EESD2021

BUILDING FLOURISHING COMMUNITIES

10th Engineering Education for Sustainable Development

University College Cork, Ireland

14th June – 16th July 2021

eesd2020.org / @EESD2021

"Building Flourishing Communities"

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EESD2021 Welcome Address

Welcome to the **10th Engineering Education for Sustainable Development Conference**, themed ***'Building Flourishing Communities'***. Of course, as the conference website (eesd2020.org) attests, this conference was originally scheduled to be held at University College Cork in June 2020, two years after the previous one at Rowan University, New Jersey. However, a global SARS-CoV-2 pandemic precipitated a rescheduling pivot to June 2021, and its continued prevalence then foisted another pivot as we moved from a physical conference to an entirely virtual one. The result of course is a dimensional loss (from a 'real' 3D to a 'virtual' 2D experience), thus losing the opportunity to welcome an international cohort of delegates to our beautiful 172 year old campus of a 176 year old university to a conference which was to be hosted in our brand new centrally located student 'Hub', which artfully combines UCC architectural heritage from the 1860's with the 2020's.

Apart from the being deprived the opportunity to sample the delights of Cork in June, including a County Mayor's invitational social evening at 'Vertigo', on the top floor of Cork County Council's 17 storey County Hall, or a technical tour followed by dinner at Ireland's largest distillery at nearby Midleton, delegates have also missed out on a range of planned workshops. Indeed, four of the six planned workshops in total have been lost, each of which required a three dimensional presence, including a tantalising *'Movement and creative practices in engineering education'* workshop, developed in conjunction with UCC's Professor of Creative Practice, Jools Gilson of the School of Film, Music and Theatre. But most of all, delegates have been deprived the opportunity to connect, re-connect, engage in fruitful dialogue, and develop seeds of research proposals and other initiatives, all around EESD, a topic that enlivens and motivates us all.

All is not lost though! While the theme of this 10th EESD, *'Building Flourishing Communities'* seeks to reflect on how both the design and built environment applications of engineering explicitly needs to cohere with the social and societal domains, with the common aim of societal (and environmental) flourishing, this point has only been accentuated by the global pandemic. The pandemic itself has precipitated much reflection, and in an EESD context, it has highlighted several EESD strands and imperatives, including I suggest;

- INEQUITY: the real and negative implications of underlying social and economic inequality/inequity;
- **CONNECTION:** the deep interconnectedness of so many facets of life, and our globalised society amid a web of complex reality (ecological, social, economic, technological), as well as the inherently social nature of learning;
- **..BEYOND COMPETITION:** a reminder of the abject incapacity of *laissez faire* systems of neo-classical economics (and corresponding models and mindsets), to adequately support the most basic health, social, and environmental rights and imperatives across our societies;
- **RESILIENCE:** the ability to actually achieve the 'impossible' and fundamentally 'reimagine' our societies, particularly when we are forced to;
- **FRAGILITY:** the fragility of our society, exacerbated by humans' ever expansive encroachment on the natural world and the resulting biodiversity crisis, one which can and has led to, among other things, enhanced zoonotic activity, and elevated risk of global pandemic.
- **TECHNOLOGY;** both what and how much we can do with it – in education (including opportunities to work, study and connect remotely) and beyond (e.g. virtual communications, online trade, the rapid development of vaccines, etc.), as well as its drawbacks; including access, equity, social disconnection and technological induced risk.

Some EESD2021 Highlights

While this first hosting of this conference 'on Irish soil' coincides with its first hosting in a virtual capacity, we do hope to provide a reasonable surrogate for the 'real' three dimensional event. We hope to do this by admixing some local Cork/UCC and Irish flavour with the universal movement and ethos that EESD represents.

We Irish are renowned for our use of language, and this will borne out by our keynote speakers from the north of our island; **Prof John Barry** and **Dr Therese Hume**, who, as transdisciplinarians *par excellence* will provocatively reflect with the engineering and architectural community on how we might navigate the transition from un-sustainability within and across the whole higher level educational landscape in these turbulent times.

This will be added to by the sage reflections of **Brendan Touhy**, who will draw upon the work of a poet from Ireland's deep south-west with truly universal connections, John Moriarty, while reflecting upon the skills needed by contemporary engineers as we face an unprecedented energy transformation.

The internationally infused local flavour is complemented by young activist engineer and UCC graduate, **Sorcha Ní Mhuimhneacháin**, who also took her Engineering for Sustainable Development MPhil at Cambridge and works out of Munich, as she seeks to change the world in a socially conscious way, and fast!

We also welcome keynotes from North America, for the Leo Jansen Best Paper Keynote, in **Dr Michelle Marincel Payne** and **Dr Wayne Padgett** of Rose-Hulman Institute of Technology, Indiana, who consider the importance of entrepreneurship, empathy and diversity in humanitarian engineering, as a means of enabling students and communities to flourish.

Finally, with a nod to EESD history and heritage, which from its original inception at TU Delft in 2002, has been hosted right across Europe and North America, we welcome a previous (2008) host from TU Graz, in **Prof. Michael Narodoslawsky**, who will reflect on the import of his work which has brought him from chemical engineering to community engagement in the area of bioenergy, and some perspectives for engineering education.

In addition, we are delighted to welcome as **workshop hosts**, academics from two previous EESD hosts at the **University of Cambridge** (2013) and **Rowan University** (2018) respectively. One workshop will seek to dust down and update the 2nd EESD's **'Barcelona Declaration'** (2004) (p.41), while the other will consider how the engineering curriculum which can best incorporate inclusivity, diversity and sustainability.

A real highlight of the EESD2021 promises to be the **EESD2021 Industry Forum**. Chaired by **Dr John Hayes** of UCC, this will feature a range of panelists from our sponsors **ESB** (who provide 43% of electricity generation capacity in Ireland's all-island market), **AbbVie** (a biopharmaceutical business with significant footprint across Ireland focused on novel and breakthrough therapies for tough-to-treat diseases and unmet medical needs), and local authority **Cork County Council**, the largest local authority on the island by geographical area.

The Forum will reflect on the **sustainability related knowledge, skills, and values that contemporary twenty first century graduates require**, increasingly with a high degree of uncertainty, while working in multi- and transdisciplinary settings and teams; as highlighted by COVID-19 pandemic! It will provide a valuable opportunity for delegates to engage and reflect with our local and national expert industry panel on issues of universal concern.

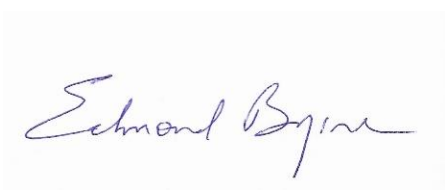
A Green University College Cork 'Céad Míle Fáilte'[1]

Finally, I'd like to welcome you to UCC, while highlighting some of our sustainability values and credentials – which hopefully you can witness first hand on an actual visit in the not too distant future. UCC's green credentials have benefited from the multi-decadal pioneering leadership of its Interim President **Prof. John O'Halloran** in this space, and Head of College of Science Engineering and Food Science and **Environmental Research Institute** (ERI) Director **Prof. Sarah Culloty**, a great promoter of multi- and transdisciplinary scholarship. The university is currently ranked 8th in the world by the Times Higher Education (THE) Impact Rankings, a rankings system based on progress with the UN Sustainable Development Goals. UCC is currently ranked 9th on the UI GreenMetric World University Ranking, was the first third level institution in the world to be awarded a Green Flag in 2010 from An Taisce on behalf The Foundation for Environmental Education, and in 2018 became the first university outside North America to win the gold Sustainability Tracking, Assessment & Rating System (STARS) rating from the Association for the Advancement of Sustainability in Higher Education (AASHE).

Apart from all this, UCC seeks to walk the walk; a **student led Green Campus** programme, enthusiastically supported by the Office of Buildings and Estates seeks to provide a campus which is as sustainable as it is beautiful, while research institutes such as the ERI recognise the need to go beyond "research-as-usual" thinking to help address today's multi-faceted environmental challenges, since the complexity of the global sustainability challenge requires experts from multiple disciplines and sectors to collaborate together to successfully develop usable knowledge and robust solutions.

Across its programmes too, UCC seeks to highlight and **embed 'sustainability'**, and allied to this **'inter- and transdisciplinarity'**. Indeed these are two of six pillars making up **UCC's Connected Curriculum** model, led by Prof. O'Halloran, which aspires to permeate throughout and across its full range of programmes (research based teaching, employability, civic and community engagement, and global reach are the other four). The Process and Chemical Engineering programme won the second ever Sustainability Teaching Award in 2016 from the UK professional accreditation body, the Institution of Chemical Engineers (IChemE), while a strong sustainability thread runs through all our School programmes in Civil, Structural and Environmental Engineering, Electrical and Electronic Engineering, in Energy Engineering and in Architecture.

