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Chapter 19
Engineering with Social Sciences and Humanities; Necessary Partnerships in Facing Contemporary (Un)Sustainability Challenges?

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Abstract: Traditionally, the relationship between engineering, social sciences, and the humanities (SSH) has often been, to varying degrees, fraught, imbalanced and/or non-existent. Engineering has oftentimes been guilty of envisaging SSH as either providing a 'soft' window dressing or counterbalance to 'hard' projects representing 'real' progress, or to be used to more effectively 'communicate', for example in overcoming public reticence around such projects. The stories, histories, (her)stories, myths, language, text, images, art provocations and critical insights which emanate from and characterize SSH are in this (dulled and marginalized) context more likely to be conceived as mere frivolous pursuits to help fill and support leisure time or promote cultural pursuits. This, we argue, not just feeds into the disconnect between respective disciplinary approaches, but seriously and dangerously miscomprehends the value (and values) that SSH can and indeed must bring to the table, in particular when facing emerging and emergent contemporary interconnected challenges around (un)sustainability. SSH can also benefit from such authentic and pragmatic engagement with engineering and science, while highlighting the necessary and invaluable contribution it can make to society, and across our universities, in particular in facing contemporary challenges. This chapter draws upon academics and practitioners from both sides of the house in an Irish university context, who have journeyed together upon such pathways. The terrain and nature of some of these journeys are described, including some of the inherent difficulties and challenges. We highlight the need for journeying together with 'disciplinary humility', as equal partners, if we hope to make authentic progress. Finally, some historic and contemporary examples of potential points of convergence are proposed.

Keywords: transdisciplinarity, engineering education, social sciences, sociology, sustainability.

21.1 Mutual Complementarities: Engineering and the Social Sciences

Engineers have been to the forefront in developing a range of technologies around such things as artificial intelligence (AI), smart systems, nuclear power, wind and solar power farms, high voltage electricity distribution lines, data centers, the digital society, smart society (cities/farms/healthcare/etc.), genetically modified foods, and nanotechnology. Many of these technological developments have emanated from economic and policy drivers, but what has often been less developed has been an initial regard for broader societal contexts, including ethical implications, potential unintended consequences, the precautionary principle and/or local public acceptability. Technological advances are often seen and employed either as economic opportunities and/or as singular techno-fixes to what are essentially complex, 'wicked' societal problems. The latter involve problems that are both normative and deeply contested, and which necessarily impinge upon ethical and social domains, as well as those in environmental, technical and economic spheres.

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A holistic, integrative and complexity embracing paradigm would embrace each and all of the aforementioned domains. A clear repercussion of this, however, is a common realization of the need for the social sciences, the humanities (SSH), engineering, and science to all work together, both in concert and in complement, *'contraria sunt complementa'*, as twentieth century Nobel prize winning quantum physicist Neils Bohr put it. This is particularly pressing in relation to contemporary challenges of (un)sustainability, which emerged on the basis of 'a paradigm of reduction and separation' (Byrne, 2017, p. 43, after Morin, 2008). This paradigm has now dangerously brought us to this juncture through ignoring deep interconnectivity across various domains and scales (spatial and temporal), to the detrimental exclusion of both system *context* and contingent recursivity, and in this way foreclosing possible solutions and coping mechanism to our planetary emergency.

Whereas too often engineering has used SSH for its own (narrowly defined) ends, there is a new realization that both can mutually benefit from a partnership of equals. With the insights, knowledge bases, approaches and values that SSH can provide, and the unique abilities of these disciplines to go ~~places~~ beyond a 'reductionist pale' of a narrowly defined science, there arises new integrative and enabling possibilities and exciting creative vistas. This benefits both parties raising the recognized value of SSH to society by placing it front and center among both engaged academic endeavor and societal development. Moreover, if engineering acts in concert with SSH, it can proactively enable the facilitation of a broader conception of engineering itself, as a profession which reflexively seeks to conceptualize its own practice to explicitly incorporate broader context, and associated competences and values (Gutiérrez Ortiz *et al*., 2020), and in so doing publicly commit to its overarching mission of improving the world.

Borrowing lessons and knowledge from SSH, while working on an equal and respectful basis with their practitioners, facilitates engineers going places that would otherwise be impossible. Indeed, we would argue that these are the very places we need to uncover and explore if we are to hope to competently and creatively address emergent challenges of unsustainability. For example, on issues such as climate change, while we have long known the scientific facts around greenhouse gas (GHG) emissions, and the required trajectory we must take to address this challenge, nevertheless we still remain, as a global society, on an accelerated course towards the metaphorical iceberg, with all its uncertain consequences (Hulme, 2020; Bradshaw *et al*., 2021).

