experiments is not achievable in the real world. Therefore causal mechanisms must be studied as part of open systems where their effects may be blocked by the operation of other mechanisms (Robson, 2011). Thus their impact is conditioned by the context in which they operate. Realist seek to show how it is that in the particular situation in which research is taking place "there was a particular configuration involving a set of mechanisms that had the particular pattern of results achieved" (Robson, 2011:37).

Secondly, social structures are maintained through the activity of people. CR offers a particular social ontology focused on the relationship between structure and agency. It is committed to an explanatory model "in which the interplay between pre-existent structures, possessing causal powers…and people possessing causal powers…of their own results in contingent yet explicable outcomes" (Carter and New 2004: 6). CR is committed to *analytical dualism* in that structure and agency are seen as objects of a radically different type possessing different properties and powers (Carter and New 2004). Thus CR acknowledges the value of interpretivist methodologies which focus on discourses, beliefs, motivations and meanings as human reasons (or as Carter and New call them "psychological mechanisms") can serve as causal explanations. They are critical though of interpretivists who fail to relate these to underlying social structures which may enable or constrain action. On this account social and cultural structures are seen to be causally efficacious. The tranformative potential inherent in human agency can only "begin to bite when structural contexts ...are generally supportive of those potentialities being actualised in some durable form." (Reed 2005:302).

3 CR and Research Design

CR acts as a general orientation to research practice. In arguing for its usefulness in research design, Robson (2011) highlights some of the features of CR discussed above: "First. A general issue. Research very commonly seeks to provide explanations. Answers to 'how' or 'why' questions – how or why did something happen? Realism addresses these issues directly, providing a helpful language for this task. Secondly…(t)his is that virtually all real world research takes place in a 'field', rather than laboratory situations. Realism provides a way of approaching such open, uncontrolled situations" (Robson 2011: 30). He also points out that particular features of the CR ontology are useful in providing an ontological justification for using mixed methods. This is significant in light of his claim that those who use mixed methods need to explain their design but also have "the additional task of clarifying and making explicit your rationale" for mixing methods (2011: 168).

A full discussion of the latter issue is beyond the scope of this paper other than to point to the

importance of different research paradigms in providing researchers with ways of thinking about which kinds of research questions are important and what constitutes answers to these questions (Robson 2011). Many researchers rely on pragmatism to justify their use of mixed methods allowing the research questions to dictate their methods. While CR is sympathetic to this position the problem is that there is always an implicit or explicit conception of the nature of reality which generates particular research questions. Further if you "presuppose that social science studies are conducted in an open system but nevertheless study the phenomenon using quantitative methods, which require a closed system, you must be very observant about what conclusion can be drawn" (Danermark *et al.*, 2002: 152). Thus attention must be paid to the connection between ontology and methods.

CR is not committed to any particular methods but rather argue for the use of "critical methodological pluralism" (Danermark *et al.*, 2002). Given their rejection of the ontologies underpinning qualitative and quantitative methods critical realist prefer to talk about combining extensive and intensive methods given their different roles in identifying mechanisms and how they manifest themselves in different contexts. Mixed methods are necessary to reveal different features of the same layered reality and offer a robust option for uncovering generative mechanisms while also identifying which phenomena occur most frequently (Hurrell, 2014). As reality is stratified data collected at the empirical level can shed light on the operation of mechanisms. Extensive methods need to be complemented by intensive methods focused on processes and *how* a mechanism works in a concrete situation.

While some are critical of CR for being overly focused on theory (for example Robson 2011, who describes his approach as 'realism-lite'), research based on CR tends to be conceptual. Given its focus on unobservable generative mechanisms it tends to seek to provide theoretical explanations of the social world and generalise about theoretical propositions. In doing research CR tends to emphasise the importance of abstraction, abduction and retroduction.