Final thanks goes to our **EESD2021 Local Organizing Committee**, which I'd like to thank for their valuable input and several planning meetings from three years ago in helping realise this conference. In particular, the immense work of **Claudia Cashman**, Conference Manager must be thanked, as with the technical support provided by **John Barrett**, and the academic leadership of **Dr John Fitzpatrick** in overseeing the paper submission and peer review process. A massive thank you goes to our colleagues in UCC Conferences, specifically **Michael Kenneally** and **Sian James**, without whose input and support we could not have virtually hosted EESD2021. Here's to an enjoyable and productive 10th EESD conference!



Edmond Byrne

Chair, EESD2021

1 Gaelic (saying): 100,000 Welcomes!

EESD2021 Prenotes

In anticipation of EESD2021, and following the postponement of ESD2020, we hosted **EESD2021 Prenotes**, a series of free online interactive webinars. The webinars incorporated a number of thought-provoking speakers who addressed key themes associated with the conference series.

The first of these was held to coincide with the original EESD2020 conference date, on 9th June 2020, while this was followed up by a second one on 8th September 2020.

Details of the Prenotes, including some recordings are on the EESD2021 website at:

https://www.eesd2020.org/prenotes/

while the EESD2021 Prenotes speakers are featured on the following pages.

PRENOTES WEBINAR SERIES

EESD2021

BUILDING FLOURISHING COMMUNITIES

First EESD Prenote: Contemporary Industry Perspectives on EESD, 9th June 2020

The first EESD Prenote involved a number of industry based engineering practitioners whose work brings them into engagement with various societal and environmental projects.

They presented their thought provoking reflections and challenged engineering educators about how programmes ought evolve to produce fit-for-purpose contemporary engineering graduates who are capable of addressing emerging sustainability related challenges/crises/transitions, thus making a positive contribution to society and our environment. This was followed by a lively audience participatory dialogue.

Facilitator:

Dr Páraic Ryan, UCC

Speakers were as follows:

Clodagh O'Donovan – Arup – is a Director and the Planning Team Lead at Arup in Ireland. This team advises and delivers value to clients on projects in climate change and carbon, transport planning, master planning and urban design, statutory consent and environmental assessment. With 25 years' experience in civil and environmental engineering, Clodagh has extensive expertise in the management and delivery of complex, multidisciplinary projects. This includes guiding projects through the Environmental Impact Assessment (EIA), Appropriate Assessment (AA) and statutory consent process, as well as having significant experience in stakeholder consultation. Clodagh is a chartered engineer with Engineers Ireland (CEng, FIEI) and a registered consulting engineer with ACEI (FConsEI).

Sorcha Ní Mhuimhneacháin – Canadian Solar – graduated with a degree in Energy Engineering from University College Cork and an MPhil in Engineering for Sustainable Development at the University of Cambridge. During her studies at UCC she spent a year at the Technical University of Munich (TUM), specialising in renewable energy technologies. She also led the Engineers Without Borders Chapter in UCC, which became a dominant voice for sustainability issues on campus and a force for change in the education of engineering students. Her University of Cambridge research, sponsored by the Arthur Shercliff Memorial Trust, focussed on bottom-up strategies to accelerate the electrification of remote mountain communities in Nepal. In 2018 she returned to Munich to join Canadian Solar as part of their burgeoning Systems Solutions department. She now works on turnkey execution of photovoltaic projects in Europe. As well as informing technical design, she collaborates on strategy development for new market entry. Her priority is to target ventures which are mutually beneficial to both community and company.

Second EESD Prenote: 'Building Flourishing Communities; *With* rather than *For* Communities', 8th September 2020

The second EESD Prenote drew on the respective experiences and insights of an engineering professional practitioner and an architectural academic to consider how we might best go about *'Building Flourishing Communities'*, by working *with* rather than *for* communities.

From both sides of the Atlantic, Ireland and the USA, they reflected on their own experiences and on implications for contemporary education of professional engineers, planners and architects..

Facilitator:

Prof Brian Ó Gallachóir, UCC

Speakers were as follows:

Marguerite Sayers was appointed ESB's Executive Director, Customer Solutions in May 2018. Prior to this, she held the role of Managing Director, ESB Networks DAC – the electricity Distribution Network Operator for ROI. Marguerite joined ESB in 1991 and holds a primary degree in Electrical Engineering from University College Cork. Previous roles include being Head of Asset Management for ESB Networks and Customer Service Manager for Dublin South Division, as well as other senior roles in HR, Network Planning, Operations and Construction. Marguerite was also Manager of ESB Generation for two years where she was responsible for ESB's generation portfolio in Ireland and the UK. She is Chartered Engineer and both a Fellow and Past President of the Institution of Engineers of Ireland.

Stefani Danes, AIA LEED AP designs places that connect people with each other and their environment. Her socially responsive design arises out of a creative bridging of research, practice, and teaching. As a principal in the firm of Perkins Eastman, she focused on urban housing in distressed neighbourhoods, where affordability and resource conservation are critical goals. Prior to joining Perkins Eastman, she was a founding partner of an architectural office that specialised in community development. She was a Planning Commissioner for the City of Pittsburgh for six years. In addition to her professional work, she teaches at Carnegie Mellon University and practices as a Research Fellow of the Remaking Cities Institute. Stefani received her master's degree in architecture at Yale U.

EESD2021 Local Organizing Committee

Prof. Edmond Byrne

EESD2021 Conference Chair

Edmond Byrne is Professor of Process and Chemical Engineering at University College Cork. He has a Chemical Engineering degree (1995) and an MSc (1996) from University College Dublin, as well as PhD (2001) and MA in Teaching & Learning in Higher Education from UCC (2008). He is lead/co-editor of 'Transdisciplinary Perspectives on Transitions to Sustainability' (Routledge, 2017) and 'Metaphor, Sustainability, Transformation: Transdisciplinary Perspectives' (Routledge, 2021). A PI with UCC's Environmental Research Institute and MaREI, he is currently involved in a range of sustainability and transdisciplinary related projects such as DIIS, Imagining 2050 and Dingle 2030.

Director of the BE/ME in Process & Chemical Engineering, he co-led (with Dr John Fitzpatrick) the programme's Sustainability Teaching Award from the Institution of Chemical Engineers in 2016, and is a recipient of the IChemE's Morton Medal for Excellence in Chemical Engineering Education.

Claudia Cashman

EESD2021 Conference Manager

Claudia Cashman has worked as Personal Assistant to the Head of the School of Engineering and Architecture for close to 8 years. She was previously employed as a PA for the CEO for Food for Health Ireland and spent many years as administrator in the 'Food Area' in UCC. Claudia has 20 years experience in Event Planning at UCC ranging from International Conferences hosting audiences of over 200 to Industry Training Workshops and local Team Building Experiences.

John Barrett

EESD2021 Technical Support

John Barrett works in technical / IT support in the Department of Process & Chemical Engineering, University College Cork. His initial qualifications from Waterford Institute of Technology were in the area of Biotechnology. He later developed an interest in IT / Multimedia and completed an MSc in Multimedia Technology in the Department of Computer Science, University College Cork in 2007. He has also been responsible for the production of various multimedia devices for use in publicity and teaching, both within the school and in collaboration with other departments within UCC; These include this and other websites associated with the school, posters, promotional leaflets and short video presentations.

Dr John Fitzpatrick

Abstract/Paper Submission and Peer Review Process Lead EESD2021

John Fitzpatrick is a Senior Lecturer in Process & Chemical Engineering. He has a Bachelor of Engineering degree in Agricultural & Food Engineering from University College Dublin and a Master of Science in Food Engineering from University of Massachusetts. He also holds a PhD in Agricultural Engineering (Bioprocess Engineering) from Texas A&M University and a Diploma in Environmental Science & Social Policy from UCC. He is a corporate Member of the Institution of Engineers of Ireland (MIEI) and MIChemE. His current research areas are Powder and Particle Technology, Scholarship of Teaching and Learning (he holds an MA in Teaching and Learning in Higher Education from UCC) and Sustainable Process Engineering.

Dr John Hayes

Dr **John Hayes** is a senior lecturer specializing in electric vehicles, energy systems, power electronics and drives. He received a B.E. degree from UCC, an M.S.E.E. degree from the University of Minnesota, an M.B.A. degree from California Lutheran University, and his PhD from UCC. He worked at Power One Inc., of Camarillo, CA. He joined General Motors Advanced Technology Vehicle. He pursued a PhD as a Howard Hughes Corporate Fellow. Subsequently, he worked as a technical manager on EV battery chargers and infrastructure. John led a technical team collaborating with Toyota Motor Company. John joined the academic staff at UCC as a lecturer and currently teaches power engineering and power electronics and drives. His research interests are power electronics, machines, and magnetics for automotive, industrial and renewable energy applications. John directs UCC's Power Electronics Research Laboratory.

