The Barcelona Declaration revisited: core themes and new challenges

Richard Fenner and David Morgan

[1]Department of Engineering, Cambridge University, Cambridge , UK

raf37@cam.ac.uk

dcm32@cam.ac.uk

Abstract

The 2004 Barcelona Declaration is briefly reviewed and gaps reflecting current thinking around sustainability are identified. We ask is the Barcelona Declaration still fit for purpose, and what can be added or amended to reflect new trends and challenges that should be the over-riding concern of all responsible engineers? Our aim is to stimulate a debate so that EESD 20 can collectively agree to update a new version of the Declaration which reflects with urgency the growing emergency we face. We identify 9 dimensions which are not explicitly reflected in the original Declaration and propose 6 new competences which might be added to reflect how the drivers behind engineering education for sustainable development must reflect an understanding of six imperatives: values, context, uncertainty, change, limits and vision.

1 Introduction

The 2nd International Conference on Engineering Education for Sustainable Development in 2004 issued a call to engineering educators to produce a different kind of engineer with a broader understanding of complex issues and who would be guided by a longer-term, systemic approach and ethical considerations in decision making (see Appendix A) . Known as the Barcelona Declaration it has been referred to many times in succeeding Conferences and its spirit was evoked in Philadelphia in 2018 (e.g Martinez et al (2018)) at the ninth EESD gathering. Recent international reports remind us that we are facing a climate emergency (ipcc, 2018), huge losses of biodiversity through unprecedented rates of species extinction (IPBES 2019), a global water crisis, increased hazards from extreme events (World Economic Forum 2019) and dangers of mass population movements including the trend to urbanisation (World Economic Forum 2017). Situations that were urgent in 2004 are now becoming critical, with warnings that humanity has around 12 years to enact the changes needed to save the planet. So is the Barcelona Declaration still fit for purpose, and what should be added or amended to reflect new trends and challenges that should be the over-riding concern of all responsible engineers?

There is little wrong with the Declaration calling as it does for engineers to understand how their work interacts with both society and the environment, and how it impacts in different cultural, social and political contexts. Calling for multi-disciplinary teams, much has been achieved since 2004 to adapt technology to ensure resource efficiency, pollution prevention and waste management (e.g Prasad and Shih, 2016) with principles of the circular economy becoming central to many engineering operations. Its plea to move beyond the tradition of breaking reality down into disconnected parts, borne out of a Newtonian Science tradition of problem solving, and to listen closely to demands of citizens, was arguably ahead of its time. This is now recognised in many engineering institutions where the technical fix can only achieve partial solutions to the wicked problems facing all communities and societies.

Drawing on the Barcelona Declaration, Segalas et al (2018) proposed a Sustainability Competency Map identifying four skills essential to develop in all engineering graduates. These include: critical contextualisation of knowledge; sustainable resource use and prevention of negative social and environmental impacts; participation in community processes; and application of ethical principles. These aspects of sustainability are helpfully related to the need for knowledge, understanding and application supported by specific descriptors of how this might be achieved

But it is also striking what the Declaration does not say, raising the question whether these competences are enough. For example there is no mention in the Declaration of climate, limits, growth, population, uncertainty or even the basic services needed by everyone for survival, and the tradeoffs which may have to be made in meeting these. Nor is there any sense of a future vision which can act as tangible goals for the next generation of engineers to work towards. More recently sinister forces have appeared in the form of popular denial of expert knowledge and understanding in a world which is increasingly polarised into seemingly irreconcilable viewpoints. A complete embracing of the spirit of the Barcelona Declaration is not enough in a world where the careful gathering of evidence is no longer respected as the basis for being "right" about a problem and where inconvenient truths are dismissed as fake news. Mitchell, Carew and Clift (2004) saw engineers as honest brokers, and a critical skill for future engineers is to go beyond being merely scientifically correct on an issue but to engage in ways that are more empathetic in communicating solutions that are rooted in rational analysis.