The human condition is such that scientific facts alone serve to leave us cold. It is in and through perspectives and worldviews shaped by stories, myths and narratives that we are inspired to act (Harré *et al*., 1999; McGilchrist, 2009; Larson, 2011; Sage *et al*., 2021). When these are imbued and aligned with scientific fact and engineering endeavor, societal passion is aroused and inspired in a way that can make for powerful progress of a positive kind. This fundamental realization is finally coming to pass at the highest levels. For example, the UN Environment Programme Emissions Gap Report warns that despite all we've known for quite some time, there is still yet 'no sign of GHG emissions peaking in the next few years'. As a result of our continued inaction, 'deep and rapid decarbonization processes imply fundamental structural changes are needed', changes which can only be effected and accompanied by 'deep-rooted shifts in values, norms, consumer culture and world views [which] are inescapably part of the great sustainability transformation.' (UNEP,

2019). That is, the changes needed are largely non-technological but societal. This reads as a powerful call to arms for SSH, and the embedded knowledge, skills and values therein, to work front and center and as equals with engineering and science, in eliciting transformative, paradigmatic change.

It is a recognition of this complementary and agonistic duality (Byrne, 2017), between SSH, engineering and science that has precipitated a number of academics from different disciplines at University College Cork (UCC) and beyond to reach out to initiate means of breaking down the walls between our disciplinary silos to create an authentic engagement of scholars around the issue of sustainability.

This chapter reflects on a number of initiatives which have emerged, based on a desire to seek an explicit transdisciplinary ethos among a group of academics across engineering and the social sciences largely within UCC, while seeking the development of successful sustainability transformations. Such an ethos invokes 'disciplinary humility' (Mullally *et al*., 2017a; Tripp & Shortlidge, 2019), while it recognizes and seeks to embrace different forms of knowledge, thus facilitating emergent, novel and breakthrough knowledge and wisdom in addressing such challenges. Thus framed, transdisciplinarity is considered to incorporate the three major discourses of *transcendence, problem solving* and *transgression* (Klein, 2014; see also Mullally *et al*., 2017a, p.10), for example, seeking to address 'social and/or societal problems' while/or endeavoring to seek out 'new and emergent knowledge' which goes beyond the capacity of any singular discipline (Mullaly *et al*., 2017b, p.32-33). This entails being explicitly pluralist and open to surprises, creative, non-planned and sometimes contingent upon contextual specific knowledge and solutions.

Building on our collaborative experiences, we reflect on the respective value of engineering to SSH (in particular sociology), and on the value of SSH to engineering. Finally, we reflect on what this may mean for higher education, particularly the problem of educational silo-ization in our universities (Byrne and Mullally, 2016). This we regard as critical, for in our view third-level institutional structures have far reaching influence on societal norms and shape the ways we evaluate possible approaches to addressing contemporary challenges. Will these be entirely technological fixes untested by social or cultural compatibility, perhaps led by heroic entrepreneurs? Or can they emerge from a collaborative process of co-design where innovation occurs in both technical and social/institutional realms enabling a better societal fit?

21.2 Collective Initiatives, Explorations and Investigations

21.2.1 Transdisciplinary Conversations

The experiences of the authors, collectively and individually, lay no claim to cover all the explicitly transdisciplinary endeavors across our institution(s). Nevertheless, our collaborative work does provide a glimpse into the potential for what can be achieved when undertaken in a positive spirit of engagement and trust in order to address contemporary challenges. One strand of this collaboration, emerging from a series of workshops, open seminars, and conferences at UCC (Byrne *et al*., 2017a) was an edited book on *'Transdisciplinary Perspectives on Transitions to Sustainability'* (Byrne *et al*., 2017), with contributions from 15 academics from engineering

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and science to SSH, including six of the present authors. A subsequent book *'Metaphor, Sustainability, Transformation: Transdisciplinary Perspectives'* (Hughes *et al*., 2021) also incorporates 15 authors (including eight among the authors here) from across engineering, science and SSH. These initiatives have helped to seed a number of transdisciplinary research projects involving societal engagement on energy, food, and climate transformations in which several of the authors collaborate. Some of these are discussed below.