Dr Maria Kirrane

Maria Kirrane holds a BSc. in Environmental Science from UCC and a PhD in Ecology, which was undertaken between UCC and the United States Department of Agriculture in Baton Rouge, Louisiana. Prior to taking on the role as Sustainability Officer, Maria worked as a programme manager for the Natural Environment Research Council in the UK, and then as a postdoctoral researcher at the University of Limerick. The latter post explored the role of universities in driving the transition to a more sustainable society. As the Sustainability Officer for UCC, Maria is based within the Buildings and Estates department, but works with and across multiple offices and departments within the university. Research interests are principally around environmental education and innovative approaches to improving environmental performance, circular economy and biodiversity conservation.

Prof. Brian Ó Gallachóir

Brian Ó Gallachóir is Professor of Energy Engineering at University College Cork and Director of MaREI, the €60 million SFI Research Centre for Energy Climate and Marine. Brian leads MaREI's research on building and using energy systems models that have underpinned Irish and EU energy and climate mitigation policies and energy company strategies. He is also MaREI's Education and Public Engagement Champion and received the Science Foundation Ireland Best International Engagement Award 2020. Brian is elected Chair of International Energy Agency Technology Collaboration Programme on energy systems modelling (IEA-ETSAP) and an elected Fellow of the Irish Academy of Engineering. Brian has published extensively (over 110 journal papers and h-index of 44), has a B.Sc. from TCD and a PhD from UCC.

Dr Páraic Ryan

Dr **Páraic Ryan** is a Lecturer in Civil Engineering at University College Cork and a Conjunct Research Fellow at the University of Newcastle, Australia. Prior to joining UCC Páaraic was a Lecturer in Civil Engineering at NUI Galway for two years, where he was nominated by his students for the President's Award for Teaching Excellence. Before this he held the position of Research Academic at the word-renowned Centre for Infrastructure Performance and Reliability (CIPR), at the University of Newcastle Australia, where he worked in climate adaptation engineering for three years. Páraic also has a number of years industry experience, having worked in Civil Engineering Consultancy. Páraic holds an undergraduate Degree in Civil Engineering from NUIG, and a PhD, an MSc and a PGD form Trinity College Dublin. His main research interests are in risk and uncertainty modelling, material deterioration and climate change vulnerability and adaptation.

Dr Elena Tsalaporta

Elena Tsalaporta is a Lecturer in the Discipline of Process & Chemical Engineering at UCC since 2017. She received her BEng and MEng from the Department of Chemical Engineering in Aristotle University of Thessaloniki and was awarded a PhD from the School of Chemical and Bioprocess Engineering of University College Dublin. Her area of expertise is Carbon Capture, Utilization and Direct Air Capture and has led industry projects in collaboration with the European Cement Research Academy (ECRA). While she was a Senior Research Engineer in the CRANN Institute of Trinity College Dublin, she led the development of several patents and a spin-out company, called Trinity Green Energies. Elena is a Principal Investigator in UCC's Environmental Research Institute (ERI) and her current research priorities are related to Carbon Capture, Utilisation and Energy production; she is leading the development of sustainable engineering technologies and solutions with her "Carbon Lungs" project and the "MARS L.U.N.G.S." project, in collaboration with the European Space Agency (ESA). She is also actively working on research related to Teaching and Learning, as well as gender equality, while she is the director of a bespoke summer school in Sustainability, organised by the School of Engineering and Architecture in collaboration with the ERI, that will be launched in 2022.

Veronica Ottonello & Dr Andresa Ramos

The EESD2021 Local Organizing Committee were fortunate, and extremely grateful to have contributions at various planning stages from **Dr Andresa Ramos**, and **Veronica Ottonello**, whilst they were working at UCC. Andresa oversaw the compilation of the EESD2021 website (https://www.eesd2020.org/), while the structure and much of this programme is down to the work of Veronica.

EESD2021 International Scientific Committee

EESD2021 would like to thank the input of the conference **International Scientific Committee** members, for their support during a number of temporal and virtual pivots, and in particular for their work on the peer review process.

NAME	ORGANIZATION/ UNIVERSITY	COUNTRY
SANTIAGO ARANGO ARAMBURO	Universidad Nacional de Colombia	Colombia
EDMOND BYRNE	University College Cork	Ireland
STEFANI DANES	Carnegie Mellon University	USA
ADAM DE EYTO	University of Limerick	Ireland
RICHARD FENNER	University of Cambridge	UK
FREDRIK GRONDAHL	KTH Royal Institute of Technology	Sweden
GEAROLD JOHNSON	Colorado State University	USA
OLGA KORDAS	KTH Royal Institute of Technology	Sweden
BERNARD MAZIJN	Institute for Sustainable Development & Ghent University	Belgium
KAREL MULDER	The Hague University for Applied Sciences / TU Delft	Netherlands
MICHAEL NARODOSLAWSKY	TU Graz	Austria
SUSAN NESBIT	University of British Columbia	Canada
JAVIER OROZCO MESSANA	Universitat Politècnica de València	Spain
MARIANO SAVELSKI	Rowan University	USA
JORDI SEGALAS CORAL	Universitat Politecnica de Catalunya, Barcelona Tech	Catalonia, Spain
THOMAS SILLER	Colorado State University	USA
PRITPAL SINGH	Villanova University	USA
CORINNE SUBAI	INSA Lyon	France
MAGDALENA SVANSTROM	Chalmers University of Technology	Sweden

Energy for generations

ESB (Electricity Supply Board; established 1927) is a leading Irish utility focused on providing excellent customer service, with a regulated asset base of approximately €9 billion and 43% of electricity generation capacity in the all-island market. ESB currently supplies electricity to approximately 1.4 million customers throughout the island of Ireland. ESB Group employs approximately 8,000 people. As a strong, diversified, vertically integrated utility, ESB operates right across the electricity market: from generation, through transmission and distribution to supply. In addition, ESB extracts further value at certain points along this chain: supplying gas, using our networks to carry fibre for telecommunications, developing electric vehicle public charging infrastructure and more. ESB's mission is to bring sustainable and competitive energy solutions to all customers and our vision is to be Ireland's foremost energy company competing successfully in the all-island market.

AbbVie are a highly-focused research-driven biopharmaceutical company, who seek to come up with new approaches to addressing today's health issues—from life-threatening illness to chronic conditions.

AbbVie target specific difficult-to-cure diseases, leveraging core R&D expertise to advance science. AbbVie are constantly working to create solutions that go beyond treating the illness to have a positive impact on patients' lives, on societies—and on science itself.

At AbbVie, it's both what we do and how we do it that matters. We go beyond medicine, using our resources to improve healthcare and communities. We're committed to:

Improving health outcomes. We're targeting unmet needs and working to enhance access to healthcare across geographies.

Operating responsibly. It's the very basis of how AbbVie does business. We are committed to cultivating an ethical, transparent and inclusive culture to drive sustainable growth.

Contributing to communities. We're passionate about partnering with our communities to address challenges of the underserved.

EESD2021 Sponsors and Affiliates

NATIONAL FORUM
FOR THE ENHANCEMENT OF TEACHING
AND LEARNING IN HIGHER EDUCATION

The **National Forum for the Enhancement of Teaching and Learning in Higher Education** is the national body responsible for leading and advising on the enhancement of teaching and learning in Irish higher education. We work with those who teach, learn and shape policy and practice to ensure a valued and informed teaching and learning culture in Irish higher education. We focus on the professional development of all those who teach, teaching and learning in a digital world, teaching and learning within and across disciplines, and student success.For more information, please go to:
https://www.teachingandlearning.ie/conferencevideo/
or www.teachingandlearning.ie or follow us @ForumTL.

Fáilte Ireland
National Tourism Development Authority

As the National Tourism Development Authority, **Fáilte Ireland**'s role is to support the long-term sustainable growth in the economic, social, cultural and environmental contribution of tourism to Ireland. In addition, Fáilte Ireland supports Business Tourism, managing the bidding for and securing of larger conferences, meetings and events to be hosted in Ireland.

Comhairle Contae Chorcaí
Cork County Council

Cork County Council is the largest local authority in the country in geographical area and with a population of 332,255, is the second largest Local Authority nationally, the largest outside Dublin. With a revenue budget for 2021 of €348m and current staff numbers of approximately 2,000 (WTE), the Council delivers a broad and diverse range of services including Roads, Motor Taxation, Housing, Planning, Environmental Services, Economic Development, Tourism, Community Development, Arts & Heritage, Fire Services and Library Services. Cork County Council operations govern the most unique and diverse combination of areas in the country. of larger conferences, meetings and events to be hosted in Ireland.