It is not the purpose of this paper to re-write the Barcelona Declaration, but to stimulate a debate so that EESD 20 can collectively agree to update a new version which reflects with urgency the growing emergency we face. Some issues which may have a bearing on this discussion are described in the following sections and we are sure others will emerge that are not identified here. Segalas et al (2018) analysed the key themes expressed in 600 papers delivered over 8 EESD conferences. They found topics that had declined were environmental design, LCA and management and policy, whilst transdisciplinarity, circular economy, and ethics and philosophy had increased. They also concluded that EESD was not happening at the pace it should in many Universities despite initiatives to promote integrating sustainable development in higher education (Lozano et al 2015; Ramos et al 2015). Lazzarini and Perez-Foguet (2018) point to the commodification of higher education as a barrier and impediment to a clear institutional commitment to the Barcelona Principles with university rankings (and the metrics which underlie these) becoming increasingly more important for measuring universities global competitiveness.

It is clear that many are still coming to the debate for the first time with Wilson (2019) (citing evidence nearly a decade old) boldly claiming that "most engineering programs do not explicitly prepare students to engineer within the bounds of sustainability". So it is worth reflecting on what, in some cases, is being discovered for the first time, and ask are the notions of sustainability as expressed 16 years ago still fit for purpose, if they are to guide how engineering education for sustainable development is adopted, developed and delivered? There is a need to move beyond the (implicitly balanced) triple bottom line simplification of sustainability to more nuanced arguments which directly address the concerns raised above, and as Wilson calls for, build skills to address the major challenges that face engineers in the 21st century such as responding to the full range of Sustainable Development Goals (Leal Filho et al, 2019).

2 Missing dimensions of the Barcelona Declaration

2.1 Uncertainty, Avoiding Technical Lock-In and Adaptation Planning

We live in very uncertain times, ranging from instabilities emerging in our political systems to the extent of impacts from climate change and the consequences of interfering with the global ecosystem. Uncertainty arises in many ways, such as from inherent *unpredictability* of systems, *incomplete knowledge* of system responses, and multiple legitimate, and often competing, *knowledge frames* and world views of stakeholder groups which influence how problems are perceived and defined.

Managing that uncertainty will increasingly be required by engineers. This has been achieved in the past through large infrastructure projects where technical precautions smooth out environmental variabilities; examples include providing shelter, flood protection, drought mitigation, pollution prevention and so on. However we don't live in a static system, with step changes becoming apparent away from the trends we can discern in the historic record. This means predicting and planning for an uncertain future is extremely difficult, as decisions made now may have huge impacts - and the propensity to get things wrong is very high. Effectively operating under this uncertainty will be a cornerstone of how future engineers deliver their services, and they should always retain flexibility in the solutions they propose.

It is essential that future engineers avoid the trap of creating a technical lock-in to inflexible solutions, often manifest as large infrastructure projects such as the Thames Tideway Tunnel in London, which comes with a very high cost burden (and carbon footprint) and may no longer be fit for purpose in just a few years time. This requires a paradigm shift from a "design and defend" or "predict and control" mindset which implicitly conveys a false sense of security, to an approach which follows the principles of adaptation planning.

Adaptive pathways are becoming more widely used by keeping a range of alternative options open so a wide variety of relevant uncertainties can be explored. Short-term targets are connected to long-term goals over time, commitment is made to short-term actions while retaining flexibility to move to alternative pathways as new information and understanding becomes available, and the world is continuously monitored and actions taken when required performance standards can no longer be met (Walker et al, 2013). Examples of this approach have been given by Kosmielja and Paslawski (2015) in relation to road schemes in Poland; Wirkus (2016) in relation to railways and by Hall et al (2019) who explore pathways for tidal flood risk management in London based on the adaptation options identified by the Thames Estuary 2100 project (Bloemen et al, 2018).

