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CHAPTER 2

Mapping the Global Dimension within teaching and learning

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Global Dimension in Engineering Education

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2 MAPPING THE GLOBAL DIMENSION WITHIN TEACHING AND LEARNING

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EXECUTIVE SUMMARY

This chapter attempts to map the Global Dimension of engineering within the academic setting and hence provide some pointers as to how academics can incorporate Global Dimension perspectives and capacities into engineering programmes. It takes its cue (both in terms of defining the Global Dimension and in framing the problem of Global Dimension incorporation) from the Engineers Against Poverty publication “The Global Engineer: Incorporating global skills within UK higher education of engineers” (Bourne and Neal, 2008), and proceeds to propose some possible interventions. For this reason, this chapter should be read in conjunction with the above mentioned publication, which is available online.

LEARNING OUTCOMES

After you actively engage in the learning experiences in this module, you should have developed the following:

- Capacity to map the Global Dimension onto existing educational contexts and engineering practices, including both content and the relevant regulatory frameworks.
- Awareness of specific opportunities incorporation of Global Dimension related initiatives and perspectives within teaching and research programmes.

KEY CONCEPTS

These concepts will help you better understand the content in this session:

- The mapping process; how to explicitly develop links between the Global Dimension and engineering education programmes.
- Mapping against regulatory frameworks.
- How to identify opportunities for integration of Global Dimension related perspectives and capacities into engineering education programmes.

GUIDING QUESTIONS

The guiding questions for this chapter relate to how the Global Dimension and its related perspectives and capacities can relate to and be successfully incorporated into engineering education programmes. The aim here is not to consider the Global Dimension as additional material which is simply added to an already overburdened programme in addition to 'core material'. Rather, the aim is that Global Dimension perspectives and capacities would be seen as a model or vehicle for enhancing existing engineering programmes in such a way that will enable them be both relevant and fit-for-purpose in facilitating the education of engineers for our contemporary world and society.

The approach is therefore critical of current pedagogical approaches ("*We are not equipping graduates for dealing with complexity and uncertainty.*" (Bourne and Neal, 2008)), while it views Global Dimension initiatives as being orthogonal to 'core material' so that Global Dimension issues permeate right through a programme. It does not so much require extra material, but a different perspective on how programmes are constructed and delivered. This is of course based on an understanding of engineering as a normative endeavour, i.e. that engineering has an ethical responsibility: "*the overall mission of the profession as contributing to human welfare*" (Colby and Sullivan, 2008). This goes against the opposing conception, which is rooted in the belief that "*the profession is 'value neutral' [and] that we are all but 'guns for hire'*" (Bucciarelli, 2008). Indeed it is this latter vision, Bucciarelli (2008) argues, which remains "*implicit in all of our teaching in the core of our disciplines*". This however, he argues is simply irresponsible of engineering educators:

> "*While teaching the 'fundamentals' of science and mathematics, and the engineering sciences remains necessary, we must do so in more authentic contexts, showing how social and political interests contribute in important ways to the forms of technologies we produce. We ought not as faculty imply as we do, that solving single answer problems or finding optimum designs alone, uncontaminated by the legitimate interests of others is what engineers do all of the time. This is irresponsible.*" (Bucciarelli, 2008)

This chapter concurs with Bucciarelli's basic thesis, as well as that of the late educationalist Paulo Frieire who reflected that "*it seems fundamental to me to clarify at the beginning that a neutral, uncommitted and apolitical education practice does not exist*" (Shaughnessy et al., 2008). This also coheres with the concept of the 'new engineer', as articulated by Sharon Beder (1998), which essentially describes an engineer who "*recognises that values and ethics pervade all engineering practice, leaves hubristic illusions of control aside and embraces context, complexity, inherent uncertainty and risk*" (Byrne and Mullally, 2014).

INTRODUCTION

The 21st Century contemporary world and society we inhabit presents a range of unprecedented interconnected meta-trends which have emerged as part of the ongoing evolution of our global (ecological, social and techno-economic) system. These include:

- Unprecedented rates of anthropogenically induced climate change
- Unprecedented levels of ecological destruction
- An anthropogenically induced Halocene extinction event, culminating in the current elevated levels of species extinction rate
- Unprecedented human global population
- Unprecedented levels of (absolute and per capita) human consumption rates and appropriation of materials and energy
- Access to unprecedented scientific knowledge and capacity
- Unprecedented levels of technological ascendancy, complexity, prowess and technological encroachment on people's lives
- Unprecedented levels of human connectedness at the global level and an increasingly globalised world
- Unprecedented levels of disconnect and isolation between humans/human society and our environment/the natural world

Added to these is an economic system characterised by boom-bust cycles which both requires continual economic growth to maintain itself and which tends to promote increasing levels of wealth concentration and economic inequality (Jackson, 2009). Such a system is unsustainable (Morgan, 2013). In addition, there are associated significant health and social problems globally such as elevated levels of unemployment, anxiety, isolation, violence, depression and issues associated with unprecedented levels of obesity.

These issues, it has been argued, represent symptoms which are the inevitable culmination of a modern conception of progress which envisions progress as a linear determinate pathway towards increased ascendancy, complexity, control and certainty (Wright, 2005; Ehrenfeld, 2008; Ulanowicz, 2009; Kauffman, 2010, Ehrenfeld and Hoffman, 2013). Regardless of how one envisages the diagnosis, the issues outlined above are very real and will impact greatly upon the professional and personal lives of engineers practicing through the 21st Century as well as that of society and our world more generally. It therefore behoves the community of engineering educators and associated stakeholders to seriously consider how these issues should impact on, and influence the education of contemporary engineers so as to enable them to be fit-for-purpose in understanding and addressing these interconnected issues. Introducing a Global Dimension to engineering education can help facilitate this.

INTRODUCTION TO INTEGRATION OF THE GLOBAL DIMENSION INTO PROGRAMMES

Bourne and Neal (2008) in their Global Engineer publication make the argument that:

> "*Higher education needs to prepare engineers of the future with the skills and knowhow they will need to manage rapid change, uncertainty and complexity. Key here is the ability to tailor engineering solutions to the local social, economic, political, cultural and environmental context and to understand the impact of local action on the wider world.*"

They also state that within the Education for Sustainable Development (EngSD) realm, the focus has traditionally been on "*environmental rather than social and political dimensions*", which is a claim substantiated by the leaders in the field of Engineering Education for Sustainable Development (EESD) (Segalàs et al, 2012; Desha and Hargroves, 2014).

Conlon (2008) expresses concern that an overly instrumentalist and technological approach taken by engineering at the expense of broader humanitarian and social issues not only does reputational damage to the profession but also helps facilitate continued gender imbalance in the profession, and suggest that "*to attract women, the humanitarian role of engineering should be highlighted including the role of engineering in promoting sustainable development*".