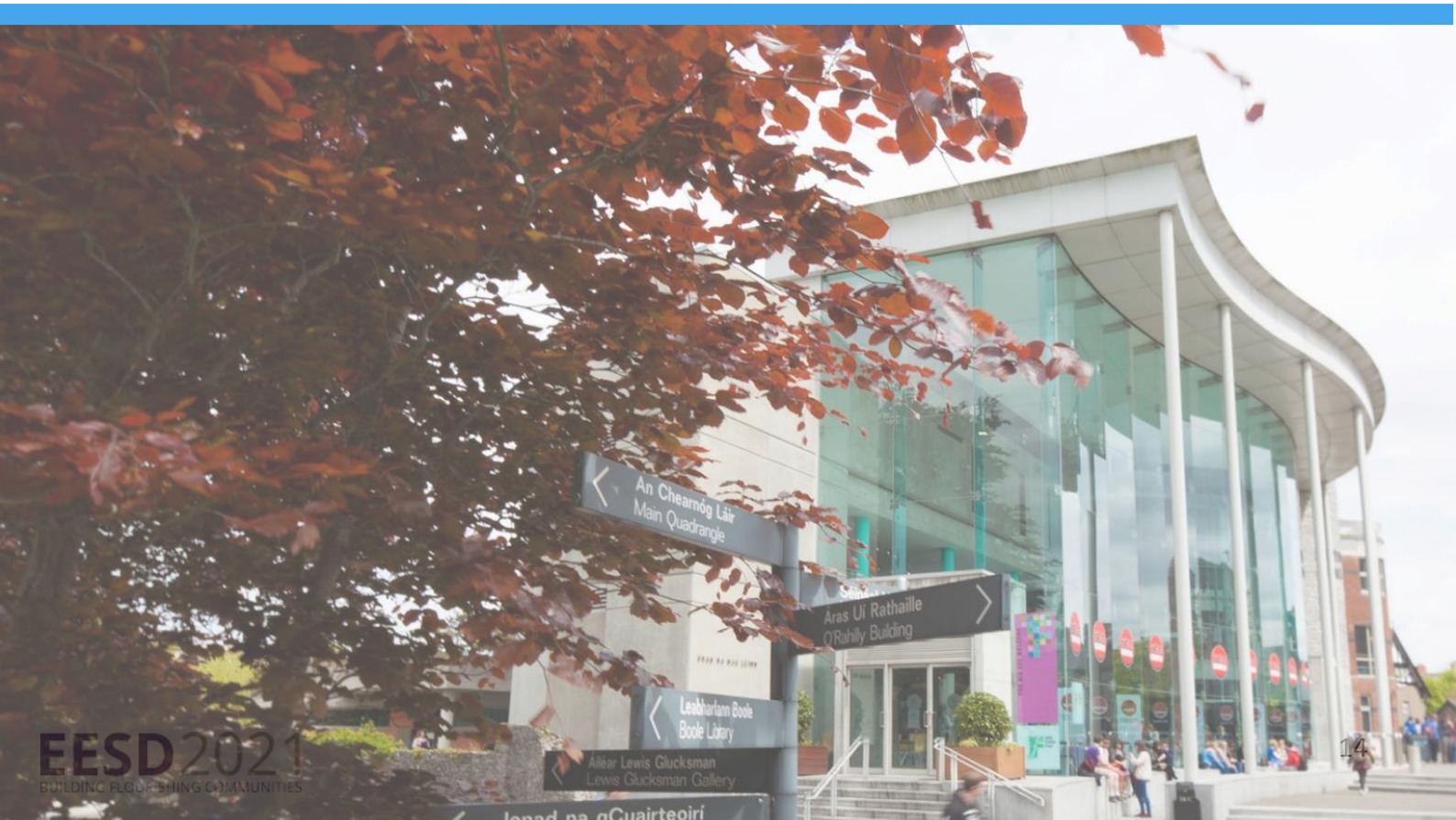
EESD2021 Programme

For full papers see ***'Proceedings of the 10th Engineering Education for Sustainable Development Conference'*** (ISSN: 2737-7741) via the EESD2021 website (eesd2020.org) or online via UCC's CORA Open Access repository from June 2021.

@EESD2021

Day 1 – 14th June 2021 (Opening Session)

TIME	SESSION
8:55 – 9:00	**EESD2021 Chair's Welcome** **Prof. Edmond Byrne,** *Professor of Process and Chemical Engineering, UCC*
9:00 – 9:10	**EESD2021 Welcome and Introduction** **Prof. John O'Halloran,** *Interim President, University College Cork*
9:10 – 10:00	**Dr Therese Hume and Prof. John Barry** *Sligo Institute of Technology and Queen's University of Belfast* *'Education in turbulent times: Navigating the transition from un-sustainability'*
10:00 – 10:50	**Sorcha Ní Mhuimhneacháin** *'"Activism in Engineering": The importance of elevating the ideas of young idealistic engineers as well as the value of modern activist culture'*



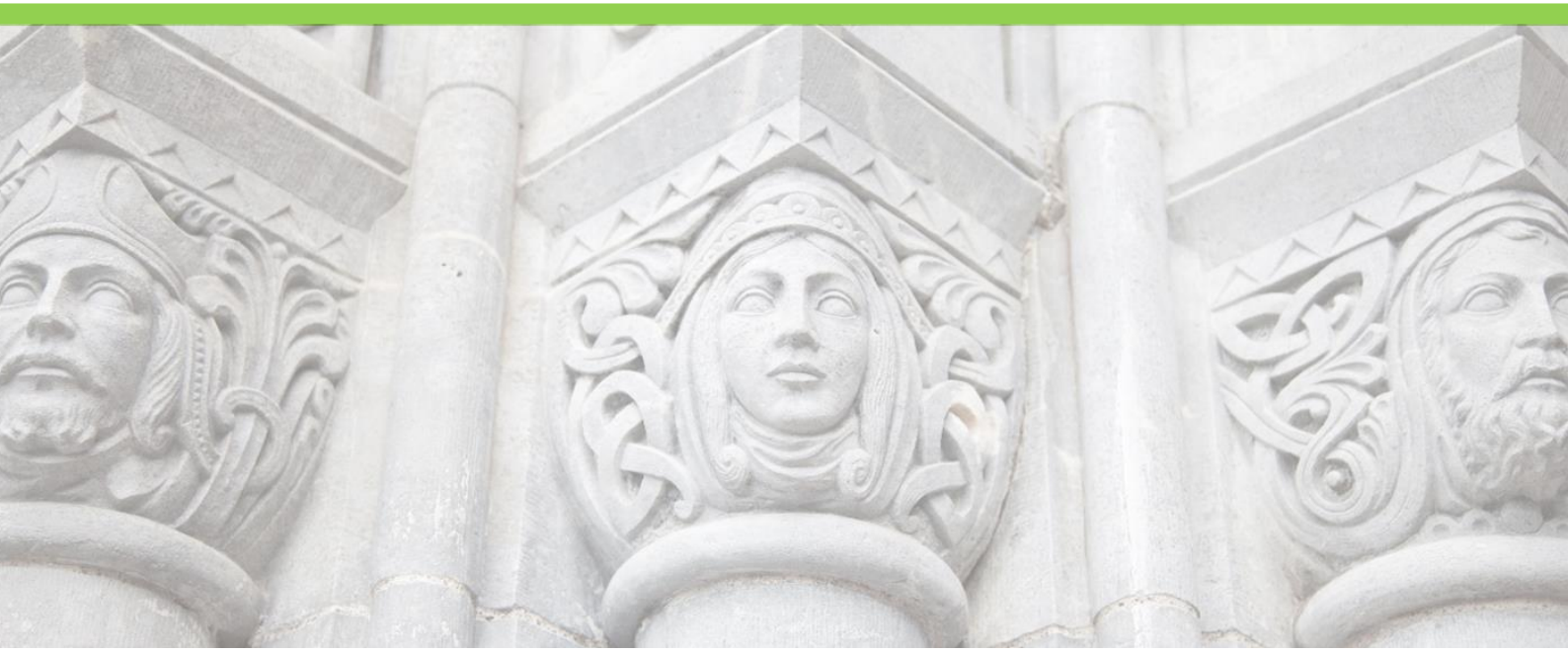
Day 1 - 14th June 2021 (Paper Presentation Sessions)