2.2 Respecting planetary boundaries and stakeholder positions

Engineering is constrained by the finite resources it both consumes and needs to protect. Engineers will have to quickly learn how to work within increasingly stringent carbon budgets and wider resource scarcity. In short , they will need to do more with less in ways that meet the changing societal behaviours, pressures and expectations. These are changing far more rapidly than in the past, as seen recently in the public's changing attitudes to plastics. Engineers will have to modify future operation accordingly as these are redefined against new (and perhaps unexpected) pressures, as the criteria by which successful projects are judged will radically change. This requires another paradigm shift away from building and manufacturing solutions to meet societal wants but responding with minimum interference to meet essential needs. This can be partly achieved by following the sustainability hierarchy in Figure 1, where the preferred option is to reduce demand and make existing assets more productive with large engineering solutions only considered as a last resort

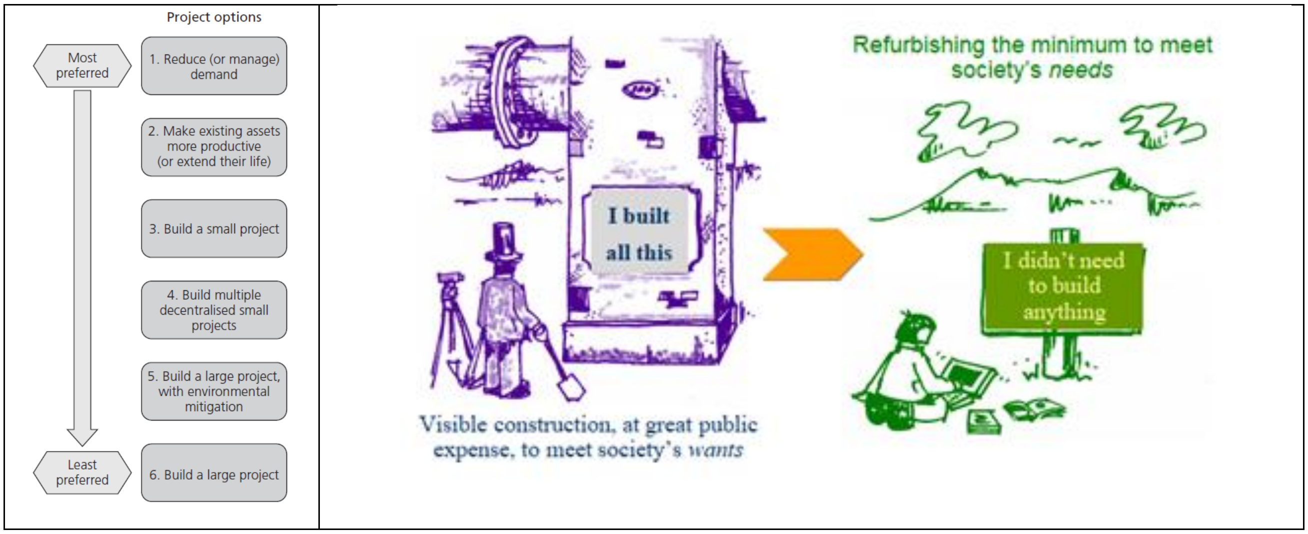

Figure 1 : A sustainability hierarchy and a change in engineering culture (after Ainger and Fenner 2014)

This fundamentally challenges many aspects of our current engineering culture, in which much of our job satisfaction comes from building and making things. New skills and education, coupled with new business models, are needed to achieve this so environmental limits are respected and society's needs are met, but wider wants such as cheap unlimited air travel are restrained/

2.3 Delivering change against a future vision

Meadows, Meadows and Randers (2004) believed that " a sustainable world can never be fully realised until it is widely envisioned, while accepting that vision without action is useless and needs to be disciplined by scepticism". It is important is to possess the vision that improvements in the quality of environment, social fairness and economic prosperity can be sought through change. But Prince Charles (2012) observed in a direct address to engineers: "So much of modern (engineering) thinking seems to have ignored the importance of looking to the long term". The process of working with scenarios directly aids broader thinking, stimulates new ideas and assists in shaping how new interventions can be implemented.