This appears to be backed up by research, such as for example evidence that female engineers are particularly attracted to a profession which can enable them "*make a [positive] difference to the world*" (Alpay et al, 2008) as well as to programmes which are "*more interdisciplinary, contextualised*" and which require "*a complex understanding of technological knowledge and student-centred learning*" (Du and Kolmos, 2009). This points to a need for a broader self-perception of the engineer as one which will not just provide instrumental 'value free' design and analysis, but as Bourne and Neal (2008) put it, are also adept at "*recognising the contribution engineering can make to securing economic and social change*".

This in turn raises a couple of key questions:

- 1. How, for example, might engineers be equipped to understand the context that surrounds their practice?

- 2. If engineers are to be part of a process of socio-economic economic change (as opposed to playing a disinterested technocratic role) then in what direction should this be directed?

There is general consensus around the answers to these questions, certainly among Global Dimension and EngSD education practitioners and researchers. In response to the first question, Bourne and Neal (2008) contend that 'global skills' incorporate competencies in areas such as "*critical thinking, multi-disciplinarity, team working, the ability to work across cultures and contexts, systems thinking and strong inter-personal and communication skills*". Furthermore, they identify the following Global Dimension related concepts:

- Sustainability
- Development education
- Global ethics
- Human rights
- International relations
- Political analysis
- Justice and equality
- Cross-cultural capability
- Diversity
- Inclusivity
- Gender/Race/Ethnicity/
- Nationality/Disability
- Business responsibility
- Citizenship

Bourne and Neal (2008) then proceed to cite the "*framework for the global dimension within the engineering profession*" under three generic headings: Themes, Skills and Dispositions (see Table 3 in Chapter 1).

Drawing from an earlier publication by the Development Education Association (McCollum and Bourne, 2001), Bourne and Neal (2008) point out that the upshot of all this is that for them to be effectual, 'global skills' must include "*essential skills in critical engagement*", which means that their "*education needs to prepare students for life-long learning in a globalised society which enables them to cope with and adapt to this complexity, uncertainty and vulnerability*", and this demands "*fundamental shifts in course content and delivery*". This means they propose, that (engineering) graduates must be educated to recognise (and consequently handle):

- The value of critical thinking
- The complex nature of the world in which we are living
- The increasingly vulnerability of economies and societies to global shocks
- That the future is uncertain and there are not necessarily a series of easily identifiable solutions

To accomplish this, Bourne and Neal (2008) propose the following four perspectives and approaches within the context of engineering education:

- A futures perspective
- A business case (recognising the social role of business in the 21st Century and corporate social responsibility)

- A critical perspective (recognising engineers actions have social consequences and equipping graduates to recognise and handle complexity and uncertainty)
- A whole systems approach (recognises the interconnectedness of actions; social and economic)

These perspectives can be represented by a worldview which aligns with the concept of the new engineer (Beder, 1998), and more broadly with what other conceptions of reality such as 'complexity thought' (Morin, 2008), 'new era thinking' (Gidley, 2013) and approaches to transdisciplinarity (Nicolescu, 2008). It is also informed by well-established approaches to science and reality including the concepts of post-normal science (Funtowicz and Ravetz, 1993), mode II science (Gibbons et al, 1994), wicked problems (Rittel and Webber, 1973), integral and postformal studies (Gidley, 2013), the 'new science of complexity' (Jörg, 2011), the 'end of certainty' (Prigogine, 1997) and a 'third window' on the world (Ulanowicz, 2009).

Embracing the above approaches, including developing futures, critical and whole systems approaches, facilitates the comprehensive formulation of an answer to the second question regarding what direction engineering practice should take. This is an unapologetically normative construction of the engineer as one who is a co-creating participatory agent for positive change (alongside fellow professionals, other disciplinary experts, stakeholders and publics alike); an engineer who is working towards a progressive society and world where we collectively steer away from the unprecedented mega-trends discussed earlier, which can, in this context, be regarded as mere representations of the interconnected symptoms of an unsustainable societal construct.

The upshot is a radically transformative way not simply of 'doing' engineering but of fundamentally 'viewing' it (Byrne & Fitzpatrick, 2009), consistent with "*a new Enlightenment, to redefine our notion of progress*" (ICEE, 2007). Academically, in terms of programme construction and delivery, it requires that programmes incorporate the Global Dimension and its accompanying ethic throughout. As Bucciarelli (2008) argues:

> "*If we, as engineering faculty, still claim that it is our job and responsibility to teach 'the fundamentals', it's time explicitly to recognise that what is fundamental to engineering practice goes beyond scientific, instrumental rationality; I hold that failure to acknowledge this fact is 'just about unethical'*."

DEVELOPING LINKS BETWEEN GLOBAL DIMENSION PERSPECTIVES AND CAPACITIES IN ENGINEERING PROGRAMMES

There is strong overlap between Global Dimension related perspectives and capacities in engineering programmes (Bourne and Neal, 2008) and those articulated in the EngSD literature (Lourdel et al, 2007, Segalàs et al, 2010; Byrne et al, 2013). Thus the model proposed by Bourne and Neal (2008) in relation to the application of Global Dimension to engineering education (as outlined above) is adopted here.

One modification here though is that the order of the four perspectives is changed: it is deemed that three of the perspectives are fundamental (and deeply interconnected): the critical perspective; the whole systems approach, and; the futures perspective. Meanwhile the business case emerges as a practical and pragmatic approach which requires the previous three perspectives to be successful.

Each of the perspectives are discussed and elaborated upon in Bourne and Neal (2008; pp. 6-8) and so won't be repeated here. However, the business case is revealed as problematic as constituted within the framework because it does not, generally in practice, either recognise or act consistently with the other three perspectives.

For example, Bourne and Neal (2008) point out that "*a review of the primary anticipated growth markets for engineering and construction companies shows they are concentrated in the developing countries and in regions prone to conflict and entrenched poverty*" including:

- Investment in oil, gas and mining with over $600bn projected expenditure over the next 10 years in Africa alone.
- Opportunities arising from the global application of emerging computing, energy, nano- and bio-science technologies.

Developments in the fields of fossil fuel and mineral resource exploitation and the application of emerging technologies do not, of course, proceed within a technological vacuum or closed system. In fact, the technological aspects (particularly for engineers) typically represent the easy part to solve for any larger problem!