Since social systems are open it is very difficult to examine their structures in controlled conditions (Sayer, 2000). CR's logic of abstraction allows researchers to conceptualise the components of an open system and investigate each component's influence on the system in isolation. Abstraction encourages the development of conceptual frameworks which identify what is significant in examining the phenomena under investigation. Critical realists use two distinct explanatory logics in moving from the empirical to the real: abduction and retroduction. The former describes the observed in an abstracted or more general sense in order to describe the sequence of causation that gives rise to regularities in the pattern of events, while the latter seeks to ascertain what the wider context must be like in order for the mechanisms we observe to be as they are (O'Mahoney & Vincent, 2014). Retroduction is a mode of analysis in which events are studied with respect to what may have, must have or could have caused them: "In explaining associations they seek to distinguish what must be the case from what merely can be the case" (Sayer, 2000: 27). Having set out some key features of CR the remainder of this paper will discuss how this general orientation influenced our research.

4 Research question and conceptual framework

Our initial research goals were focused on understanding the integration of ESD in engineering education in Ireland. Influenced by CR and the absence of research on the Irish situation we needed to first establish the pattern of integration by collecting and analysing empirical data. But we also wanted to explore the causal mechanisms which might explain the pattern of

integration. In order to do so it was decided to focus on a small number of programmes (7) in a small number of institutions (3) of different types. Four of the programmes were in one institution. The other three were in similar and different disciplines in the other two. This would allow us to gather both extensive and intensive data on a small number of cases and also allow us to consider whether the disciplinary and institutional context was significant in shaping the pattern of integration.

The data collected was based, firstly, on a student survey (with 371 respondents in either their final or first year). This built on Carew & Mitchell (2002) and Azapagic *et al*., (2005) and mainly asked students to rate their knowledge of a variety of SD principles, tools, issues and policies but also asked them to describe SD, sought to establish their commitment to SD and sought their opinions on issue related to strong and weak sustainability. Secondly, programme documents were analysed (296 separate modules were examined) to identify coverage of learning outcomes for SD as set out in the Barcelona Declaration (BD) and SD competencies as identified in the literature (e.g.Wiek *et al.,* 2011). Finally, interviews with the seven programmes chairs/leaders were conducted. They were designed to explore their views of SD and the integration of the concept in their programmes, as well as their views about the factors that impact programme design. An interview was also conducted with a representative of the accreditation body for professional engineers (RAB from here).

The first two provided considerable data which allowed us to extensively map the pattern of integration while the latter allowed us to intensively explore what shaped this pattern of integration. When the project was initially conceived the plan was to conduct a survey of staff but this was abandoned, in favour of in-depth interviews with programme chairs,, given the need to explore in greater depth what the underlying mechanisms might be: "Qualitative methods can help to illuminate complex concepts and relationships that are unlikely to be captured by predetermined response categories" (Mc Evoy & Richards 2006: 71). We needed to move from the empirical to the real and retroductively explore the mechanisms that explain the pattern of EESD.

In doing all of this we were clearly influenced by the literature and the conceptual and theoretical issues that arose from it and its identification of various factors which influence the integration of ESD. Given the limitations of space here it is not possible to cover all the issues[1] other than to say that a CR lens encouraged us to adopt a systems approach to ESD (Sterling 2004). There was a desire to maintain a focus on the system as a whole and interaction of different mechanism while at the same time ensuring that both the descriptive and explanatory gaols of the project were met. There was a concern to maintain a focus on the interrelationships between the different aspects of the phenomena.

In light of this a conceptual framework (See Fig 1) was used to guide the research process in moving from the descriptive to the explanatory. It summarises the research landscape regarding EESD. At the top the focus is on the empirical dimensions of EESD: students' knowledge and the curriculum[2]. These can be evaluated in light of learning outcomes and competencies which have been identified as necessary for SD (the latter can be seen as ideal types which allow for the evaluation of concrete instances). At the bottom there are three interacting dimensions: professional accreditation process and the professional culture; academic and organisational cultures and lectures knowledge of and beliefs about SD. These dimensions have been identified

[1] Most of the key issues are identified in Ashford (2004), Boyle (2004) and Mulder et al. (2012).

[2] While issues to do with teaching methods were examined as part of the project the focus in this paper is on programme content.

as having an important influence on EESD and as such represent explanatory mechanism which would need to be explored in the course of this project. When drawing this up we were more conscious of the need to abstract out the key elements of EESD rather than hypothesise any particular pattern of causality at that stage.