TIME	SESSION
11:10 – 12:30	**Parallel Session 1A: Pedagogical Approaches I** ***Chair: John Fitzpatrick (University College Cork)***
11:10 – 11:30	Sustainability Shares in the Classroom [33] *David Shallcross, U. Melbourne, Australia*
11:30 – 12:00	Challenge Driven Education for sustainability in engineering. A White Paper [94] *Gemma Tejedor [1], Anna-Karin Högfeldt [2], Jordi Segalas[1], Lena Gumaelius [2]. [1] UPC-Barcelona, Spain. [2] KTH, Sweden*
11:50 – 12:10	Using field trips in engineering education to facilitate the understanding of energy systems, technologies and transitions: an overview [81] *Lukas T. Gast, U. Cambridge, UK*
12:10 – 12:30	Walking the walk; meaningfully engaging people with engineering challenges [24] *Connor McGookin, Brian Ó Gallachóir, Edmond Byrne, UCC, Ireland*
11:10 – 12.30	**Parallel Session 1B: Teaching Circular Economy & Greener Technology I** ***Chair: Páraic Ryan (University College Cork)***
11:10 – 11:30	Teaching circular economy: Discussing limitations and opportunities of teaching about sustainable production [84] *Helen Kopnina, The Hague U. Applied Sciences, The Netherlands*
11:30 – 11:50	Circular Design project. Educating the Design Community in Sustainable Design [85] *Jordi Segalas [1], Adam de Eyto [2], Moireann McMahon [2], Yekta Bakirkioglu [2], Gemma Tejedor [1], Boris Lazzarini [1], Sine Celik [3], Alex Jimenez [4], Jonas Martins [5]* *[1] UPC-Barcelona, Spain, [2] U. Limerick, Ireland, [3] Stichting NHL, Netherlands, [4] Nut Creatives, Spain, [5] Ceci N'est Pas Une Holding B.V., Netherlands*
11:50 – 12:10	Connecting the Dots: Understanding Professional Development Needs of Istanbul's Makers for Circular Economy through Distributed Fabrication [72] *Yekta Bakırlıoğlu [1,2], Maria-Laura Ester Ramirez Galleguillos [1], Ivon Bensason [1], Asım Evren Yantaç [1], Aykut Coşkun [1].* *[1] Koç U., Turkey, [2] Middle East Technical U., Turkey*
12:10 – 12:30	Embedding Sustainability in Engineering Education through Interactive Industrial Design Case Studies [38] *Kevin Gibson, Jorge Oliveira, Denis Ring, UCC, Ireland*
12:30 – 13:20	**BREAK**

13:20 – 15:00	**Parallel Session 2A: Architecture and Sustainability** ***Chair: Adam de Eyto (Limerick School of Art and Design, LIT)***
13:20 – 13:40	Re-Structuring Practice for Sustainability: Learning from Case Studies [91] *Stefani Danes, Carnegie Mellon U., Craig Stevenson, Auros, USA*
13:40 – 14:00	Application of CDIO Standard for teaching the Architectural Composition Subject with a practice competition about green architecture at Ho Chi Minh City University of Technology, Vietnam [37] *Hai-Yen Hoang, Ho Chi Minh City U. of Technology, Vietnam*
14:00 – 14:20	Combining Sustainable Design Education with Research on Zero Energy Building Standards in Historic Buildings [104] *Kevin McCartney [1,2], Kevin Busby [1,3].* *[1] Centre for Architectural Education, [2] UCC, [3] Munster Technological University, Ireland*
14:20 – 14:40	Urban agriculture and its applications for office buildings in large urban areas in Vietnam [21] *Hai-Yen Hoang, Ho Chi Minh City U. of Technology, Vietnam*
14:40 – 15:00	Birr Community School – A Case Study in Retrofitting and Conserving Modern Architecture [105] *John McLaughlin, UCC, Ireland*
13:20 – 15:00	**Session 2B: Global & Sustainability Competences** ***Chair: Karel Mulder (TU Delft)***
13:20 – 13:40	How do Graduate Civil Engineers Working in London Enact Global Responsibility and Support UN Sustainable Development Goals? [28] *Shannon Chance [1,2], Inês Direito [1], John Mitchell [1].* *[1] UCL, UK, [2] TU Dublin, Ireland*
13:40 – 14:00	Sustainable Engineering Management for International Development: lessons learned from a new and interdisciplinary MSc programme [36] *Xiaojun Yin, Patricia Xavier, James Holness, Krijn Peters, Swansea U., UK*
14:00 – 14:20	The Contemporary Engineer: Developing Sustainability Competences and Transferable Skills through Open-ended Activities [4] *John Fitzpatrick [1], Edmond Byrne [1], Francisco Javier Gutiérrez Ortiz [2]* *[1] UCC, Ireland [2], U. Seville, Spain*
14:20 – 14:40	A New Course on Sustainable Innovation and Entrepreneurship [22] *Pritpal Singh, Villanova U., USA*
14:40 – 15:00	Education for Sustainability: Rethinking Digital Teaching and Learning Strategy [102] *Morag Munro, Maynooth U., Ireland*
15:00 – 15:20	**BREAK**

15:20 – 16:40	**Parallel Session 3A: Pedagogical Approaches II** ***Chair: Susan Nesbit (University of British Columbia)***
15:20 – 15:40	Social and Ecological Responsibility within Engineering Education. A Modular Student-Driven Course Design that is Implemented at Seven German Universities [41] *André Baier, TU Berlin, Germany*
15:40 – 16:00	What works? Sustainability Grand Challenges in Engineering Curricula via Experiential Learning [23] *Amy Landis [1], Claire Dancz [2], Kristen Parrish [3], Melissa Bilec [4].* *[1] Colorado School of Mines, CO [2] Clemson University, SC, [3] Arizona St. U., AZ, [4] U. Pittsburgh, PA, USA*
16:00 – 16:20	Developing Inclusive and Sustainable Curriculum for Environmental Engineering Courses [47] *Kauser Jahan, Sarah Bauer, Jagadish Torlapati, Tiago Forin, Rowan U., NJ, USA*
16:20 – 16:40	Innovation Clubs: Mobilizing Local Creativity for Sustainable Development and Pedagogy [7] *Christianos Burlotos, Tracy Kijewski-Correa, Lamarre Presuma, Alexandros Taflanidis, William Cunningham. U. Notre Dame, IN, USA*
15:20 – 16:40	**Parallel Session 3B: Pedagogical Approaches III** ***Chair: Brian Ó Gallachóir (University College Cork)***
15:20 – 15:40	Perspectives on Challenge Driven Education for future Engineering education [107] *J. Hedvall, H. Lindberg, A. Rosén, Lena Gumaelius, KTH, Sweden*
15:40 – 16:00	Using an open course pack to support interdisciplinary learning in Sustainable Energy Engineering [100] *Kamaria Kuling, Taco Niet, Sheena Miao Ying Tan, Simon Fraser U., Canada*
16:00 – 16:20	'Storying Architecture' Pilot Study; Trial and Tribulation. Detailing the Methodology, Implementation, and Initial Findings of a Postponed Research Project in Bali, Indonesia [80] *Alastair Brook, UCC, Ireland*
16:20 – 16:40	Educating Engineers for the post-COVID 21st Century [106] *Paul Leahy [1], Dylan Furszyfer [2,3], Benjamin Sovacool [3], Aoife M. Foley [2].* *[1] UCC, R. Ireland, [2] QUB, N. Ireland, [3] SPRU, U. Sussex, UK*

16:50 – 17:45	**The Leo Jansen Award Recipients Keynote Address**
16:50 – 16:55	**Prof. Sarah Culloty** *Head, College of Science Engineering and Food Science, UCC; and Director, Environmental Research Institute, UCC* Welcome & Introduction
16:55 – 17:45	**Dr Michelle Marincel Payne and Dr Wayne Padgett** *Rose-Hulman Institute of Technology, Indiana, USA* *'Enabling students and communities to flourish: the importance of entrepreneurship, empathy and diversity in humanitarian engineering'*



Day 2 - 15th June 2021

TIME	SESSION
9:00 – 9:05	**Prof. Jorge Oliveira** *Head of School of Engineering & Architecture, University College Cork* Welcome & Keynote Introduction
9:05 – 9:50	**Brendan Touhy** *'An Bradán Feasa (The Salmon of Knowledge) and its relevance to Engineering Education'*
10:00 – 11:00	**Parallel Session 4A: Complexity & Uncertainty** ***Chair: Magdalena Svanström (Chalmers University of Technology)***
10:00 – 10:20	Case studies in professional-oriented education: engaging with sustainability and complexity [48] *Kristen MacAskill, U. Cambridge, Catherine Tilley, King's College London, UK*
10:20 – 10:40	Challenging energy engineering undergraduates with diverse perspectives on nuclear power [42] *Fionn Rogan, Hannah Daly, Paul Deane, James Glynn, Paul Leahy, Edmond Byrne, UCC, Ireland*
10:40 – 11:00	Data Mining for Sustainability Analytics: An Education Approach [70] *Mustafa Al Tekreeti, Salwa Beheiry, Ayman Alzaatreh, American U. Sharjah, UAE*
10:00 – 11:00	**Parallel Session 4B: Embedding Sustainability in the Curriculum I** ***Chair: Marguerite Nyhan (University College Cork)***
10:00 – 10:20	Challenging Practice Traditions to Embed Education for Sustainable Development within the Engineering Curriculum [59] *Sloan Trad, Rosalie Goldsmith, Roger Hadgraft, Anne Gardner, U. of Technology Sydney, Australia*
10:20 – 10:40	Non-Discipline Specific Sustainability Knowledge & Competences in the Chemical Engineering Programme at UCC [2] *John Fitzpatrick, Edmond Byrne, UCC, Ireland*
10:40 – 11:00	E-Mining@School; A Cross-Curricular Initiative To Embed Sustainability In The Junior Cycle Curriculum [31] *Lisa Kiely [1], Jude Sherry [2], Colin Fitzpatrick [2]. [1] Castletroy College, [2] U. Limerick, Ireland.*
11:00 – 11:30	**BREAK**
11:30 – 12:30	**Parallel WORKSHOP 1:** *Revisiting The Barcelona Declaration an update for the 20s?* **Prof. Richard A Fenner and Dr Dai Morgan** *University of Cambridge*