The reality is that technological innovation and resource exploitation do not simply proceed along one way streets, leading to progress through realising simple end game 'solutions' (in the guises of GDP increase, economic growth and 'lifting all boats') that act as all-round unproblematic goods. Questions of power, decision making processes, rights of local and indigenous communities, patchy environmental laws and their enforcement – if considered and viewed from Global Dimension perspectives – may lead to alternative framings and possible outcomes (including ruling out or constraining the techno-economic developments).

Example of a Global Dimension change in perspective: global food supply and demand

Engineers play a key role at many levels and stages in the production of food. The dominant narrative dictates that – with a global population growing and predicted to reach 8 to 10 billion by 2050 – food production will need to increase by about 70% by 2050 (FAO, 2009). This would be done courtesy of a (techno-optimistic) projection of the green revolution, employing a number of productivist measures.

These measures would include raising the efficiency of production (e.g. "*yield improvements, adoption of improved production technologies, including improved seed varieties*" (G8 New Alliance for Food Security, 2012)) and related technological initiatives (including biotechnology, genetic modification, agrochemicals, irrigation, synthetic fertilisers, etc.), along with increased land use and instruments such as liberalised international trade and economies of scale (moving from small subsistence family producers towards agricultural industrialisation). The 'value free' conception of engineering education uncritically adopts the values and ideology inherent in this dominant worldview.

A Global Dimension infused engineering education – which requires the three perspectives of critical thinking, whole systems and the futures perspective – would on the other hand, find this simple 'solution' problematic on a number of levels. The fundamental shortcomings and deeply problematic nature of this approach have been widely articulated (Sage, 2012; Action Aid, 2014; McKeon, 2014) and a number of these are highlighted in Table 1 in terms of the three Global Dimension perspectives.

But we can go further. Elaborating on the point made in Table 1 about the additional energy gained from organic and more labour-intensive modes of agriculture ('pre-industrial') compared with wholly productivist approaches in the production of rice, Table 2 is based on data presented in Ho and Ulanowicz (2005). It shows that, in fact, the ratio of energy output-to-input is far higher in the 'pre-industrial' model. It also shows that similar (and even higher) differences between total energy of agricultural inputs and outputs can be just as good as (and in some cases better) with low intensive methods. Indeed, they conclude that "*there seems to be a plateau of output per hectare around 70–80 GJ regardless of the total input*" (Ho & Ulanowicz, 2005).

An understanding of the Global Dimension perspectives would have caused engineers to raise these questions and to recognise these traditional solutions.

Table 1 *Using Global Dimension perspectives to critique dominant approach to problem of feeding the world.*

Global Dimension Perspective	Critique the dominant approach to global food problem: *"A third more mouths to feed [yet] food production will have to increase by 70%"* (FAO, 2009)
Critical perspective (recognising social consequences, complexity and uncertainty)	• Inequality is the main driver behind global hunger and food insecurity, not food production or population; there is ample food in the world to feed everybody, even with a larger population; problems of obesity and under nutrition mirror each other globally. • Fails to address problem of (hugely resource intensive) meat production as well as animal welfare issues around intensive agriculture; assumes increased per capita consumption of meat, whereas a reduction would help mitigate problems. • Increased uncertainty and reduced resilience as a result of a globalised productivist model of food production with ever longer and more efficient supply chains. • Most critically, the productivist model fails to recognise finite global limits of land and (material and energy) resources.

Whole systems approach
 	
(recognising interconnectedness)
	• A worldview characterised by reduction and separation ignores or plays down the reality of a multitude of deeply interconnected features which impact on production and consumption levels, and which are exacerbated by an intensive agricultural model 'solution' e.g.
	    • climate change (and associated increase in extreme weather events)
	    • water availability and stresses
	    • energy security and availability
	    • environmental degradation (freshwater resources, desertification, deforestation, soil fertility) and biodiversity loss
	    • monoculture agriculture
	    • effects of overfishing on marine biodiversity (Worm et al, 2006)
	    • corporatisation and rural/agrarian unemployment
	    • transnational and multinational land grabs within a globalised framework alongside displacement of indigenous rights and increased concentration of power and wealth, fuelling increased inequality
	    • disempowering consequences of corporatisation and control of agricultural inputs e.g. through pushing the spread of genetically modified seeds
	    • replacing family farm units with low paid (often migrant) farm workers
	    • social disruption due to reduced viability of small farmholdings (unemployment, depression, suicide)
	• The additional energy provided by food produced from a productivist model of intensive agriculture which employs large energy inputs (e.g. high technology, synthetic fertiliser and pesticides) is no greater than the additional energy provided by low intensive (e.g. more labour intensive, organic fertiliser) cyclical whole system approaches (Ho and Ulanowicz, 2005), though the former results in increased soil depletion and environmental degradation, as well as greater social alienation and unemployment. Moreover, monoculture crop

	models promote increased soil depletion and reduce productivity (Ho & Ulanowicz, 2005). • Would support adopting policy supports for food production methods such as family farm units, organic farming, urban agriculture, grow it yourself, cooperative models of production and distribution/sales, small local retailers and markets as well as support for consumption patterns such as unprocessed, locally produced and vegetarian options. • A circular economy which coheres with social and ecological cycles requires an alternative economics to the linear 'boom-bust' classical model which requires perpetual growth to avoid economic and social hardship (Jackson, 2009; Morgan, 2013; Barry, 2013; Alexander, 2014). Consideration of this, the nature of such a model and its implications for practice may be considered.
Futures perspective	• Economic growth is associated with dietary change, including higher consumption of meat and processed food, as well as rising obesity levels and associated health issues. • Potential for mass social unrest and war fuelled by a growth based intensification model within a finite global (land, material and energy) limits, as these limits (e.g. water, land, energy) are stretched and passed.
Business role	• Taking on board all the above, the case may be made for an alternative business (and perhaps economic) model to emerge; perhaps one based on small localised enterprises within a planetary whole, with an increased respect for the artisan over the mass produced, a transformative shift from the profit and shareholder/share price/quarterly performance driver to a longer term ethos which values the long term sustainability of the enterprise through rooting it in the locality, with local suppliers and customers, empowerment and profit sharing among staff and a recognition of the primacy for care of social and environmental factors. • Engineers may also reflect on and critique the ethical implications of current business and economic constructs, and on their own future career paths and potential contributions.

Table 2 *Comparing energy flow of high and low intensive models of agricultural production* (data from Ulanowicz and Ho, 2006).

Rice fields	# Studies	Fossil fuel input (%)	Human input (%)	Energy Output / Input	Output-Input (per hectare) GJ
'Pre industrial'	8	2-4	35-78	6.9-29.2	2.4-166.9
'Semi industrial'	10	23-93	4-46	2.1-9.7	51.75
'Full industrial'	7	95	0.04-0.2	>~1	65.66

As this example shows, an engineering education which views the profession as ‘value free’ and education in general as ‘neutral, uncommitted and apolitical’ will choose to construct a sanitised (though incomplete and wholly inadequate) version of reality, which excludes all but the utilitarian and narrow ‘scientific’ aspects.