The Infrastructure Transitions Research Consortium (https://www.itrc.org.uk/) recognised it is not possible to design a subsystem as complex as civil infrastructure, decades in advance with a specified strategy for phased implementation where many adaptations will be needed in the intervening years. Nevertheless such systems don't arise spontaneously and need strategic intent, so that "the pathways for reaching sustainable end points from the current state ....need to be set now" (Hall et al, 2013). Engineers need to look far enough ahead so as not to be constrained by current barriers and mindsets. Always asking "where do we want to be 50 years from now" can help focus on long term sustainable objectives.

2.4 Resilience

Some are beginning to argue that concepts of sustainability have proven too hard to deliver in engineering practice and parts of the engineering industry has moved on to simpler and more tractable terms such as resilience (Ashley et al, 2020). This is often referred to in relation to infrastructure systems but often misconstrued as simple durability.

But "Resilience" doesn't have a generally consensual definition. Key features of engineering resilience are the resistance to disturbance and the speed of return to equilibrium. Other formulations refer to ecological resilience which sees resilience in a more dynamic way where the capacity to absorb the magnitude before changing its structure is the main feature (Bertillson et al, 2018). Holling (1996) stresses that engineering resilience focuses on efficiency, constancy and predictability while ecological resilience focuses on persistence, change and unpredictability.

Abdulkareem and Elkadi (2018) provide a thorough discussion of the different forms of resilience contrasting the engineering fail-safe approach with the ecological safe-to-fail response, which has a profound implication for how engineers are trained in engineering design.

2.5 Responding to wicked problems

The world is fundamentally messy with many problems not amenable to the technical fix which much of engineering education promises. Indeed many challenges may be intractable in terms of a "right" or "wrong" solution which a reductionist education traditionally seeks. Lonngren, Ingerman and Svanstrom (2017) suggest current educational practice may not adequately prepare students to deal with such problems. In an often cited quote, Schon (1987) contrasts the high hard ground of manageable problems with "the swamp wherein lie the problems of greatest human concern". Educating engineers to operate effectively in this swamp is fundamental if elegant, sophisticated and difficult solutions are ever to be accepted and implemented in the real world.

These problems are often emergent properties of complex systems and arise because understanding the system behaviour cannot be reconciled to a single perspective but have to be understood through multiple legitimate and often competing viewpoints. However such complexity should not be looked at as something nasty that has to be reduced or avoided, but accepted as a pre-condition for innovation and transition (Geldof and Stahre, 2006).

2.6 Fit for purpose solutions (context)

Engineering for Sustainable Development is not a prescriptive science. It can't be treated like a Code of practice, where if stringent guidelines are followed a sustainable solution will emerge at the end of the process. A greater skill is asking a wider set of question which expose the context within which the engineering solution must be delivered. Davide Stronati (2017) points to a fundamental misunderstanding in arriving at sustainable solutions where the sustainability approach may be the same across different projects *but the solutions are not*, as these must emerge from highly specific local contexts. This view is reinforced by Rogers (2012) who states "What is sustainable is determined locally". This requires an ongoing strategic engagement with many different stakeholders and constant dialogue with all the teams delivering an engineering project. In this way sustainable solutions will effectively emerge, in ways acceptable to all parties that result in a higher chance of successful implementation.

2.7 Handling tradeoffs

A fundamental fallacy of sustainable development is the apparent balance which the classic Venn diagram of equally weighted social, environmental and economic domains implies. This looks pleasingly neat on the page but necessarily unattainable in practice. Tradeoffs will always be necessary and some issues require more weight than others, such as the fundamental protection of Natural Capital in the strong sustainability interpretation of the 5 capitals model (https://www.forumforthefuture.org/the-five-capitals)..

If we extend the criteria by which engineering is assessed then ways of handling this multi-dimensional and interdisciplinary complexity need to be applied. In an LCA for example, simply incorporating more impact categories may result in confusion, unless it is understood how some categories may have more importance, significance and relevance to the problem

Multi-criteria analysis and negotiation skills become essential tools in the engineer's toolkit. This may require a diversion into the realms of subjectivity (judgement and opinion) which leave many classically trained engineers uncomfortable because their objective view of the world may be challenged.