21.2.2 Future Imaginings

Imagining2050, an Irish EPA (Environmental Protection Agency, www.epa.ie) funded transdisciplinary research project (2018-2021), sought to engage with Irish society to explore in a collaborative manner visions and pathways for a sustainable and socially inclusive future (Revez *et al*., 2021). The project leverages the expertise and innovative power of its transdisciplinary consortium by drawing from a collaboration between different strands of science and various community and local perspectives in order to develop an integrated research approach. It makes use of performative research practices through visual and interactive communication tools to maximize the ability to capture and disseminate research findings among different publics (Chapman & Sawchuk, 2012; Haseman, 2006; MacDonald, 2017).

A core part of the project was dedicated to staging and evaluating deliberative community engagement initiatives. With the guiding principles of inclusion, equality and considered judgment, the Imagining2050 approach blended elements from a variety of participatory and deliberative innovations to develop what were termed 'Deliberative Futures Workshops'. These adopted a pragmatic participatory approach focused on generating positive visions for the future, aiming to bring people together for collective problem solving and to co-produce the future of their locality. They tend to involve three stages: critical analysis (identifying the collective problem), visioning (imagining solutions and futures), and pathways (developing an action plan). They can be a valuable form of social learning on complex problems and can be influential if the process includes those with power to effect change. Inclusion and equality guidelines ensure diversity in terms of participant composition, opinions and situated experiences. They also emphasize agenda setting powers and equal opportunities for 'voice' within facilitated discussions that use a mix of expert information and deliberation to co-develop visions and pathways.

The process involves informed, reasoned and respectful discussions on futures involving iterative, reflexive feedback loops, and in which disagreement is not something negative or to be avoided. Such a process thus offers promising opportunities to share information and enable dialogue that transcends interest group dynamics, entrenched positions, academic disciplinary divides, misinformation, misunderstanding and negative views of science (Revez *et al*., 2019).

21.2.3 Co-created Transitions

Another not dissimilar research project involving engineers and social scientists is that of the Dingle Peninsula 2030 project, a regional sustainability transition project in rural south west Ireland (Watson *et al*., 2020). The aim of this project is to help create a sustainable future for the peninsula; through working with the local com-

munity, schools, business and farming sectors to explore, support and enable broader societal changes required for the low carbon transition. As part of the project, which has been taken up by the United Nations as an exemplar case study of community engagement (UN, 2020), researchers from engineering and sociology based in UCC's national Marine and Renewable Energy (MaREI) Centre, formed a transdisciplinary committee with local stakeholders and the national electricity distribution operator (ESB Networks). The two central areas of research focus are exploring the interaction between top-down and bottom-up stakeholder groups and identifying ways of collaboratively forming visions for the future energy system. Through this approach, the research team is actively supporting initiatives in the region, as well as building an understanding of the technical, social and economic elements of the transition, and reflections on multi-stakeholder collaborations.

21.2.4 Deep Institutional Innovation for Sustainability

The 'Deep Institutional Innovation for Sustainability and Human Development' project, also based in the MaREI Centre, is another manifestation of this research, but one taking a broad and ambitious scope. This project endeavors, at a profound moment of multi-dimensional challenges (involving environmental but also rising social inequity, economic crises, populism, and geo-political tensions), to establish the foundations for a critique and reimagining of the major social institutions in society, and the development of principles, visions and imaginaries for guiding the coming transformations. External participants include the Austrian Humanistic Management Network and the New Approaches to Economics Challenges (NAEC) unit of the OECD.

21.2.5 Curricular Transformation

These research initiatives have been accompanied by developments in teaching. Those which have proved particularly fruitful have involved bringing together undergraduate students of engineering with others from sociology and government. While students took modules from respective departments ('sustainability in engineering' and 'environmental sociology'), they were brought together to work on a common group assignment on a sustainability topic with all its attendant complexity. A second, more broadly encompassing effort has been the development of a university-wide module in sustainability, which since 2016 has been made freely available to students, staff and the wider community (Kirrane *et al*., 2020). With its explicitly transdisciplinary and accessible ethos, the module has drawn on academic contributions from over 15 disciplines across the university and has helped provide a foundation for other cross-university initiatives, such as a recently launched UCC postgraduate programme in 'Sustainability in Enterprise'.