11:30 – 12:30	**Parallel WORKSHOP 2:** *Revolutionizing Engineering Curriculum and Culture: Tips for Addressing Inclusivity, Diversity and Sustainability* **Kauser Jahan, Stephanie Farrell, Mariano Savelski, Tiago Forin and Harriet Hartman** *Rowan University*
12:30 – 13:30	**BREAK**
13:30 – 14:50	**Parallel Session 5A: Ethics & Social** ***Chair: Javier Orozco-Messana (Universitat Politècnica de València)***
13:30 – 13:50	Engineers as advocates for Sustainable Development: countering misinformation and the need for Aristotelian Rhetoric [9] *Richard Fenner, U. Cambridge, UK*
13:50 – 14:10	Integrating ethics across the curriculum through sustainability topics [17] *Diana Adela Martin [1,2], Eddie Conlon [1], Brian Bowe [1]. [1] TU Dublin, Ireland; [2] TU Eindhoven.*
14:10 – 14:30	A Novel Pedagogical Approach to Teaching Climate Change and Ethics [77] *Alandra Kahl, Penn State Greater Allegheny, USA*
14:30 – 14:50	One Assignment, Two Courses, Multiple Skills: A Major Engineering Assignment with Social, Political and Ethical Dimensions [52] *Vivian Neal, Taco Niet, Simon Fraser U., Canada*
13:30 – 14:50	**Parallel Session 5B: Sustainability & Design** ***Chair: Denis Ring (University College Cork)***
13:30 – 13:50	Towards a Sustainability-Centred Design Curriculum in Civil Engineering [20] *Thomas Froese [1], David Bristow [2]. [1] Keagan Rankin [2]. [1] U. Victoria, BC, [2] U. New Brunswick, Canada*
13:50 – 14:10	Identifying Students' Sustainability Preferences to Improve Design Team Performance [27] *Elise Barrella [1], Justyn Girdner [2], Robin Anderson [2], Mary Katherine Watson [3]. [1] Wake Forest U, NC, USA [2] James Madison U., VA, USA, [3] The Citadel, SC, USA*
14:10 – 14:30	Emotional Intelligence in engineering education: incorporating soft skills in the capstone chemical engineering design project [43] *Elena Tsalaporta, UCC, Ireland*
14:30 – 14:50	Approximating Professional Practice in a First-Year Engineering Curriculum: The Wind Turbine Maker Project [99] *Paul Leahy, Connor McGookin, Hannah Daly, UCC, Ireland*

14:50 – 15:20	**BREAK**
15:20 – 17:00	**Parallel Session 6A: Teaching Circular Economy & Greener Technology II** ***Chair: Mariano Savelski (Rowan University)***
15:20 – 15:40	Closing the Circularity Gap Via Engineering Education for Circularity with a Whole Systems and Biomimetic Perspective [34] *Ross Lee, Karl Schmidt, Villanova U., USA*
15:40 – 16:00	Nature knows better? Nature as exemplar and/or inspiration? [65] *Laura Stevens [1], Karel Mulder [1,2], Helen Kopnina [2], Marc De Vries [1]. [1] Delft U. Tech, [2] The Hague U. Applied Sciences, The Netherlands*
16:00 – 16:20	Industry 4.0 as an Enabler for Sustainable Manufacturing: – An Educational Perspective [15] *Caoimhe Coleman, Sara Abu Selmia, Ingrid Carla Reinhardt, Jorge Oliveira, Denis Ring, UCC, Ireland*
16:20 – 16:40	Sustainable Approaches to the Management of Innovation and Technology in Engineering (SAMITE II) [61] *Iain Stalker [1], Rinkal Desai [2], Rachel Studd [3]. [1] U. Bolton, [2] U. Warwick, [3] The U. Manchester, UK*
16:40 – 17:00	Designing Laboratory Experiments for Electricity Grid Integration of Renewable Energy using Microgrid, Test-Rig Emulators and Real Time Simulation Tools [44] *Donal Murray, Nuh Erdogan, Alparslan Zehir, Barry Hayes, UCC, Ireland*
15:20 – 17:00	**Parallel Session 6B: Social, Economic & Political Dimensions** ***Chair: Elena Tsalaporta (University College Cork)***
15:20 – 15:40	Engineering Education for a Zero Growth Economy [5] *Gearold Johnson, Thomas Siller, Colorado St., USA*
15:40 – 16:00	Eco-design, circular economy & social responsibility [89] *Valerie Massardier, Corinne Subai, INSA Lyon, France*
16:00 – 16:20	Social Impact Audit Tool [11] *Tatiana Vadimovna Vakhitova, Mike Ashby, ANSYS Granta, U. Cambridge, UK*
16:20 – 16:40	Sustainability, pandemia and women in academia: breaking the “good girl” culture to enhance sustainability in engineering education [101] *Eleni Tsalaporta, Elizabeth Kyte, Maria Sousa Gallagher, UCC, Ireland*

Day 3 - 16th June 2021

TIME	SESSION
9:00 – 9:50	**Prof. Jerry Murphy,** *Professor of Civil Engineering, UCC; Director MaREI* Keynote Introduction and Chairing: **Prof. Michael Narodoslawsky** *'Sustainable solutions – From technology centred to community centred'*
10:00 – 11:00	**Industry Forum:** **'***Industry Perspectives On Educating Contemporary Engineering Graduates for Sustainability'* ***Chair: Dr John Hayes, University College Cork*** ***Panel: Conor Healy (ESB), Orla Cronin and John O'Connell (AbbVie) and Kevin Morey (Cork County Engineer)***
11:00 – 11:30	**BREAK**
11:30 – 12:50	**Parallel Session 7A: Pedagogical Approaches III** ***Chair: Jordi Segalas (Universitat Politecnica de Catalunya)***
11:30 – 11:50	Mind-mapping for Interdisciplinary Sustainable Architecture [3] *Javier Orozco-Messana, UPV, Spain*
11:50 – 12:10	Crossing technical and non-technical skills: French case study of ecodesign in engineering education [39] *Catherine Perpignan [1], Yacine Baouch [1], Vincent Robin [2], Benoit Eynard [1]. [1] U. Compiègne, [2] U. Bordeaux, France*
12:10 – 12:30	Engineering Accreditation Objectives and their Relationship to the Quality Assurance Standards for Engineering Education Programmes in Ireland [90] *Maria Kyne, Limerick IT, Ireland*
12:30 – 12:50	Art into Engineering: Demonstrating how Origami creativity can inform Robotics education [12] *Guangbo Hao [1], Alex Pentek [2]. [1] UCC, Ireland, [2] National Sculpture Factory, Ireland*
11:30 – 12:50	**Parallel Session 7B: Teaching Circular Economy & Greener Technology III** ***Chair: Hannah Daly (University College Cork)***
11:30 – 11:50	Global Perspectives on Electric Vehicle Education: Part I [68] *John Hayes [1], Yue Cao [2], Xinmei Yang [3], Jessica Suda [4], Xiaofeng Yang [5], Jens Friebe [6], Osmar Ogashawara [7], John Renie [8], G.A. Goodarzi [9].[1] UCC, Ireland, [2] Oregon St. U, OR, USA [3] Jilin U, China, [4] Southern Illinois U, IL, USA, [5] Beijing Jiaotong U, China, [6] Leibniz U., Germany, [7] U. Fed. de Sao Carlos, Brazil, [8] Indiana IT, IN, USA [9] US Hybrid Corp., CA, USA*