This is essentially an exercise in reductionism par excellence, the ultimate consequence of Cartesian dualism from which has emanated our modern and contemporary ‘age of separation’ (Eisenstein, 2011). It is an ultimately unsustainable and inadequate (world) view of reality based upon reduction and separation/disjunction (Morin, 2008).

A Global Dimension approach, by contrast, would seek to encourage students – with both increased intellectual honesty and reduced hubris – to embrace the messy complexity and indeterminacy that is part of facilitating a better understating of reality, and to competently deal with emergent issues. This requires recognising and considering the underlying context and values that are always part of real world engineering practice.

MAPPING ENGINEERING AGAINST AND ACROSS CONTEMPORARY ISSUES

Bourne and Neal (2008) suggest that in an independent review of strategic global trends to 2036, the UK Government concludes that human activity will be dominated by three pervasive 'ring road' issues which will define contemporary society globally: climate change, inequality and globalisation. These issues frame the environmental, economic and social pillars of sustainable development. In their report on the global engineer, Bourne and Neal (2008) proceed to map out many of the relationships in terms of linkages and impacts between each of these three macro-societal issues and engineering (practice). The useful linkages and impacts matrix that they constructed is reproduced as Table 3.

Bourne and Neal (2008) recognise the interconnected and inherently complex nature of each of the issues as they identify the co-evolutionary nature of each of the respective pillars through binary feedback or causality loops. For example, engineering can impact on poverty through "*providing pro-poor energy, transport, shelter, health and water products*", while poverty impacts on engineering through its requirement for "*low cost solutions that are appropriate to cultural, political, social and economic environment*".

In Table 3, the respective impacts are generally presented in a positive manner as (self-rectifying and largely unproblematic) negative feedback loops. In addition, there is no commentary or proviso presented.

This however is problematic as the table presents a largely idealised version of reality. For example, in reality the current dominant societal model underpins an economics that shows no propensity to produce 'pro-poor' products. (Quite the opposite in fact, as the only products that are promoted are 'pro-market'.) Likewise, in places where widespread and endemic poverty are prevalent – such as throughout much of the global south – this may indeed lead to low-cost (and comparatively low-tech) engineering solutions being chosen where relevant. However this is not the case in ostensibly wealthy parts of the world where there are very high levels of societal inequality. In these places high-cost, high-tech options are generally available to society, though these are unaffordable to those affected by poverty. A closer examination of Table 3 thus facilitates the raising of questions about the problematic nature of these linkages.

In general, a more thorough and critical examination of proposed linkages and impacts in Table 3 can serve to demonstrate how critical, whole systems and futures thinking can lead to alternative conceptions of reality (rather than uncritically accepting the dominant largely unproblematic narrative). It can help develop a broader and radically improved understanding of our interconnected (social, technological, economic, environmental) reality and thus may help reduce risk of system failure, and improve resilience and sustainability.

Table 3 *Mapping three 'ring road' issues with engineering* (taken directly from Bourn and Neal, 2008).

Climate change linkages and impacts	Impact of climate change on poverty • Poor hit earliest and hardest with the least capacity to adapt. Climate change may led to: • Loss of habitats & biodiversity, • Loss of livelihoods / new opportunities, Increased frequency / severity of natural disasters, flooding and extreme weather, • Water scarcity & desertification, • Conflict, civil unrest and migration, • Health impacts & food insecurity. • Complex trade-offs: e.g. biofuels could boost or undermine livelihoods of poor, carbon markets could reduce or entrench poverty.	Impact of climate change on globalisation • The impacts of carbon trading and the shift towards a low carbon economy especially in energy, transport, foodstuffs, manufacturing, construction & tourism markets, • Localisation of supply chains & markets due to higher transport costs, • Increased risk, uncertainty & market volatility, Disruption to agriculture & infrastructure, • Failure to address climate change undermines global economy and support for globalisation processes.	Impact of climate change on engineering • New markets and opportunities in renewable energy, alternative fuels, energy conservation & waste reduction, • New research / innovation opportunities, • Disaster preparedness and relief and post-disaster reconstruction, • Low carbon economy especially in energy, infrastructure & construction markets.
Impact of poverty on climate change • Farming, energy, transport, urbanisation and development choices of developing nations are critical if global CO_2 reduction targets are to be met especially in rapidly industrialising economies (Brazil, Russia, India & China). • Global carbon trading and emissions targets must recognise the needs and rights of the poor and the obligations of industrialised nations.	**Poverty linkages and impacts**	Impact of poverty on globalisation • The responsibility to act ethically, contribute to poverty reduction and involve poor in decision making is becoming recognised by global corporations, • Failure to act responsibly or to address poverty undermines support for (current models of) globalisation. • Globalisation criticised by international development & trade reformers.	Impact of poverty on engineering • Requires low cost solutions that are appropriate to cultural, political, social and economic environment, • Requires participation of the poor and local knowledge, • Developing countries are often high risk / high return markets.
Impact of globalisation on climate change • International supply chains increase energy and transport impacts, • Reduced production costs increase waste and consumerism fuelling carbon emissions • Environmental impacts displaced to less developed country (LDC) production centres.	Impact of globalisation on poverty • Social, legal & environmental safeguards often lower in less developed countries (LDCs), • Offers economic opportunities esp. in natural resources & agriculture, tourism, manufacturing and fair-trade goods, • LDC economies vulnerable to capital flight and brain drain, trade rules disadvantage LDCs and undermine national sovereignty.	**Globalisation linkages and impact**	Impact of globalisation on engineering • Growth in LDC markets esp. in utilities, infrastructure & the extractive industries, • International supply chains promote technology transfer & standardised systems, • Growth in labour mobility, access to knowledge.
Impact of engineering on climate change • Transport, energy, agriculture, infrastructure and manufacturing choices determine impacts, • Engineering and innovation key to mitigation and adaptation, • Engineering key to disaster preparedness and reconstruction.	Impact of engineering on poverty • Engineering key to providing pro-poor energy, transport, shelter, health and water products and services, • Platform infrastructure and technologies provide an enabling environment for growth, • Engineering supply chains and technology transfer offer poverty reduction opportunities.	Impact of engineering on globalisation • Engineering knowledge and innovation especially in transport, energy, manufacturing and ICT are the drivers behind economic integration and globalisation, • Sustainability and climate change will force a revised model of engineering and globalisation.	**Engineering linkages and impacts**

Case study: Globalisation as problematic; alternative visions

A critical, whole systems and futures thinking perspective can also highlight the problematic nature of the phenomenon of market-driven globalisation. Exploration of problematic nature of globalisation as it is currently conceived and practiced and its linkages and impacts on the issues of poverty and climate change respectively – and how these can in turn relate to engineering practice – can yield potentially productive learning opportunities, particularly in terms of developing critical, futures and whole systems thinking skills among engineering students (see, for example, the proposed activity for this chapter).