21.2.6 Institutional Leadership

While supporting these initiatives across research and teaching, the initiatives have also served to encourage the university to, in a positive sense, 'institutionalize' a commitment to sustainability. Enjoying strong institutional support and pioneering leadership, amongst the most successful expressions are the UCC Green Campus

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initiative, which has brought together students, staff and the university's Buildings and Estates unit to develop a more holistic management strategy of its natural and constructed resources (Reidy *et al*., 2015; Kirrane *et al*., 2020). This initiative has also supported several transdisciplinary 'living laboratory' research projects supporting and informing the development of the Green Campus, including one investigating change levers around the transition away from single-use plastics across campus. The result has been a number of pioneering sustainability awards and rankings, supported by a Sustainability Office and a UCC Sustainability Strategy (UCC, 2016), while the university's Academic Strategy (2018-2022) incorporates programme imperatives for both 'inter- and transdisciplinarity', 'sustainability' and 'civic and community engagement' as part of the UCC 'Connected Curriculum' model (UCC, 2018).

21.2.7 Research Innovation

Top-down supports for explicitly inter- and transdisciplinary approaches are also increasingly evident in research, in particular when addressing emerging large scale societal challenges, not least at the European level. The Horizon Europe research program (2020-2028) recognizes that 'interdisciplinarity and inclusion of Social Sciences and Humanities (SSH) aspects is a prerequisite for addressing a number of societal challenges, which are cross-cutting by nature and should be actively implemented throughout the whole research programme.' (European Commission, 2019, p.20).

Indeed, the above statement encapsulates a key driver behind the initiatives; that a transdisciplinary ethos is vital to facilitate the requisite understandings, trust and human capital necessary if we are to make any headway in facing contemporary (un)sustainability challenges to elicit meaningful and positive societal transformation.

21.3 Mutually Enhancing Value through Different Types of Knowledge

Elsewhere in this volume, Murphy *et al*. (2021) usefully highlight how what often appear to be theoretical disagreements may in fact be founded simply on diverse ways to analyze and interpret observed reality. They point out that this is particularly problematic in our multicultural globalized environment, where what appears to be incompatible disagreement can also be founded in whole, or partially on misunderstanding. A lack of appreciation of this can also be deeply problematic when it feeds into a reductive social and political discourse increasingly characterized by in-group echo chambers which seek and serve to demonize or scapegoat 'other' groups and perspectives. Indeed, as Morin argues, our unwillingness to embrace or even to fully see complexity suggests that we are yet 'still in an age of barbarism' (Morin 2008, p. 6).

Neither are our respective academic disciplines immune from such mutual misunderstandings. Hubristic disciplinary self-perceptions around being uniquely positioned to capture and frame reality, with a resultant downgrading of other disciplinary, experiential, local and/or indigenous knowledge bases, not only improperly

serve our human need for emergent knowledge generation, and integration, but imperil our very societal being.

21.3.1 Sociological Perspectives

In practical terms, both disciplinary cultures can symbiotically and mutually benefit each other. Sociology as a discipline often gives focus to the social and cultural process at a somewhat abstracted distance. Through working alongside engineers, a greater awareness is gained of the practical implications of different transition pathways from technical and natural science viewpoints. This insight gives greater depth to the analysis of respective social and cultural processes. A solution-orientated approach to research, or research as 'problem solving' is inherent in engineering, while with social scientific research the practical, when it is applied to addressing problems, is irreducibly and ineliminably social.

Another significant area is different operating cultures and norms in terms of engineering's self-understanding of producing 'disinterested' knowledge (which is never really the case), while sociology is more explicit about its own ideological and normative assumptions, and commitment to producing 'interested' knowledge, particularly in more critical social science. Working within a team of predominantly engineers, of which there may be numerous sub-disciplines and areas of interest, there is a unified sense of purpose under this shared goal of 'problem solving'. Left to its own devices, sociology can often remain within 'problem defining' or 'problem analysis' domains, thus constraining its real, practical and transformative potential. Moreover, exposure of the social scientist to the disciplinary language of engineering, while filling one with different terminologies and acronyms, may also lead to greater awareness and reflection on the density of one's own disciplinary language.

This relates to the point on 'misunderstanding'; often, due to immersion in one's own disciplinary area, people become blind to the difficulty others may have in understanding their specific terminology. Engineers and scientists may thus find the language of the social scientist somewhat impenetrable and/or not based in 'reality' as they see it. This of course works both ways; the pragmatic logic of engineers quickly seeks out an 'optimal solution' and may fail (or be unable) to entertain alternative framings, knowledge bases, or values, while key tools in the social science repertoire, are seen as bewildering. Both may then suffer, for different reasons, in terms of getting their voices heard in a way that produces productive policy which feeds into a wider range of imperatives.