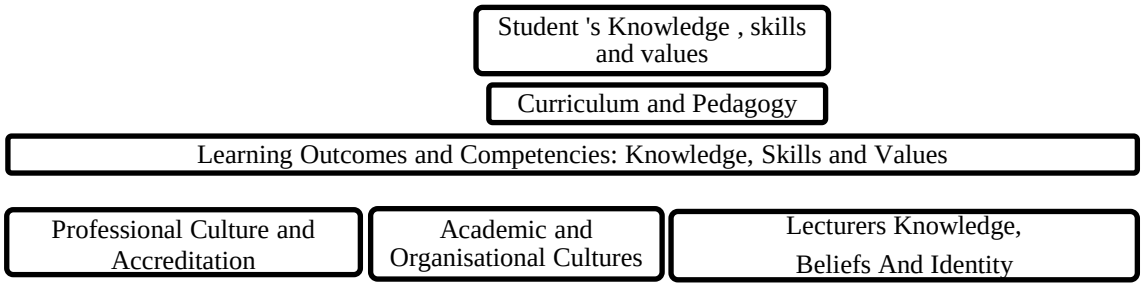

Figure 1 Conceptual Framework

5 What do we know?

As most of the data has been presented previously, what follows is a short summary of the data gathered using extensive methods followed by a discussion of the mechanisms identified from the interviews with programme chairs. The data from the extensive phase of the project are presented in Tables 1 and 2.

Table 1: Summary Results of Student Survey

Final year students rate their knowledge somewhere between "Heard but could not explain" and "Have some knowledge" (2.49 on a scale of 1 to 4). First year students average score was 2.24.
They rate their knowledge better in relation to environmental issues and tools
They do not report the same degree of knowledge about social issues (equity, social inclusion and public participation) and legislation and policy
Final year students' descriptions of SD are focused on the environmental dimension. Less than 10% mentioned the social dimension in their descriptions.
Final year students tend to focus on one dimension when describing SD. Those who see it as multidimensional describe it as an environmental and economic concept.
When final year students' self-reported data were compared with new entry students' data it was found that there are similarities regarding their perceptions of their knowledge Differences were identified on issues, such as energy, resource management and environmental protection, directly related with final year students' discipline.
There was evidence that to suggest that students' knowledge of the social dimension did not differ significantly from new entry students' self-reported level of knowledge.
Students' self-reported knowledge is significantly related to their programme of study.
Final year students agree that the environment should be protected but not at any cost.
They are more likely to see SD as a professional requirement rather than a personal commitment

Whilst perhaps unsurprising, there is a clear alignment between both sets of data. The evidence would suggest a fragmented, rather than a holistic, approach to SD. While students say they have some knowledge of important components of SD their knowledge is focused on the environmental dimension including the use of resources. The focus is on those aspects of SD close to the disciplinary core of the different programmes. While some modules can be seen to be addressing outcomes for SD, they do not specifically address SD in their learning outcomes or content descriptions. Others have content relevant for SD but no reference to SD in their outcomes. The focus tends to be on delivering engineering fundamentals though a consideration of issues such as energy and environmental protection. When issues related to SD are addressed

in modules they are often not linked to wider discourses linked to SD. This is also the case for many of the modules which focus on skills development. They are not contextualised by the need, for example, to foster stakeholder engagement or public participation in decision making about technology. Rather the focus is mainly on improving the communication and teamwork skills of students in the context of improving their employability.

Table 2: Summary Results of Curriculum Investigation

Programmes' overall focus is on transferable skills (such as communication) development over knowledge and values for SD. While there is some evidence for the development of critical thinking, the higher domain (evaluation) of critical thinking is developed to a lesser extent.
Programmes from Institution 1 focus on skills while programmes from Institutions 2 and 3 focus more on knowledge for SD
Modules that deliver content for SD focus on the environmental aspect of the concept
Regardless of the degree the programmes focus on elements from two BD outcomes which address engineers' social and environmental obligations and the need to keep abreast with SD technologies. In relation the former the emphasis is on their environmental obligations.
The social dimension of SD is not evident in the programmes. Only one module addressed the issue of stakeholder participation in its learning outcomes. Only four addressed the BD outcome focused on understanding their work in different cultural and political contexts.
It is not evident how commitment to SD values is generated in the programmes. Modules that focus on ethics focus on micro ethical issues and professional responsibilities as set out on the code of ethics
The knowledge that is delivered for SD is related to each discipline. Hence, based on the discipline different elements of knowledge about principles, legislation, tools and issues are covered
There is very little evidence of inter or multidisciplinarity in the programmes