While Table 3 makes the bold claim that "*sustainability and climate change will force a revised model of engineering and globalisation*", this is a questionable claim – particularly unless a critical approach is taken by the engineering profession as well as by society at large. Indeed the dominant perspective would hold that globalisation is a largely unproblematic good, and (as is claimed in Table 3) fuels "*engineering knowledge and innovation especially in transport, energy, manufacturing and ICT*" which are iteratively "*the drivers behind economic integration and globalisation*" and thus global economic growth.

Again this positive and largely unproblematic framing neglects to critically assess the social and ecological degradation that such a dynamic brings, the centralised ascendant concentration of power and wealth, as well as the ever-longer and more efficient global supply chains that facilitate separation of producers from consumers. While globalisation (as it is currently constituted) results in the emergence of new types of jobs, these are often of a lower paid or less secure nature, and often involve displacement to locations where social and environmental protections are weak and/or laws are poorly enforced. This benefits neither citizens of the north nor south.

Moreover, the overall result is the displacement of human jobs by technology. Given that the energy inherent in one barrel oil is equal to approximately ten years human labour, the economic 'value set' which dictates that human labour is worth several orders of magnitude less than oil means that the system is blind to the physical reality of material and energy limits necessary for sustainable long term flourishing of human society and its environment. MIT chemical engineering emeritus professor John Ehrenfeld (2014) identifies the intersection between the effects of globalisation and the importance of critical thinking (and a concomitant comfort with inherent uncertainty and indeterminacy) to engineers:

> "*You may say 'Why are your children being less exposed to critical thinking by the growing emphasis on the so-called STEM curriculum (science, technology, engineering and math)'… These are the very subjects that are assumed to be the basis of the improvements in efficiency that will cost some of these very students their jobs in the future. When that happens and someone says to them 'Sorry, but it's a fact of life that with more efficiency comes fewer jobs' they will not have the tools to dig down to discover the arbitrariness behind that 'truth'. And without that ability, they can do very little about the quality of their lives. Vaclav Havel, the intellectual liberator and President of Czechoslovakia, wrote 'Keep the company of those who seek the truth, and run from those who have found it'.*"

Picking up on the wisdom of Havel, the former Czech leader suggested that "*the time has come for people who feel a responsibility for the future of humankind on this planet*" to envision a globalisation of a different type, namely a "*globalisation of good*" (Havel, 2001). This would displace the emerging globalisation of ascendancy and control that marked both the failed totalitarian reductionist ideology of 20th Century communism as well as the analogous, and similarly flawed, totalitarianism that an ideology of globalised unfettered markets creates. Both seek to deny the humanity through control and the reification of an empty materialism (Havel, 2004):

> "*I believe that every kind of centralisation is dangerous... it is quite possible that some of us will live in countries where the gross domestic product is growing by leaps and bounds, where everything is flourishing, the superstores are full of goods, the roads are teeming with lorries, energy is getting cheaper all the time, there is more and more construction, more and more industrial zones, bigger and bigger multiplexes, and more and more persuasive advertisements assail us from all sides – and yet everything is somehow dull, desolate, empty, soulless, ugly and, in spite of its pretence of diversity, infinitely uniform. And people are more and more nervous, disenchanted, lonely and sad.*"

Havel summed up his alternative vision as follows (Havel, 2001a):

> "*It seems to me that the global world which we are entering - the globe enveloped in one single interconnected civilisation - must grow from mutual respect for various identities, various cultures and various instances of otherness and from a commitment to the principle of equality of all these cultures.*"

This 'globalisation of good' has been articulated by others under different formulations including as the new 'planetary première' involving emerging efforts "*by those who are in the process of constructing a future of solidarity and sustainability*" as a counterbalance to the 'Men of Davos' (Petrella et al, 2000). Earlier echoes are obvious in Teilhard de Chardin's original concept of 'planetisation' – one based on the emergence of an unprecedented global human consciousness or 'noosphere' i.e. the "*thinking envelope of the Earth*" in the wake of unparalleled interconnectedness and complexity on our finite planet (Chardin, 1959). These developments are often posited around the process of human self-realisation and our place within a larger emergent 'big history' of cosmic evolution (Chaisson, 2009). The related socio-geologic terms of 'anthropocene' (Crutzen and Stoermer, 2000; Crutzen, 2002), 'Gaia' (Lovelock, 2007) and of the unified planetary consciousness inherent in 'homeland earth' (Morin, 1999) serves to reflect our recent self-awareness as interpenetrating and interdependent collaborators in global socio-environmental change.

MAPPING AGAINST REGULATORY FRAMEWORKS

Bourne and Neal (2008, p.16) proposed a five-stage framework for embedding the Global Dimension in engineering programmes. The following steps are proposed for academics and course leaders interested in embedding the Global Dimension into their programmes:

- **Stage 1:** Develop their own understanding of the Global Dimension of engineering by mapping the issues and skills which have a Global Dimension and which are relevant to their courses and to map how these issues and skills are currently address within the curriculum.
- **Stage 2:** Understand how, by addressing these issues and skills, many of the accreditation-required learning outcomes are also addressed.
- **Stage 3:** Identify and prioritise opportunities to embed these issues and skills within the curriculum as well as extra-curricular activities. Develop and pilot new course material, methodologies and approaches.
- **Stage 4:** Seek opportunities to link course components together so that learning builds upon prior learning and so that cross cutting themes such as ethics, business responsibility and sustainability become integrated throughout.
- **Stage 5:** Pilot, monitor and evaluate the course innovations introduced and measure their effectiveness against course learning outcomes. Ensure staff have adequate time to monitor and evaluate course innovations and to reflect on and share this learning with colleagues as well as investing in additional professional development of teaching staff and in course assessment and development if appropriate.

Stages 1-3 are complemented by tables in Bourne and Neal (2008, pp.16-18).

Stage 2 involves a mapping exercise whereby facets of the Global Dimension are mapped against the UK SPEC learning outcome requirements (the formal requirements for professional accreditation of programmes by UK engineering bodies). The applicable learning outcomes used were from the then applicable requirements.