Such authentic collaborative endeavor within an open and humble transdisciplinary ethos can not only help deliver real and valuable practical implementation, it can provide a valuable center stage for the social scientist. Moreover, authentically engaged interdisciplinary work can provide an enhanced understanding not just of scientific and technical landscapes or social, and socio-technical constructs, but may also promote increased awareness of our respective disciplinary blind spots and biases which may become clearer through working alongside others, while also providing new insight and appreciation of the knowledge bases (and difficulties) that are present.

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21.3.2 Enhancing Engineering Practice

The value of the social sciences and humanities, if they were appreciated at all, has too often lain chiefly in a prescribed utilitarian purpose in helping to communicate and persuade a skeptical public to accept particular projects, which are underpinned by scientific rationality. A second role has been to perform a sort of decorative embellishing which could be enjoyed or indulged afar from the 'real' work of scientific and engineering endeavor. Indeed, this was, and is still the precarious preserve of such SSH disciplines in many of today's universities, subject to dismemberment, either by *diktat* or by stealth as situation demands.

This is not just unfortunate but dangerous. From the perspective of the engineer, authentic collaborative engagement with social scientists can help understand the complexities of human nature and the societies we build around us. Greater appreciation of the value of multiple perspectives, framings and knowledge bases may temper a rush to seek an 'optimum solution', and instead more slowly but productively grapple with contingent and multi-level complexities. Context is thus critical (Byrne & Mullally, 2014; 2016); scientific models, no more than economic models, in themselves can only go so far in terms of algorithmically finding 'the solution' to the real, messy complex, interconnected world that we inhabit, a world which often requires more pragmatic recursivity and an acceptance of natural propensity over a quest for rigid abstract causal effect.

Enhanced understanding of this reality and its wickedness, including considering multiple and diverse problem framings, can come through interactions and engagement with social scientists on such projects. Many engineers and engineering firms have found that they have needed to learn this, often for the first time, in the wake of public opposition to various projects. Such projects may at first glance seem to be opposed by an ignorant, belligerent or overly self-interested public, who only need to be 'educated' to learn to adopt the 'correct' framing. As articulated previously, we are moved to act in response to stories, narratives, myths and metaphor, as opposed to mere cold hard facts (as our global incapability to cut greenhouse gas emissions makes clear, following 'this narrow approach' (Barry, 2017, 116)). While scientists and engineers can identify the source and amount of greenhouse gases we emit, and calculate how much is needed to reduce them, the key question of *why* we continue to pump them into our environment is one that perhaps social scientists are better equipped to address. Invariably such matters lead us directly into the very real and messy world of *values* that lie at the heart of complex situations (Diwekar *et al*., 2021).

21.4 Educational Imperatives, Implications and Opportunities

21.4.1 The Value(s) of a University Education

C.P. Snow (1961) identified and decried the separation between rational science and relational humanities which has come about across our universities, as the 'two cultures'. This development goes back to the pivot from a humanistic early modernity to the hugely successful rational late modernity (Toulmin, 1990), and the neo-Cartesian paradigm of reduction and separation which followed (Morin, 2008). The context of the institutional separation and silo-ization of engineering and science on

the one hand, and SSH on the other, is a central issue in need of addressing through (re-)conceiving disciplinary curricula and approaches which would be transdisciplinary enough (in both method and ethos), if we are to hope to begin to address the scale, complexity, and the wicked character of emerging crises of (un)sustainability (Byrne & Mullally, 2016). This too requires a pedagogical conception which would reach beyond the conventional spatio-temporal parameters of the university and into the wider community so as to be expeditious in facing the urgency of the issue(s) at hand. It thus challenges both conventional structure and traditional pedagogical approaches.

Etymologically, *educare* (from the Latin) means to cultivate, to lead forth, to draw out from within; and wisdom (Old English) is derived from *vis* in 'vision' with *dom* meaning judgment and authority. When we consider the transition and transformation that the wicked problems associated with (un)sustainability requires of us, we realize that it is not just innovation in economy and technology that is at issue, but more fundamental deep institutional changes: a revitalization of our political, cultural and moral institutions, including the cultivation of a whole new type of subject and a holistic new way of life. Our individual and collective abilities to be self-reflexive, innovative and creative, to adapt to change and to reinvent our society and our economy to face the challenges of (un)sustainability will come primarily from vision and the exercise of 'warranted judgment' based on good authority and full transparency and accountability; guided by higher values and ideals and inspired by good models; for education is mimetic, we learn by imitation. Education is concerned with relations of influence, and thus with models that inspire us, and that we emulate, for 'once the mind is illuminated by a knowledge of what is highest, it will lead the spirit to choose what is best' (Vico, 2000, p. 364).