2.8 Persuading the sceptics and deniers

McDonough and Braungart (2013) argue that sceptics and deniers are one of the greatest assets available in delivering sustainable development, as once converted and on-side they can become the most powerful advocates for change. However, whereas arguments used to be underpinned simply by the sheer weight of supporting evidence, this is now no longer enough in a world of post-truth and misinformation and experts are frequently simply derided (such as the entire UK Environment Agency by senior Government ministers). This perhaps is one of the biggest and most insidious changes since the Barcelona Declaration was formulated in 2004. For engineers to articulate sustainable responses they need to go beyond just being merely "right" about whatever issues they are dealing with but to engage using communication skills that also engage the emotional and moral characteristics of their professional and public audiences. Equipping the next generation of engineering graduates with this skill may prove to be the most important education challenge of all

2.9 Values

Sustainability remains a contested concept and is value based. But negotiating shifts in values via indoctrination in lecture based environments is prone to failure, and instead requires more student centred learning strategies, including problem based learning, experiential learning, participatory learning, and applied learning (Wilson 2019). Whilst previous generations have focused on the logos component of Aristotolean rhetoric, increasingly the ethos and pathos are rising to the fore and these can be guided by professional and personal commitment to genuine improvements which positively benefit the environment and society. Most engineers would want their work to be worthwhile, but articulating a specific position (e.g on climate change) can help provide a touchstone by which all subsequent actions and decisions can be tested.

3. Conclusions – new competences are needed

In many ways the drivers behind engineering education for sustainable development lie in an understanding of six imperatives: values, context, uncertainty, change, limits and vision. This provides clues regarding what might be added to a revised version of the Barcelona Declaration that may emerge from this Conference. But also challenges are beginning to emerge which question the prevailing approaches to sustainability which are essentially based on a belief that sustainability can be delivered by exploiting nature in a smarter way and controlling it better based on faith in individual behaviour changes and technical fixes (Horton and Horton, 2019). More radical views on how transitions to sustainability might happen need also reflecting in the Declaration, based on living in harmony with life on earth and not dominating it. A challenging approach to sustainable development itself is necessary to avoid complacency. This requires an understanding why some have seen sustainable development as an empty idea containing within it the seeds of further environmental, human, and social degradation, where technical fixes inherently don't work, and calling for an ontology of care to replace the current ontology of need (Ehrenfeld, 2008).

The Declaration is explicit about the educational processes that should be reviewed and calls for institutional commitments, which still need strengthening further in the context of the emergency we face, so Universities become agents for change. The Declaration mentions "universal values" without defining what these might be and recognises the importance of evaluating the contribution of engineering activity in a wide range of contexts.

In concluding we propose the following as a starting point for further discussion which explicitly add new themes to what is already included in the Barcelona Declaration:

Values: to develop commitments to environmental protection and human development through contributing to the achievement of the SDGs.

Context: to connect local, regional and global concerns and systems so problems are framed against real world constraints

Uncertainty: to retain flexibility to adjust through frequent reappraisal and adaptation.

Change: to challenge orthodoxy and seek innovation.

Limits: to test all engineering decisions against their impact on planetary health (with respect to climate change, biodiversity loss, resource depletion) and societal well-being, (with respect to poverty, dignity and human rights) so as to maintain socio-ecological integrity of the planet.

Vision: the ability to formulate an anticipatory view of the future and to act within the precautionary principle , through strategic thinking.

Of course whilst this discussion revisits what should be taught in engineering education, it does not address *how* this should be done, and we acknowledge many aspects of good practice where these competencies are being effectively developed through novel pedagogies and inspiring leadership amongst educators (Leal Filho and Nesbitt, 2016**)**.

We close by highlighting the need to deliver this agenda within a rapidly diminishing window of opportunity, and this urgency provides an over-riding context for this paper. This urgency also applies with respect to the world of engineering decision making and management students will be entering. The vast majority of engineers who will be practicing and leading engineering projects through this window are already in post, so how can the University sector support Continuing Professional Development in this area? What should be prioritised in university curricula in the coming years? And finally what does the urgency of the challenge imply for EESD?