11:50 – 12:10	Global Perspectives on Electric Vehicle Education: Part II [69] *John Hayes [1], Yue Cao [2], Xinmei Yang [3], Jessica Suda [4], Xiaofeng Yang [5], Jens Friebe [6], Osmar Ogashawara [7], John Renie [8], G.A. Goodarzi [9].[1] UCC, Ireland, [2] Oregon St. U, OR, USA [3] Jilin U, China, [4] Southern Illinois U, IL, USA, [5] Beijing Jiaotong U, China, [6] Leibniz U., Germany, [7] U. Fed. de Sao Carlos, Brazil, [8] Indiana IT, IN, USA [9] US Hybrid Corp., CA, USA*
12:10 – 12:30	Engineering Mechanics and Sustainable Engineering [75] *Nand Jha, Manhattan College, USA*
12:30 – 12:50	Higher Education Approaches to Engender Students' Environmental Consciousness in Electronic Device Design [32] *Sivakumar Ramachandran, IADT, Ireland*
12:50 – 14:00	**BREAK**
14:00 – 15:40	**Parallel Session 8A: Embedding Sustainability in the Curriculum II** ***Chair: Pritpal Singh (Villanova University)***
14:00 – 14:20	How Cognitive Development Affects Student Perception by Threading Sustainability through Civil and Environmental Engineering Curriculum [62] *Jennifer Mueller, Rose-Hulman IT, USA*
14:20 – 14:40	A Sustainable Technologies Certificate Designed for Engineering and Engineering Technology Students (EESD2020) [8] *Patricia Fox, Charles McIntyre, Indiana U.-Purdue U., IN, USA*
14:40 – 15:00	Strategic implementation of education for sustainable development within the industrial engineer curriculum [57] *Nuria Llaverias, Guillermo Reyes, U. Ramon Llull, Spain*
15:00 – 15:20	Embedding Sustainability across the Built Environment Curriculum and Beyond [88] *Mark Kelly, GMIT, Ireland*
15:20 – 15:40	Teaching Sustainable Design through Simultaneous Evaluation of Economics and Environmental Impacts [49] *Kirti Yenkie, John Chea, Emmanuel Aboagye, Mariano Savelski and Stewart Slater, Rowan U., NJ, USA*
14:00 – 15:40	**Parallel Session 8B: Transdisciplinary Education & Diversity** ***Chair: Gerard Mullally (University College Cork)***
14:00 – 14:20	Exploring Transdisciplinary Education [30] *Susan Nesbit [1], Naoko Ellis [1], Stefani Danes [2], Tanya Tan [1], Edmond Byrne [3], David Morgan [4], Javier Orozco-Messana [5].[1] UBC, Canada, [2] Carnegie Mellon U, PA, USA, [3] UCC, Ireland, [4] U. Cambridge, UK, [5] UP de Valencia, Spain*

14:20 – 14:40	Guidelines to improve Engineering Education for Sustainability through transdisciplinarity learning processes [93] *Gemma Tejedor, Jordi Segalas, UPC-Barcelona, Spain*
14:40 – 15:00	Excellence in education requires excellence in collaboration: learning modules in circular economy as platforms for transdisciplinary learning [53] *Niclas Sandström [1], Anne Nevgi [1], Thomas Betten [2]. [1] U. Helsinki, Finland, [2] Fraunhofer Inst. for Building Physics (IBP), Germany*
15:00 – 15:20	Transdisciplinarity in a bio-engineering course [103] *Valerie Massardier, Sébastien Livi, INSA Lyon, France*
15:20 – 15:40	**National Forum for Teaching & Learning Research Spotlight:** A Connected Curriculum: Integrating the United Nations Sustainable Development Goals within and across the Curriculum *John Barimo, Catherine O'Mahony, Gerard Mullally, Edmond Byrne, John O'Halloran, Darren Reidy and Maria Kirrane, UCC, Ireland*
15:40 – 16:00	**BREAK**
16:00 – 16:20	CLOSING CEREMONY Prof. Karel Mulder (The Hague University of Applied Sciences/TU Delft): LEO JANSEN AWARD PRESENTATION ANNOUNCEMENT OF EESD2023 HOSTS

Education in turbulent times: Navigating the transition from un-sustainability

Prof. John Barry

John Barry is Professor of Green Political Economy in the School of History, Anthropology, Philosophy and Politics and Co-Director of the Centre for Sustainability, Equality and Climate Action at Queen's University Belfast. His areas of research include green moral and political theory; green, post-growth and heterodox political economy; the politics, policy and political economy of climate breakdown and low carbon energy transitions; normative aspects of environmental and sustainable development politics and policy; action and engaged research; the greening of citizenship and civic republicanism.

Barry is the Belfast lead for the 5 year ESRC funded 'Place Based Climate Action Network' (2019-2023); a central element of which will be the establishing Belfast City Energy Transition and Climate Commission. Barry is also a director/board member of Sustainable Northern Ireland, Training for Women Network and Green Foundation Ireland. He is a strong advocate and practitioner of transdisciplinary and action research and green and civic activism.

Dr Therese Hume

Therese Hume is a lecturer in the School of Engineering and Design, Institute of Technology Sligo, where she has worked since 1995. Her research, which draws from the fields of sustainability education and science and technology studies, is inspired by the potential of higher education institutions to act as learning spaces and regional resources to address major sustainability challenges.

She has also worked as a researcher in Queen's University on an EPA-funded research project 'Catalysing and Characterising Transition', which examined capacities needed for an Irish energy transition. In her teaching, an abiding interest has been in how social and environmental implications of technological change can be addressed within computing curricula.

"Activism in Engineering", The importance of elevating the ideas of young idealistic engineers as well as the value of modern activist culture

Sorcha Ní Mhuimhneacháin

Sorcha Ní Mhuimhneacháin graduated with a degree in Energy Engineering from University College Cork (UCC) in 2015. During her studies she spent a year at the Technical University of Munich (TUM), specialising in renewable energy technologies. She also led the Engineers Without Borders Chapter in UCC, which became a dominant voice for sustainability issues on campus and a force for change in the education of engineering students.

She completed the MPhil programme in Engineering for Sustainable Development at the University of Cambridge in 2017. In 2018 she returned to Munich to join Canadian Solar as part of their burgeoning Systems Solutions department. She now works on turnkey execution of photovoltaic projects in Europe. As well as informing technical design, she collaborates on strategy development for new market entry. Her priority is to target ventures which are mutually beneficial to both community and company.

Enabling students and communities to flourish: the importance of entrepreneurship, empathy and diversity in humanitarian engineering

Dr Michelle K. Marincel

Leo Jansen Best Paper Award Recipient

Michelle K. Marincel Payne is an assistant professor of Civil and Environmental Engineering at Rose-Hulman Institute of Technology. Michelle is co-leading an Undergraduate Research Community to support students' learning through research, efforts to integrate open-ended problems throughout civil and environmental engineering curricula, research to remove stormwater pollutants via engineered treatment wetlands, and development of an appropriate technology course and modules with strong emphasis on social sustainability.

She completed her Ph.D. in environmental engineering in civil engineering from the University of Illinois at Urbana-Champaign, her M.S. in environmental engineering from Missouri University of Science and Technology, and her B.S. in nuclear engineering from the University of Missouri-Rolla.

Enabling students and communities to flourish: the importance of entrepreneurship, empathy and diversity in humanitarian engineering

Leo Jansen Best Paper Award Recipient

Dr Wayne T. Padgett

Wayne T. Padgett is a professor of Electrical and Computer Engineering at Rose-Hulman Institute of Technology. Wayne has helped develop a course at Rose-Hulman on Appropriate Technology and worked with an indigenous village to improve their water system. He has an ongoing research project to explore the performance of an off-grid biosand filter system. He also has interests in signal processing education, fixed-point signal processing, and cybersecurity. He has Ph.D. and M.S. degrees from Georgia Institute of Technology, and a B.E.E. degree from Auburn University.

An Bradán Feasa (The Salmon of Knowledge) and its relevance to Engineering Education

Brendan Tuohy

Brendan Tuohy is Chairman of the Governance Committee of MaREI (the Science Foundation Ireland Centre for Marine and Renewable Energy), Irish Longitudinal Study of Ageing, Global eSchools and Communities Initiative and Quality Council for Kerry Education and Training Board. Since 2007, he has served on a number of boards of commercial companies and non-governmental organisations, and in November 2019 he was appointed as Chairperson Designate to the Board of EirGrid. Previously, Brendan worked in various Government Departments and served as Secretary General of the Department of Communications, Energy, Marine and Natural Resources (2000 – 2007); as Assistant Secretary in the Department (1992-2000).

He holds a degree in Civil Engineering from University College Cork (UCC) and post-graduate qualifications Dublin University, Trinity College. He is a Chartered Engineer, Fellow of the Institution of Engineers of Ireland, Fellow of the Institution of Fire Engineers and Fellow of the Irish Academy of Engineering, having served as President in 2016/17.

Sustainable solutions – From technology centred to community centred

Prof. Michael Narodoslawsky

Michael Narodoslawsky completed his Ph.D. in Chemical Engineering at Graz University of Technology. Until retirement in 2016 he headed the research group Process Synthesis, Process Evaluation and Regional Development at the Technical University of Graz, as well as the European Commission's Working Group on Bioenergy.

He is a co-founder of the European Sustainable Energy Innovation Alliance (eseia) and co-chairs the eseia Working Group on Bioresources. His chief research interests are in ecological assessment and lifecycle analysis, regional technology networks and biorefineries. Prof. Narodoslawsky hosted the 4th EESD2008 at TU Graz, and has a long history of promoting engineering education for sustainable development.

Parallel Workshop #1:

REVISITING THE BARCELONA DECLARATION AN UPDATE FOR THE 20's?