A more recent edition of the requirements published in 2014 (UK SPEC 2014) had the effect of strengthening many of the Global Dimension attributes (such as the ethical dimension and critical thinking) (Engineering Council, 2014). This follows a trend that has been common to engineering accreditation guidelines globally over the past few decades (Byrne et al., 2012). Table 4 maps the required learning outcomes for an Integrated Masters (MEng) degree programme (UK SPEC, 2014) against the relevant aspects that the Global Dimension can enhance. In total, a comprehensive application of Global Dimension perspectives and capacities can potentially facilitate the accomplishment of *over half* the total number of UK-SPEC learning outcome requirements (Table 4 includes 24 of 42 learning outcome areas).

Table 4 *Mapping the linkages between the UK SPEC learning outcomes for engineering courses* (3rd ed., 2014) *and the Global Dimension of engineering education*.

Science and mathematics	
Understanding of concepts from a range of areas including some outside engineering, and the ability to evaluate them critically and to apply them effectively in engineering projects.	The Global Dimension is essential to help develop critical thinking and helps facilitate contextualisation of engineering practice, including understanding areas outside traditional narrow engineering competences and working with people from various backgrounds.
Engineering analysis	
Understanding of engineering principles and the ability to apply them to undertake critical analysis of key engineering processes.	The Global Dimension is essential to help develop critical thinking and apply critical analysis throughout and across engineering practice.
Understanding of, and the ability to apply, an integrated or systems approach to solving complex engineering problems.	Systems thinking and its resultant approaches ranges from understanding how the components of engineering systems relate and impact on each other and whole life analysis to understanding complexity in human, natural and economic systems. The Global Dimension encourages students to place engineering within its widest context and understand global – local and engineering society linkages.
Ability to use fundamental knowledge to investigate new and emerging technologies.	The Global Dimension is essential to assess the suitability and sustainability of new and emerging technologies in different contexts.
Design	
Understand and evaluate business, customer and user needs, including considerations such as the wider engineering context, public perception and aesthetics.	Global case studies illustrate the importance and challenges of identifying end-user needs in unfamiliar contexts as well as the wider engineering and societal context.
Investigate and define the problem, identifying any constraints including environmental and sustainability limitations; ethical, health, safety, security and risk issues; intellectual property; codes of practice, standards.	The Global Dimension promotes understanding of relevant constraints, their complexity and how they vary according to the local context including environmental and sustainability issues; ethical, health, safety, security, risk and intellectual property issues, as well as appropriate implementation of relevant codes of practice and standards.
Work with information that may be incomplete or uncertain, quantify the effect of this on the design and, where appropriate, use theory or experimental research to mitigate deficiencies.	The Global Dimension is essential to help understanding of the nature of incomplete information and uncertainty and how to address it appropriately.

Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem including production, operation, maintenance and disposal.	Ensuring that all aspects of sustainability (including production, operation, maintenance and disposal) are built into problem solving is a key aspect of the Global Dimension as is creativity.
Communicate their work to technical and non-technical audiences.	The Global Dimension helps facilitate and realise the necessity for two-way communication with a broad range of stakeholders in the work of the engineer, both technical and non-technical.
Demonstrate the ability to generate an innovative design for products, systems, components or processes to fulfil new needs.	Opportunity to show the importance of creativity and innovation in addressing global challenges and adapting solutions, including via appropriate (product, system, component, process) design, in particular to a developing country context.
Economic, legal, social, ethical and environmental context	
Understanding of the need for a high level of professional and ethical conduct in engineering, a knowledge of professional codes of conduct and how ethical dilemmas can arise.	The Global Dimension is essential in helping to understand the fundamental importance of ethics and values that underpins all engineering practice.
Knowledge and understanding of the commercial, economic and social context of engineering processes.	The Global Dimension can facilitate an understanding of the social context of engineering practice as well as providing the opportunity to illustrate how these considerations vary greatly from place to place by using a wide range of examples and case studies from around the world.
Knowledge and understanding of management techniques, including project and change management that may be used to achieve engineering objectives, their limitations and how they may be applied appropriately.	Management techniques and tools for environmental, social and ethical issues provide an opportunity to explore the Global Dimension.
Understanding of the requirement for engineering activities to promote sustainable development and ability to apply quantitative techniques where appropriate.	The Global Dimension is essential to fully understand the contribution of engineering to issues of sustainability and sustainable development.
Awareness of relevant legal requirements governing engineering activities, including personnel, health & safety, contracts, intellectual property rights, product safety and liability issues, and an awareness that these may differ internationally.	The legal framework and its enforcement differs greatly between countries and sectors. Global examples can help illustrate this.

Knowledge and understanding of risk issues, including health & safety, environmental and commercial risk, risk assessment and risk management techniques and an ability to evaluate commercial risk.	The Global Dimension is essential to help understanding of the nature of risk and uncertainty and how to address it appropriately.
Engineering practice	
Understanding of contexts in which engineering knowledge can be applied (eg operations and management, application and development of technology, etc) .	The Global Dimension is essential to help facilitate critical contextualisation of engineering practice and in considering the relationships between development of technology and broader social issues and implications.
Understanding of appropriate codes of practice and industry standards.	Global case studies will illustrate how codes of practice and industry standards vary internationally.
Ability to work with technical uncertainty.	The Global Dimension is essential to help understanding of the nature of uncertainty including technical uncertainty and how best to incorporate this into context appropriate practice in various situations and locations.
A thorough understanding of current practice and its limitations, and some appreciation of likely new developments.	The Global Dimension emphasises the need to adapt and modify approaches in unfamiliar situations and to value new approaches and perspectives as well as to understand the context and drivers around current practice.
Understanding of different roles within an engineering team and the ability to exercise initiative and personal responsibility, which may be as a team member or leader.	The Global Dimension can be woven into project and design work, including within different roles through local, national and international volunteering and work placements with international engineering companies.
Additional general skills	
Apply their skills in problem solving, communication, working with others, information retrieval and the effective use of general IT facilities.	Design and research projects especially multi-discipline and team based exercises present excellent opportunities to incorporate the Global Dimension and develop these transferable skills.
Plan self-learning and improve performance, as the foundation for lifelong learning/CPD.	The Global Dimension facilitates the development of a lifelong learning approach to education, and to the development of lifelong/CPD skills and attributes such as critical thinking, understanding and dealing with uncertainty and risk, valuing and integrating knowledge from different sources and team working and communication skills.
Exercise initiative and personal responsibility, which may be as a team member or leader.	The Global Dimension facilitates the development of team-working, communication and leadership skills in the context of an uncertain and diverse global world.

Of course the Global Dimension can be mapped against other national or professional organisations accreditation/learning outcomes requirements. It can also be mapped against, for example, the UK Higher Education Academy's 'Aspects of Employability' criteria for graduates (Yorke and Knight, 2006; Byrne, 2012). In each case, to a greater or lesser extent, there is a requirement to incorporate some degree of competency in issues relating to the Global Dimension such as handling uncertainty and complexity, employing critical thinking, sustainability and ethics. (Byrne et al, 2010).