References

1. Abdulkareem M, Elkadi H., (2018) From engineering to evolutionary, an overarching approach in identifying the resilience of urban design to flood. International Journal of Disaster risk reduction Vol 28 pp 176-190
2. Ashley R., Gersonius B., Horton B (2020) Managing water – from problem to opportunity. Royal Society Philosophical Transactions A forthcoming special edition on Urban Flood Resilience
3. Bertillson L., Wiklund K., de Moura Tebaldi I., Rezende O.M., Verol A.P., Miguez M.G. (2018) Urban flood resilience - a multi criteria index to integrate flood resilience into urban planning. Journal of Hydrology
4. Bloemen P., Reeder T., Zevenbergen C., Rijke J., Kingsborough A. (2018) Lessons learned from applying adaptation pathways in flood risk management and challenges for the further development of this approach Mitigation and Adaptation Strategies for Global Change (2018) Vol 23 Issue 7:1083–1108 https://doi.org/10.1007/s11027-017-9773-9
5. Ehrenfeld J (2008) Sustainability by Design Yale UniversityPress. New Haven and London
6. Geldof G., Stahre P. (2006) On the road to a new stormwater planning approach: from Model A to Model B Water Practice & Technology Vol 1 No 1 © IWA Publishing 2006 doi: 10.2166/WPT.2006005
7. Hall J.W., Harvey H., Mannig L.J. (2019) Adaptation thresholds and pathways for tidal flood risk management in London. Climate Risk Management 24 (2019) pp 42–58
8. Holling C.S (1996) engineering resilience versus ecological resilience In Shultze P.C., (ed) Engineering within Ecological Constarints, National Academy Press, Washington Dc, USA
9. Horton P., Horton B.P (2019) Re-defining Sustainability: Living in harmony with Life on Earth. One Earth 1 (Elseveier) September 2019 pp 86-93
10. HRH Prince Charles (2012) Working in harmony with nature: the key to sustainability Proceedings of the Institution of Civil Engineers - Civil Engineering 165 Issues CE 3 pp 123-128 https://doi.org/10.1016/j.crm.2019.04.001
11. IPBES 2019) Global Assessment Report . United Nations Summary for Policy Makers available at: https://www.ipbes.net/sites/default/files/downloads/spm_unedited_advance_for_posting_htn.pdf
12. IPCC (Intergovernmental Panel on Climate Change(2018) Global warming of 1.5 degrees WMO UNEP ISBN978-92-9169-151-7 (Available at: https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf
13. Kośmieja M. and Pasławski J (2015) Flexible approach in designing infrastructure. Procedia Engineering Vol 122 (2015) pp 104 – 111 https://doi.org/10.1016/j.proeng.2015.10.013
14. Lazzarini B and Perz-Foguet A (2018) Profiling research of academics who successfully promote education in Sustainable Human Development. Journal of Cleaner Production 172 4239-4253
15. Leal Filho W., Shiel C., Paco A., Mifsud M., Veiga Avila L., Londero Brandi L., Molthan-Hill P., Pace P., Azeiteiro U.M., Ruiz Vargas V., Caerio S., (2019) Sustainable Development Goals and sustainability teaching at universities: Falling behind or getting ahead of the pack? Journal of Cleaner Production pp 285-294
16. Leal Filho W., Nesbitt S. (eds) (2016) New Developments in Engineering Education for Sustainable Development Springer International Publishing Switzerland 2016
17. Lonngren J., Ingreman A., Svansrom M. (2017) Avoid, Control, Succumb, or Balance: Engineering Students' Approaches to a Wicked Sustainability Problem Res Sci Educ (2017) 47:805–831