21.4.2 The University as Change Leader

We will now address the pedagogical role of developing inspiring good models to be imitated and emulated, beginning with the context in which we need to develop post-conventional pedagogy to bring about deep institutional change. After discussing the university context, we will turn to the broader educational system, and then to the 'interfaces', 'out-reaches', and access routes between the university and the communities it serves and of which it is a part.

Even though it is but a part of the whole, the university is essential, because it is the institution that reproduces institutions. Its primary function is the production, reproduction and propagation of knowledge and ideas, and not only of knowledge and ideas in the abstract, but also reproducing the professional scientists and engineers, the educators, as well as the political and cultural actors and social elites who are bearers and disseminators of knowledge and ideas. This reproduction of institutions is both for better and/or for worse, for university graduates have played prominent roles among the opinion leaders, 'social influencers', and drivers of progressive social change throughout history. As Facer (2020, p. 55) rightly notes:

> As a country and as a planet, we are facing profound and interconnected ecological, social, and economic crises. Universities and colleges have a central role to play in enabling us to understand, adapt and survive in these conditions. First, in their preparation of young people and adults for the challenges that are already being felt and that are likely to intensify; and, secondly, in their ongoing partnership with communities to develop the knowledge and practices that will

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> constitute ecological and economic sustainability. The situation we find ourselves in is so grave – the ecological and social harms already so great – that new thinking and a spirit of collective generosity is required. This, indeed, is a moment for systemic change of a scale we never have quite managed before – although the astonishing response to the pandemic by teachers, students and administrators begins to show what might be possible.

21.4.3 Internal Tensions and Conflicting Paradigms

The role of the university in addressing the current crisis of (un)sustainability is crucial though it is ambivalent, because on the one hand we need to recognize that the university is thoroughly implicated in the reproduction and propagation of deeply embedded systemic problems, including the problem of the separation of disciplines and segmentation of knowledge addressed here. On the other hand, crucially, the university has the potential to enable deep institutional change. For even as it fragments and differentiates knowledge into silos, and instrumentalizes ideas in favor of utilitarian and monetized values, it becomes reflexively self-aware of this problematic aspect of its own institutional development, and seeks to address it and to re-form itself, even as it reproduces itself, as indeed this present inter- and transdisciplinary discourse between engineering and the social sciences exemplifies.

The ambivalence and self-reflexivity regarding the internal tensions between complicity and perpetuation of problems on the one hand, and critical self-reflection in addressing the problem on the other, has been a feature of the development of the university for quite some time, though it has become exacerbated and amplified in recent years, especially under the auspices of neo-liberalism and the systematic reshaping of the university in accordance with market principles (Barry, 2011). These dictate that the university's mission should no longer be conceived of in terms of a public institution serving broad social goals of furthering the common good, but as a market institution, a commercial concern like any other, oriented to meeting narrower and more immediate needs of industry and the private sector.

In this way the neoliberal transformation of the university, by what is purported to be an objective market logic, may be seen as especially problematic and inimical to much of the kind of work described here.

21.4.4 Hope and Opportunities for Productive Engagement

So, this is difficult terrain upon which to 'engineer' a partnership with the social sciences and humanities, to realize more valuable and more valued disciplines and professions in facing contemporary (un)sustainability challenges. But there are some foundations upon which we might hope to build.

First, many within engineering and science and SSH commonly share the concerns associated with the undermining and re-tooling of the university, the increasing silo-ization of knowledge and the narrowing of foci in the direction of research.

Second, it is becoming increasingly clear and accepted (including by governments, funding agencies), that it is only through the very type of transdisciplinary engagement and ethos described here, and the correspondingly adequate complexity informed framing of the issue(s) at hand, that we can hope to collectively tackle the existential (un)sustainability related problems that are presenting themselves. Universities would do well to stand ready to take advantage of associated emerging opportunities and imperatives by having the ground prepared through appropriate

transdisciplinary engagement, mission-led research and a demonstrable ethos and commitment to public service.