OPPORTUNITIES TO INTEGRATE GLOBAL DIMENSION IN ENGINEERING EDUCATION

Stage 3 of the five-stage framework of Bourne and Neal (2008) presents opportunities for the integration of the Global Dimension in engineering education. This is shown in Table 5.

Table 5 *Opportunities to embed the Global Dimension* (Stage 3, Bourne and Neal, 2008).

Embedding within the undergraduate curriculum
• Ethos and core values • Core and elective lectures and modules • Visiting lectureships • Feasibility and design projects • Dissertations and research projects • Management, business, innovation and enterprise skills • Innovative pedagogies and team based working
Partnerships
• Linkages between engineering schools and other faculties and graduate and research centres • Partnerships with business • Partnerships with development and community organisations • Partnerships with overseas campuses and universities based in developing countries
Extra-curricula learning
• Informal learning events
University level strategies
• Post graduate and short course training • Careers advice • Professional development • Curriculum review processes
Inter-university, national and international
• Sharing good practice • Education centres • Course accreditation processes • National and international collaboration, debate and policy initiatives

The following initiatives and interventions in the curriculum are proposed in the context of the generic themes, skills and dispositions associated with the Global Dimension (as outlined in the introduction) as well as the corresponding four Global Dimension perspectives (of critical, whole systems, futures and business). These are by no means exhaustive nor definitive but simply represent a range of the types of initiatives that can facilitate the development of a fit-for-purpose accredited programme through the provision of Global Dimension perspectives and capacities. Many of the particular initiatives cited here represent some tried-and-tested approaches used by the author in his teaching as a means of attempting to develop Global Dimension perspectives among students. However the type and number of appropriate initiatives for incorporating Global Dimension perspectives are bounded only by imagination.

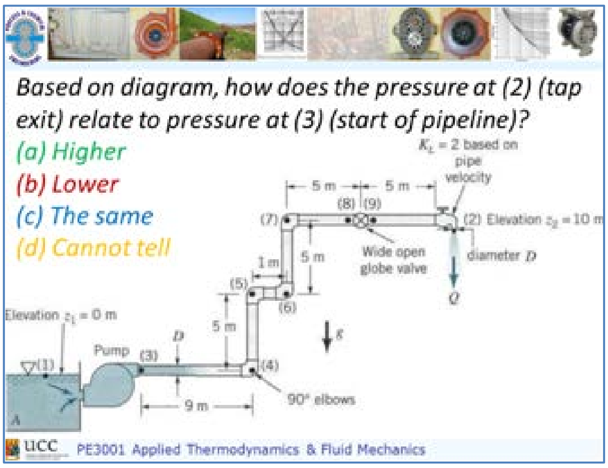
- **Support and encourage relevant curricular and extra-curricular global activities**
  The Global Dimension can be incorporated explicitly into programmes through the formal inclusion of projects, assignments, field trips, exchanges, communication link ups, etc, which deal directly with global and international issues (and in particular those relating to developing countries). These can be facilitated in association with local Engineers Without Borders groups and the wider Engineers Without Borders community. Formal programme-based initiatives can be supplemented by informal and extra-curricular activities through local Engineers Without Borders groups, which are often student led.

- **Active learning**
  A Global Dimension ethos incorporates ways of learning that facilitate active engagement. Among the Global Dimension generic skills listed by Bourne and Neal (2008) are "*active learning and practical application*". An approach to teaching which facilitates and encourages active learning can also facilitate the development of other Global Dimension related generic skills such as "*holistic thinking, critical enquiry, analysis and reflection*" (Bourne and Neal, 2008). There are many examples of active learning techniques available in the engineering education literature such as, for example, those proposed by Richard Felder (Felder and Brent, 2003, 2009; Bullard and Felder, 2007)

- **Problem Based Learning**
  Problem Based Learning is a popular and effective means of facilitating student engagement through some hands-on practical learning and is particularly suited to being employed as a means of explicitly incorporating elements of the Global Dimension (Lehmann et al, 2008; Du and Kolmos, 2009; Guerra and Holgaard, 2013).

- **Peer learning (Example 1)**
  Peer learning is a form of active learning which helps empower students with their own learning and facilitates cooperative and collaborative approaches to student learning. It can be facilitated through a wide range of techniques and formats. The physicist Eric Mazur is a proponent of an effective form of classroom based interactive peer learning involving clickers (Mazur, 1997; 2009). This can also be employed just as effectively on a more low tech easy to use basis by employing laminated coloured 'flashcards' (Lasry, 2008). It works by incorporating a series of overhead slides during the designated lecture session (as an alternative to the 'traditional' lecture). Each slide includes a question as well as four (judiciously chosen) possible multiple choice answers (see Figure 1).

Figure 1 *Multiple choice question used to facilitate active and peer learning.*



Students are then invited to individually reflect on the question and its possible answers before ‘voting’ on their chosen answer by selecting their choice either via a remote hand held clicker device or by holding up their coloured cards. If virtually all select the correct response the lecturer briefly discusses the item before quickly moving on to the next topic/slide. If however, there is a range of responses, students are asked to find a colleague sitting close or adjacent to them who has selected a different option, and to then confer/discuss/argue/debate the problem with them. After conferring, they are then asked to vote again. In many instances students tend to converge around the correct answer (Mazur, 1997).

However, and most importantly, each student will have reflected upon, actively engaged with and ultimately developed a better understanding of the topic at hand. Mazur makes a convincing argument that suggests that evangelical students learn better directly from each other (peer learning) i.e. from a fellow student who has just engaged with and developed an understanding of the topic from the first time, rather than from a professor (perhaps over twice their age and who is less able to envisage the difficulties and potential mental roadblocks surrounding learning some new concept).

In the experience of the author, this approach is much appreciated by students. On a fluid mechanics module that it was employed on, some 86% of respondents agreed that the approach of the lecturer in facilitating learning was ‘excellent’ while a similar proportion agreed that the stimulation to their thinking provided by the lecturer for this module was ‘excellent’. The following is typical of the qualitative feedback received on the initiative: “*The approach taken by the lecturer e.g. coloured flash cards and engaging the students to think about and answer questions rather than reciting notes, like most lecturers, is very effective*”.

The approach moreover can equally be used on either deterministic technical subjects or more open ended and qualitative subjects, such as sustainability and ethics for example, as a useful means of promoting active student engagement and in developing critical thinking.