18. Lozano R., Ceulmans K., Alonso-Almeida M., Huisingh D., Lozanao F.J., Waas T., Lambrechts W., Lukman R., Huge J., (2015) A review of commitments and implementation of sustainable development in higher education: results from a worldwide survey Journal of Cleaner Production , 108 , 1-18
19. Martinez E., Rogers R., Raby L., Baker P., Satreke J., 92018) Environmental Engineering for Community Development- Engineering Design for Non-Engineering majors Proceedings of 9th International Conference on Engineering Education for Sustainable Development Rowan University, New Jersey, June 2018
20. McDonough W and Braungart M (2013) The Upcycle – Beyond Sustainability Designing for Abundance. Strauss and Giroux, New York, NY, USA
21. Meadows D., MeadowS D. and Randers J. Limits to Growth— the 30-year Update. Chelsea Green Publishing, Vermont, 2004.
22. Mitchell C.A., Carew A.J., Clift R. (2004) The Role of the Professional Engineer and Scientist in Sustainable Development Chapter 2 Sustainable Development in Practice: Case Studies for Engineers and Scientists Edited by Adisa Azapagic, Slobodan Perdan and Roland Clift John Wiley & Sons, Ltd
23. Prasad M.N.V , Shih K. (eds (2016) Environmental. Materials and Waste: Resource Recovery and Pollution Prevention . Academic Press, Elsevier (doi.org/10.1016/B978-0-12-803837-6.01001-5)
24. Ramos T.B., Caeiro S., van Hoorf B., Lozano R., Huisingh D., Ceulmans K. (2015) Experiences from the implementation of sustainable development in higher education institutions: environmental management for sustainable universities. Journal of Cleaner Production 106 3-102015).
25. Schön, D.A. (1987), Educating the Reflective Practitioner: Toward a New Design for Teaching and Learning in the Professions, San Francisco: Jossey-Bass
26. Segalas J., Carracedo F.S., Hernandez A., Busquetst P., Tejedor G., Horta R.(2018) The EDINOST project. Training sustainability change agents in Spanish and Catalan Engineering Education. Proceedings of 9th International Conference on Engineering Education for Sustainable Development Rowan University, New Jersey, June 2018
27. Segalas J., Drijvers R., Tijseen J., (2018) 16 years of EESD. A review of the evolution of the EESD conference and its future challenges. Proceedings of 9th International Conference on Engineering Education for Sustainable Development Rowan University, New Jersey, June 2018
28. Stronati D. (2017) Fact. Sustainability professionals don' have all the answers . ICE The Civil Engineers blog (See: https://www.ice.org.uk/news-and-insight/the-civil-engineer/november-2017/fact-sustainability-professionals-dont-have-all
29. Walker W., Haasnoot M., Kwakkel J.H. (2103) Adapt or Perish: A Review of Planning Approaches for Adaptation under Deep Uncertainty. Sustainability 2013, Volume 5, pp 955-979; doi:10.3390/su5030955
30. Wilson D (2019) Exploring the Intersection between Engineering and Sustainability Education Sustainability 11 2019 doi: 10.3390/su11113134
31. Wirkus M. (2016) Adaptive management approach to an infrastructure project Procedia - Social and Behavioural Sciences Volume 226 (2016) pp 414 – 422
32. World Economic Forum (2017) Migration and Its Impact on Cities World Economic Forum 91–93 route de la Capite CH-1223 Cologne/Geneva Switzerland (available at: http://www3.weforum.org/docs/Migration_Impact_Cities_report_2017_low.pdf
33. World Economic Forum (2019) Water scarcity is one of the greatest challenges of our time Available at: https://www.weforum.org/agenda/2019/03/water-scarcity-one-of-the-greatest-challenges-of-our-time/

Appendix A

EESD Barcelona Declaration (Final Version, October 2004)

Settled at the 2nd International Conference of Engineering Education for Sustainable Development

Preamble

We live in an increasingly complex world and we are at a critical juncture at which humanity must make some serious choices about the future. Our current model of development poses significant challenges when it comes to achieving a more just society based on respect for nature and human rights, and demands a fairer economy and greater solidarity towards different cultures and future generations.