This disciplinary focus, which is reinforced by students having very little exposure to teachers who are not engineers, especially in the later stages of their programmes, is creating an unbalanced approach to the integration of the three dimension of SD. Analysis using Arsat *et al's*. (2011) framework shows that only four modules across the institutions are consensual: they address all three dimensions of SD. In summary it can be suggested that the focus is on "generating disciplinary knowledge and developing skills". The Barcelona Declaration specifically cautions against such an approach. The general approach, regardless of institute type and discipline, has the character of what Sterling (2004) calls a "bolt-on" approach "of sustainability ideas to existing systems, which itself remains largely unchanged". Optimistically he notes that this is "much better than nothing, and can open the door to deeper change" (59).

We wanted to explore deeper issues in the interviews with programme chairs. We wanted to raise a number of issues which had arisen from the previous stages of the project. But we also wanted to explore these issues in light of key factors that arose in the literature which were deemed to have an effect on programme design. Using abduction and retroduction we wanted to "add theory to data" (O Mahoney & Vincent 2014). We wanted to encourage reflection on what the key factors shaping programme design were and how they might be constraining the implementation of EESD in the programmes. The data was analysed using thematic analysis with an iterative analysis leading to the identification of key latent themes which focused on the professional identity of the respondents and their philosophy of engineering education and, within that, their views about SD. Some key findings are:

- All of them had an engineering focused education and significant industrial experience: SD was not a part of their engineering education;
- The majority of the programme chairs the describe SD as a concept that relates economic
- development with environmental considerations that are mainly focused on energy, materials and resource issues. Only one described it as a three pillar concept;

- Their views about SD lead to a generally positive assessment of its integration in their programmes;
- There is a strong disciplinary focus on core engineering competencies in programme design; when asked to discuss any particular focus on content for SD, the majority of them identify elements directly related to the discipline of each programme;
- They agree, when prompted, that the social dimension is not well integrated: although ethics were identified as an important characteristic of engineers who want to contribute to SD, these were limited to engineers' professional conduct in relation to materials, safety and the environment while the social context of their practice was identified to a lesser extent;
- SD is not an active consideration in programme design;
- Concern about professional accreditation was identified as the most significant influence on programme design;
- All of them value the autonomy they enjoy in designing their programmes and oppose the imposition of an institutional policy for EESD;
- The majority of the programme chairs argue strongly that the role of their programmes is to educate employable graduates that will have the competencies needed to work in industrial environments which include some elements related to SD.

It is quite clear (and RAB agrees) that SD is not a key driver in programme design. Indeed he suggests that perhaps SD is not necessarily a concern for all engineers: "If there was a programme that's in the sustainable area or the renewable resources we would get experts in that space and focus on that particular area during accreditation". According to him "discipline specifics" are dealt with most and there would be a danger that "sustainability is involved now but in five years time it might be something else". The accreditation criteria do not explicitly mention SD but rather "responsibilities towards people and the environment". While Irish EESD may lack a "bold legitimising catalyst for sustainability related curriculum development" (Jones *et.al* 2010) the real issue is what that says about the underlying approach to education.