Third, in resisting neoliberalism there have also been efforts to revive university engagements with civic society, the so-called 'third mission' of the university's mission. This facilitates the opening on reciprocal dialogue whereby the university learns from the community as well as the community learning from the university. As with transdisciplinarity so too is there a developing realization – despite various structural barriers (Boucher *et al*., 2020) – that civic and community engagement is a must if we are to make meaningful and authentic progress.

21.4.5 Modelling the World; a Common and Collaborative Endeavor

A particular foundation upon which engineers and social scientists together may be able to build is something that has quite ancient roots in the history of education, reaching behind the late-modern separation of disciplines and the silo-ization of knowledge. This is the notion of models; models as representations and realizations of theoretical ideas, and as essential to education and pedagogy. According to Aristotle, all learning is by the imitation and emulation of models. As noted earlier, such models may be fundamentally metaphorical (McGilchrist, 2009; Byrne, 2021) or developed through narrative, myth, or story (Mullally, 2017; Hughes *et al*., 2021) and communicated through the performance arts (Gilson, 2021). They may also be constructed in the physical or mathematical sense, as recognized by engineers, scientists and architects.

Ultimately, we do not, and indeed we cannot, teach (or learn) by logical methods alone. Nor can we learn by merely assimilating information: teaching and learning involve the mediation of models. Models represent the syntheses of practice and theory, empirical applications of ideas. Engineers and social scientists study models, build models, and when we have good working models we replicate and reproduce and develop and improve them. In engineering, models often take the form of proportionally scaled working representations used to investigate 'real world' problems, and models become the basis on which prototypes and eventually a full-scale assembly or system is worked up; and similarly in the social sciences models typically begin in the form of small scale, empirical, ethnographic 'case studies', worked up as ideal types, extrapolated and applied to address problems and issues at the level of broader social systems.

Amongst the many themes of commonality that could be drawn from an arc traced through a genealogy of the disciplines of engineering and the social sciences, we can find their remote unity in the valorization of human creativity and ingenuity, crystalized at exemplary moments in the person of the 'genius' as a model universal human subject: Michelangelo and Leonardo da Vinci for instance, both of whose genius is recognized and valorized as an inextricable whole combining engineer, architect, sculptor, artist, philosopher, theologian, physician. But we can also see how this type of ideal model of human being, a model that was still prevalent in modernity as the polymath, has become eclipsed by the professional 'specialist', so that humanism's model subject of the 'Renaissance man' (unfortunately excluding women) is replaced by late-modernity's model subject as a sort of 'autistic savant'.

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21.4.6 Historical Models; The Model Village

This provides a backdrop for our more immediate purpose here, which is to consider two instances of models and modelling where engineering and the social sciences have been in close collaboration. The first is an historical case; and the second is a contemporary one that may constitute a model for future engineering and social science collaboration and help to realize more valued and valuable post-conventional teaching, research and community engagement.

The historical case is that of model houses, model towns and villages of the 19th century. Examples include Robert Owen's industrial-residential-civic utopian community of New Lannark, a model that was replicated widely in England's industrial North East; in France the model was Godin's 'Familistaire de Guise'; and there were similar schemes in Essen, Wolfsburg, Basel, Breda, and numerous other 19th and early 20th century industrial cities. While these cases are exemplary models of good engineering, architecture and planning, the other key to their success is that as social models they came to be perceived as desirable forms of life, attractive and desirable models of an ideal community that were envied, emulated, and imitated, so that people began to transform their lives and their behavior in accordance with the model.

They thereby transformed themselves and their whole way of life in accordance with the model. This deep and extensive institutional transformation, extending all the way down through layers of economy, polity and culture to the anthropological level of the social-psychological dispositions, preferences and predilections of the individual person. The result was a revolution in civic virtue in which the demographic of the urban mob of displaced peasants and slum-dwelling lumpenproletariat became law-abiding and self-conscious citizens of modern society, thus quickly precipitating a dramatic paradigm shift and the emergence of a whole new way of life.

These 19th and early 20th century models prototyped and generalized in the cities of the industrial modernity, in England, France, Germany, the United States and replicated globally, are now of historical interest primarily and their importance is recognized by their having been designated UNESCO World Heritage sites. To us, their ongoing importance is not at the level of content, for their contents have come to be seen as anachronistic (although worker precarity and living wages have seldom been more relevant), but at the level of form these models retain a timeless relevance, for they show us how ideas, represented in working models, are propagated, how they become influential, and become widely disseminated by an escalating social mimesis. And the original model towns are also relevant to us because they eventually ran their course. Some models, having worked very successfully for several generations, were eclipsed by broader economic and political transformations, and some other models failed to even get off the ground, or they collapsed quickly, and it is perhaps these latter cases, such as Owen's failed model community of New Harmony in Indiana that are worth studying, because it is usually the case that there is a great deal to be learned by studying models that did not succeed.