Ignoring this reality when educating and informing future citizens, and therefore future professionals, could have severe consequences. It is undeniable that the world and its cultures need a different kind of engineer, one who has a long-term, systemic approach to decision-making, one who is guided by ethics, justice, equality and solidarity, and has a holistic understanding that goes beyond his or her own field of specialization.

Education supports a process of self-discovery and learning about the world, encourages personal development, and helps individuals find their roles in society. However, education is also a commitment to improving society by strengthening communities and stimulating social progress. This reality forces us to reconsider the purpose of our role as social actors, in particular as educators, and to construct a way of responding to these challenges.

Education, and particularly higher education, is a vital tool to be used for facing today's challenges and for building a better world. Higher education is essential if we are to achieve sustainable development and therefore social progress. It also serves to strengthen cultural identity, maintain social cohesion, reduce poverty and promote peace and understanding.

Higher education institutions must not restrict themselves to generating disciplinary knowledge and developing skills. As part of a larger cultural system, their role is also to teach, foster and develop the moral and ethical values required by society. Universities need to prepare future professionals who should be able to use their expertise not only in scientific or technological context, but equally for broader social, political and environmental needs. This is not simply a meter of adding another layer to the technical aspects of education, but rather addressing the whole educational process in a more holistic way, by considering how the student will interact with others in his or her professional life, directly or indirectly. Engineering has responded to the needs of society and without a doubt, today's society requires a new kind of engineer.

/ continued

We declare that

Today's engineers must be able to:

- Understand how their work interacts with society and the environment, locally and globally, in order to identify potential challenges, risks, and impacts.
- Understand the contribution of their work in different cultural, social, and political contexts and take those differences into account.
- Work in multidisciplinary teams, in order to adapt current technology to the demands imposed by sustainable lifestyles, resource efficiency, pollution prevention and waste management.
- Apply a holistic and systemic approach to solving problems and the ability to move beyond the tradition of breaking reality down into disconnected parts.
- Participate actively in the discussion and definition of economic, social and technological policies, to help redirect society towards more sustainable development.
- Apply professional knowledge according to deontological principles and universal values and ethics.
- Listen closely to the demands of citizens and other stakeholders and let them have a say in the development of new technologies and infrastructures.

Engineering education, with the support of the university community as well as the wider engineering and science community, must:

- Have an integrated approach to knowledge, attitudes, skills and values in teaching.
- Incorporate disciplines of the social sciences and humanities.
- Promote multidisciplinary teamwork.
- Stimulate creativity and critical thinking.
- Foster reflection and self-learning.
- Strengthen systemic thinking and a holistic approach. Train people who are motivated to participate and who are able to take responsible decisions.
- Raise awareness for the challenges posed by globalization.

In order to achieve the above, the following aspects of the educational process must be reviewed:

- The links between all the different levels of the educational system.
- The content of courses.
- Teaching strategies in the classroom.
- Teaching and learning techniques.
- Research methods.
- Training of trainers.
- Evaluation and assessment techniques.
- The participation of external bodies in developing and evaluating the curriculum.
- Quality control systems.

These aspects cannot be reviewed in isolation. They need to be supported by an institutional commitment and all decision makers, in the form of:

- A redefinition of institutions' and universities' missions, so that they are adapted to new requirements in which sustainability is a leading concern.
- An institutional commitment to quality.
- An institutional support for changing educational paradigms and objectives research funding.

Universities must redirect the teaching-learning process in order to become real change agents who are capable of making significant contributions by creating a new model for society. Responding to change is a fundamental part of a university's role in society. There is evidence that sustainable development has already been incorporated in engineering education in a number of institutions around the world. The United Nations Decade on Education for Sustainable Development (2005-20014) offers a great opportunity to consolidate and replicate this existing good practice across the international higher education community.

Universities now have the opportunity to re-orient the traditional functions of teaching and research, by generating alternative ideas and new knowledge. They must also be committed to responding creatively and imaginatively to social problems and in this way educate towards sustainable development