In a manner not dissimilar to critical realism Sterling (2004) analyses higher education using an iceberg metaphor and argues that "the deeper levels of paradigm and purpose guiding policy and practice...tend to be hidden from view and...most debate"(64). In terms of purpose the chairs support an emphasis on core engineering competences which is supported by accreditation processes which emphasise the development of employable graduates for industry. While their responses show that the integration does not follow a multi-disciplinary approach and a neglect of the social dimension, the programme chairs say that they do not see any weaknesses in the way their programmes deal with SD. Only one programme chair was critical about how SD is treated. Their descriptions of the concept suggest that the majority of them see SD as a *guarding concept* that is based on a sense of techno-optimism and traditional engineering practice focused on guarding exploitable resources, waste minimisation and environmental protection and supports a disciplinary emphasis in knowledge for SD (Carew and Mitchell, 2006). This allows them to claim that SD is adequately addressed. Seeing themselves as members of the industry which they serve, as well as of their professional body, leads to them espousing a set of values which endorses an employability agenda as a criterion of the effectiveness of their programmes. In the main they were satisfied that their programmes met the goals for which they were designed.

The structure of engineering education, based as it is on disciplinary based programmes and schools and their own experience of education reinforces their commitment to disciplinary education. This is reinforced by a strong commitment to academic autonomy. This has the effect

of reinforcing their professional identities as engineers as they are resistant to the idea of an institutional policy to guide the integration of SD, but yet had no difficulty with a policy emanating from their professional body. It appears that the autonomy they value is from non-engineers. This may be a block to institutional initiatives aimed at developing interdisciplinary engagement. At a deeper level the approach of the chairs is dominated by a commitment to a model/paradigm of engineering education located somewhere between the science and market driven approaches as identified by Jamison (2013). As part of this the see SD as mainly a technical issue focused on environmental and energy related issues with little attention to the social dimension. In CR terms there are a set of reinforcing mechanisms facilitating the provision of disciplinary education aimed at producing technically proficient, employable graduates in which the social dimension is marginalized.

6 Conclusion

Jamison's (2013) typology of engineering education is useful in that it emanates from a concern to educate "green engineers" and links specific views about engineering education to different engineering identities and views about what it means to be an engineer and therefore what the goals of engineering education should be. In arguing for a socially driven model and the creation of hybrid identities for engineers, he is seeking to build on the CR insight regarding the intertwining of the natural and social worlds and the need to understand both in addressing unsustainability. This implies "in context" learning and a commitment to interdisciplinarity.

He is also pointing to the need to focus on "deeper things" in fostering educational change. In moving towards this goal the research reported helps us understand why approaches focused on policy and practices (particularly those of individual lecturers) are likely to fail. While we can see that there is some engagement with SD and evidence that some issues are being addressed our use of CR has helped us to identify some of the locks (mechanisms) which are preventing the door being opened to deeper change. Without engagement with the culture and structures that maintain and support current practices deeper change is unlikely to occur and be sustained.

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Eddie,
Apologies for the delay in passing on the comments. The reviewers have read the article and it is certainly a topic relevant to the journal and the results are definitely of interest. The notes below are some observations and suggestions if you are interested in bring the paper forward for IJSEES.

While sustainable development is central to the research it is not explored or defined in the context of the research work being undertaken. There is no indication of what indicators/identifiers of sustainable development education are picked up in the descriptors examined. A summary table of programmes and the module titles might be useful for context. It is clear you have such background material supporting the conference paper and given the context it is normal not to include it in a conference paper but given the focus of the journal we believe it would be essential to have it included for publication.

The reviewers also felt that the overall structure of the paper gave it a slightly fragmented feel. The introduction and exploration of creative realism is not carried through to the analysis of the data gathered or the development of conclusions from the interviews and surveys. We feel this could be remedied quite quickly. There appeared to be a lot of discussion of the technique in the early stages of the paper which we are sure worked well in a conference paper context but could be reduced and footnoted for publication.

In relation to the second part of the paper, the findings are clear and well explained but the reviewers felt more detail would be helpful. For example, which programmes in which institutions were selected for study? What are the different types of institution that were selected? Were they ITs, universities or private colleges? A simple table could clearly present this information.

There were a few minor layout issues, for example the conceptual framework (Figure 1) appears to be missing and Tables 1 and 2 should follow as text referring to both is caught between the two. Lastly the abstract doesn't include the research findings and we suggest that this should be amended to do this.

I hope these comments are of some use and as I said above we are interested in publishing the paper so if you have any queries please don't hesitate to get contact. Again my apologies for the delays in responding.

Deiric