- **Peer learning (Example 2)**

  Another example of peer learning which also helps develop critical thinking skills might involve group assignments requiring, for example, a design exercise such as the design of a biopharmaceutical facility involving process and chemical engineers. The design exercise might require the compilation and submission of a formal report. The lecturer takes the submitted reports and redistributes then among the various project groups, asking each group to critique the report they have received with a 1-2 page assessment. A week later, having forwarded their completed critiques to the lecturer, the respective design groups are then required to make a synopsis presentation on their respective designs to all of their peers and the lecturer in a formal setting. Following each presentation, the critiquing group are invited to question the presenters (in 'Dragon's Den' style) drawing from their short critique document as well as from the presentation just given. The lecturer then grades each component of the exercise (including the design report, critique, presentation, and how each group addresses questions from their peers). From experience and feedback, this works very well among students who acknowledge that the process really helps them engage with the material and develop their critical thinking skills through the respective modules.

- **Wicked problems**

  The term 'wicked problems' was coined in a seminal paper by Horst Rittel and Melvin Webber (Rittel and Webber, 1973). It relates to complex and messy real-world problems to which not only is there no definitive nor determinate 'solution', but whose very framing is contested; there can be wide disagreement on what the problem actually is.

  They thus summarise that "*it makes no sense to talk about 'optimal solutions*" and indeed "*there are no 'solutions' in the sense of definitive and objective answers*". Nor can there be any a-priori test to the 'solution' to a wicked problem, except through a pragmatic approach where options are tried and experiential knowledge is gained.

  Wicked problems therefore go beyond purely technical problems with defined and closed system boundaries; they involve some societal aspect or interaction with people. Values and ethics are inherent in describing and in tackling such problems. Socio-economic and policy/value based approaches are inevitably required in addressing wicked problems alongside any technical or technological initiatives. Resolutions of wicked problems thus never come from simple answers or simple thinking.

  Assignments can be set up and framed as bespoke wicked problems, as part of for example, ethics or sustainability related modules (Byrne, 2012a, Byrne and Mullally, 2014). Alternatively, the wicked nature of broader design considerations can be emphasised for the final year capstone design project (and incorporated in the framing and grading of assessment descriptions) to enable and encourage students to frame the design problems beyond narrow (largely black-and-white) technical limits. This helps to contextualise and posit the design in the real world; to incorporate messy social, ethical and environmental considerations.

- **Inter- and trans-disciplinary projects**
  Inter- and trans-disciplinary interactions and projects can act as very useful platforms for developing Global Dimension perspectives and capacities. For example, one initiative undertaken by the author has involved working with an academic colleague in sociology to facilitate the bringing together of two groups of students from different modules (though each is in the area of sustainability) for a number of collaborative workshops. This involved watching a documentary (which critically reflects on issues of social and ecological degradation in the global south as a result of interventions from the global north, as a consequence of the market driven model of globalisation) as well as a number of sessions whereby students were matched up into groups and asked to articulate, consider and ultimately present on some aspect of sustainability. This exercise incorporated part of the assessment for each of the modules. The general response from students (both engineers and sociologists) was overwhelmingly positive, not least as it gave each of them the opportunity to engage with, challenge, understand and reflect on very different perspectives and methods, including their conceptions and epistemological frameworks common to their own respective disciplines.

- **Ethics**
  Modules dealing with ethics are an ideal platform upon which to incorporate the Global Dimension. Projects, assignments and teaching and learning strategies such as those outlined above can be readily, imaginatively and productively incorporated onto ethics modules, thus bringing them to life and transforming the ethics class from a turgid box ticking exercise (typically involving some individualistic micro-ethical dilemma which requires students to answer to ‘What would you do if…?’) into an opportunity for insightful and reflective student learning dealing with broader macro-ethical one (e.g. around issues of sustainability and societal, organisational and professional norms) (Herkert, 2000, 2005; Bucciarelli, 2010; Conlon, 2010; Conlon and Zandvoort, 2012; Byrne, 2012a).

- **Final Year Capstone/Project**
  Final year design projects and other such capstone courses provide an ideal platform for exploring and integrating Global Dimension perspectives, for example through broadening the scope of the assignment to incorporate issues around ethics, sustainability and effects and appropriate considerations with respect to the developing world. Ultimately this implies a broader (re)conception of the role and nature of design

"*towards a reflective, creative practice*" to the point where engineers would "*view design as a reflected social practice ideal for open, complex problems at the intersection with other professional fields*" (Petersen, 2013).

The role that the above-mentioned initiatives can play in meeting accreditation criteria are highlighted in Table 6, in relation to how they can be applied to meeting the core requirements of 'basic' engineering (scientific and mathematical, computational and modelled design) and 'embedded' material (sustainability, ethics, safety, uncertainty, risk, social, environmental, contextualised design decisions) learning outcomes as well as those relating to 'transferable' (communications, team-working, knowledge sharing) skills.

Table 6 *Some initiatives which promote Global Dimension perspectives and their respective accreditation requirements.*

Initiative	Basic	Embedded	Transferable
Supporting and encouraging relevant curricular and extra-curricular global activities		✓	✓
Problem Based Learning	✓	✓	✓
Active learning	✓		
Peer learning	✓		
Problem framing			✓
Wicked problems		✓	✓
Inter- and trans-disciplinary projects		✓	
Ethics		✓	
Final Year Project	✓	✓	✓

The initiatives described above present only a small subset of possible initiatives that can be undertaken to incorporate Global Dimension and Global Dimension perspectives/capacities into engineering programmes. Indeed, imagination is the only limit to the possibilities. Various constraints (times, resources, etc) will always apply, and not every initiative will meet with immediate (or eventual) success. The key ingredient required, however, is an aspiration to enable and empower learners to meet their full potential by developing the necessary skills and aptitudes (critical, reflective and complex thinking, self-awareness and empathy, teamwork, listening and communication skills) to be fit-for-purpose in addressing the complex issues around (un)sustainability and human flourishing in a contemporary, globalised 21st Century society. Once this aspiration remains the driver, all manner of creative possibilities can emerge.

CONCLUSION

The current chapter had described a framework for the Global Dimension in engineering education which builds on contemporary state of the art (re)sources on this area. It has proposed a number of (inexhaustive) possible initiatives that can facilitate the incorporation of the Global Dimension and Global Dimension perspectives that can also help meet contemporary and emerging programme accreditation requirements. It is suggested that an enthusiasm for incorporation of Global Dimension perspectives by relevant actors and academics – coupled with appropriate programme-level and module-level experimentation – can go a long way in helping precipitating the necessary transformational change to develop engineering programmes and graduates that are fit-for-purpose in addressing contemporary societal issues.

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FURTHER/SUGGESTED MATERIAL

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