21.4.7 Contemporary Model Eco-villages; Future Insights?

The model of the eco-village offers a contemporary example from which we can mutually develop shared knowledge with potential future value around sustainable societal living. Real-world models of 'sustainable future ecological communities' have emerged over recent decades, as experimental utopian projects: striving for net zero carbon emissions, solar and wind powered, constructed neighborhoods of efficient, low-cost housing, permaculture that is self-sufficient and commercially viable in terms of organic vegetarian food production.

Extending beyond notions of 'ecology' that are conventionally or narrowly technically conceived, these sustainable ecological communities strive to develop models of processual consensus building, problem solving and decision making, and models of alternative post-conventional education, childcare, and socialization. In other words, these sustainable ecological communities strive to bring about deep institutional change by developing new holistic models for ways of life that incorporate and assimilate ecological sustainability within a broader and deeper vision of a good life as healthy and happy, ethical, meaningful and beautiful. But it is in striving to realize these ideals of political community that sustainable ecological communities very often founder. Why did 'New Harmony' fail and disintegrate so quickly and so completely? Why do so many new sustainable ecological communities suffer a similar fate today? We need to research why these promising and hopeful models and experiments in new ways of living often break down and are unsustainable over time. Nevertheless, even in assumed failure, such as in the case of New Harmony as an ecovillage, there can nevertheless be some success indicators: there were a number of ideas that emerged from New Harmony that had positive impacts on developments in other US towns, while prominent leaders and scholars also emerged (e.g. the first president of Purdue University).

There are presently several hundred such working real-world models worldwide, linked through networks such as Eco Villages International, and Eco Villages Europe, amongst them are 'Dancing Rabbit Ecovillage' in the USA, 'Dyessekilde' in Denmark, 'Findhorn' in Scotland, and in Ireland the exemplary case is 'Cloughjordan Ecovillage.' These four in particular are relatively long established successful working models, which aspire and seek to achieve a holistic deep institutional transformation, while their self-understanding is not to be as self-enclosed, inward-focused microverses, but rather they see themselves as having a public, political and educational role that they hope will be influential models for others to learn from and to emulate. This represents an important opportunity.

Engaging with university-based engineers and social scientists, many of the founding members of these ecovillages are themselves university graduates, in engineering and science and in the social sciences and humanities, in several cases they are self-professed 'de-professionalized intellectuals' who have left the university to undertake what they see as a necessary mission to bring about deep institutional change in the face of climate breakdown and (un)sustainability.

21.5 Conclusion

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The model of the eco-village itself may act as a useful metaphor for the task at hand. For if we draw on the African proverb that *'it takes a village to raise a child'*, there is recognition here that the enriching experiences of the developing child can best be offered through the multi-level diversity of their relational contacts – through their parents, family, friends, teachers, and the wider community. This perspectival diversity is key; as another saying goes, *'all work and no play makes Jack a dull boy'*; we might put it that an appreciation of the value of myth, metaphor, narrative and more broadly encompassing models of reality are equally required as much as a grasp of the *'cold, hard facts*' (and vice versa). Seeking to successfully address complex emergent issues and crises borne from (un)sustainability, equipped with the knowledge bases, insights and imagination of engineering or science alone without SSH, or vice versa, can at best offer a partial perspective, destined to fail.

Our universities in the main offer a diverse range of disciplines, making up an academic village of sorts, alongside neighborhoods with opportunities for wider and more diverse forms of community engagement. Properly oriented, we can hope to provide within these institutions the ideal environment to facilitate the growth and development of our children, and indeed our metaphorical child-like and adolescent selves, having collectively rebelled against our Mother, Earth, over several most recent decades. Through going beyond necessary (though self-referential) disciplinary knowledge and experiences, to also seek out reciprocal transdisciplinary engagement, we can thus strive to come of age, so to speak, and develop the maturity and wisdom required to adequately address the substantial challenges and interconnected crises we have been party to creating. The question facing us now is not only 'what is to be done?', but whether universities are part of the solution or part of the problem in addressing and responding to our planetary emergency.

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