Facilitators:

Richard Fenner and **David Morgan** – Department of Engineering, University of Cambridge, UK

Description:

Building on their EESD2020 conference paper 'The Barcelona Declaration revisited: core themes and new challenges' (see full paper from p.32 of this programme), Fenner and Morgan seek to work with EESD2020 delegates in asking the question; *'Is now an opportune time to revisit the Barcelona Declaration?'* and if so *'What should a fit-for-purpose Barcelona Declaration look like for the 2020's?'* The 'Barcelona Declaration' (p. 41) emanated from the 2nd EESD held at UPC, Barcelona in 2004 and sought to outline what engineers and engineering educators must do in light of our 'increasingly complex world' within which 'we are at a critical juncture at which humanity must make some serious choices about the future'.

Now more than ever, these sentiments ring through, though perhaps nearly two decades on, it is now time to dust down this worthy Declaration, and consider whether in might be upgraded as the issues (crises?) become ever more acute and pressing, and if so, to seek to garner the collective wisdom and insights of the EESD community to ask how we might reformulate and update.

Richard Fenner has led the MPhil in Engineering for Sustainable Development at University of Cambridge, and hosted the 6th EESD at U. Cambridge in 2013. Dai Morgan is lead member of the MPhil in Engineering for Sustainable Development team at U. Cambridge. Both academics research and publish in the EESD area.

Workshop #2:

ENGINEERING CURRICULUM AND CULTURE: TIPS FOR ADDRESSING INCLUSIVITY, DIVERSITY AND SUSTAINABILITY

Facilitators:

Kauser Jahan – Civil & Environmental Engineering, Rowan University, Glassboro, New Jersey, USA

Stephanie Farrell – ExEEd, College of Engineering, Rowan University, Glassboro, New Jersey, USA

Mariano Savelski – Chemical Engineering, Rowan University, Glassboro, New Jersey, USA

Tiago Forin – ExEEd, College of Engineering, Rowan University, Glassboro, New Jersey, USA

Harriet Hartman – Sociology & Anthropology, Rowan University, Glassboro, New Jersey, USA

Workshop Description:

This will be an interactive workshop for engineering educators on addressing inclusivity, diversity and sustainability (IDS) in their courses and overall curriculum. Research indicates that including IDS content helps enhance the overall student experience in the classroom and makes the course content personal and relevant.

The Civil Engineering department at Rowan University received two NSF grants to develop and integrate IDS in their core engineering courses. The team will share their experience with content development.

Participants will be provided with worksheets so that they develop IDS content for their own courses. This workshop is open to all engineering and science educators. The workshop will also focus on strategies at the administrative levels to recruit a more diverse student body including the support structure needed to retain the students and provide them an inclusive atmosphere.

Industry Perspectives on Educating Contemporary Engineering Graduates for Sustainability

*The **EESD2021 'Industry Forum'** features a number of industry stakeholders from some key sectors operating in the Cork region and in broader national and international contexts.*

*The Forum will be Chaired by **Dr John Hayes** of UCC School of Engineering and Architecture, and will feature **Conor Healy**, ESB, **Orla Cronin** and **John O'Connell** of AbbVie, and Cork County Engineer **Kevin Morey**.*

*Panelists will reflect on and discuss **the sustainability related knowledge, skills, and values that contemporary graduates require,** based on their own educational experience, professional practice and on evolving contemporary societal imperatives and industry norms, for graduates (engineers, architects and planners), who will work up to and beyond the middle of the current century.*

The reality is that engineers rarely or never work on projects which are merely just in the technical domain, but also encompass economic, societal, environmental and ethical domains, oftentimes with a high degree of uncertainty, and increasingly working in multi- and transdisciplinary settings and teams; just look at the COVID-19 pandemic!

A dialogue with delegates, drawing on their own insights and experiences, will ensue to tease out some of the issues, hurdles and opportunities that arise, including around sustainability related attributes, and graduate, academic and industry imperatives.

Given the context of EESD2021, the Cork Harbour region will be taken as a case study.

This region has significant engineering activity and employment, including a high concentration of industry (particularly bio/pharmaceutical and food), served by local higher education institutions/universities and research centres (e.g. MaREI, Ireland's national Marine and Renewable Energy Research Centre) and a broad mix of rural, urban and naval.

The region has significant growth potential in the years and decades ahead, but it also requires transformation and resilience in terms of energy systems, transportation, planning and other societal and socio-technical issues, each of which are intertwined with issues around climate change, environmental degradation and biodiversity loss, all requiring broader productive public engagement and dialogue.

– What therefore is the appropriate skillset of the mid twenty first century engineer in this context?

– What role can today's educators and industry stakeholders play in facilitating the 'fit-for-purpose' engineer? In doing so, what are the win-win situations, and are there more problematic areas?

– How might the experiences of Cork and those of other regions of the world, be used to learn from each other on this journey?

The Barcelona Declaration revisited: core themes and new challenges

Richard Fenner and David Morgan
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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 EESD2021 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.

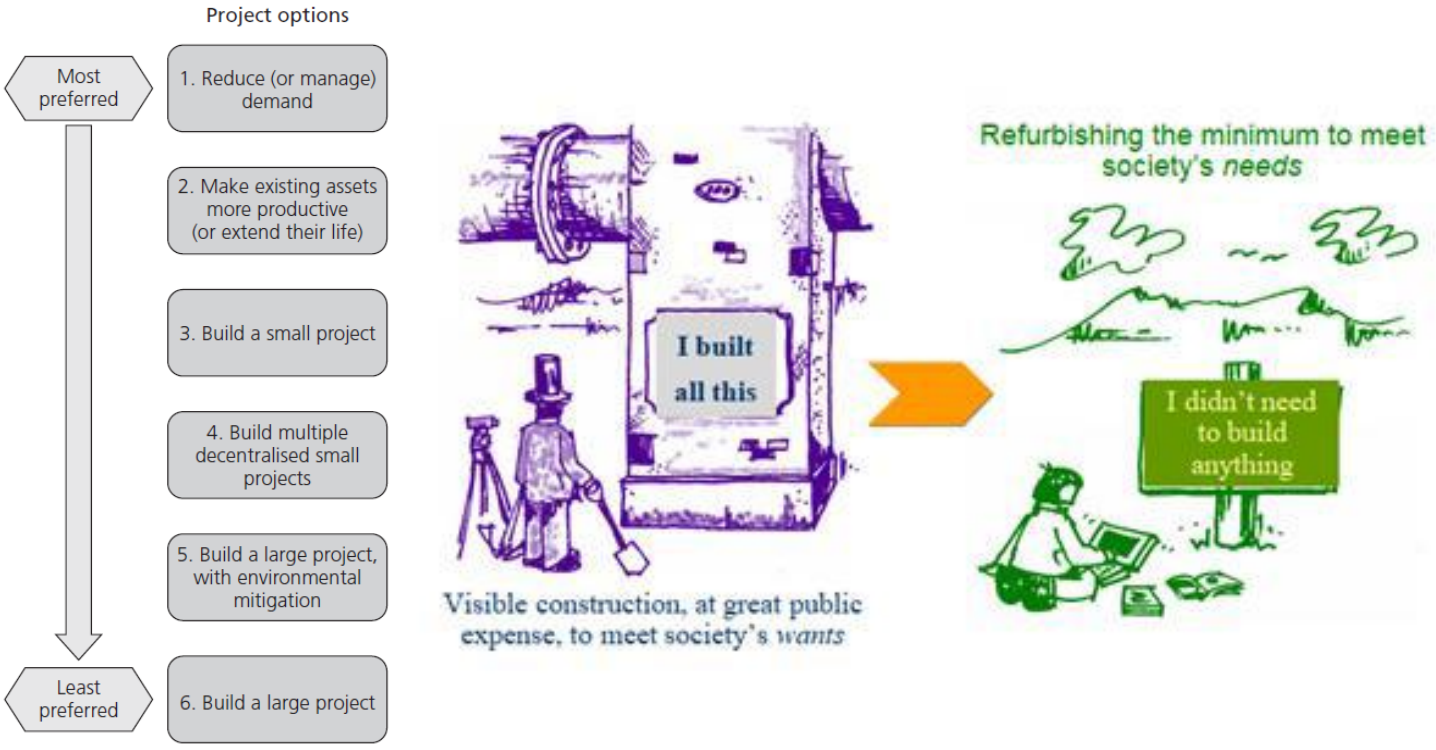

Figure 1: A sustainability hierarchy and a change in engineering culture (after Ainger and Fenner 2014)

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.

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?

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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.

We declare that

Today's engineers must be able to:

o Understand how their work interacts with society and the environment, locally and globally, in order to identify potential challenges, risks, and impacts.

o Understand the contribution of their work in different cultural, social, and political contexts and take those differences into account.

o Work in multidisciplinary teams, in order to adapt current technology to the demands imposed by sustainable lifestyles, resource efficiency, pollution prevention and waste management.

o Apply a holistic and systemic approach to solving problems and the ability to move beyond the tradition of breaking reality down into disconnected parts.

o Participate actively in the discussion and definition of economic, social and technological policies, to help redirect society towards more sustainable development.

o Apply professional knowledge according to deontological principles and universal values and ethics.

o 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:

o Have an integrated approach to knowledge, attitudes, skills and values in teaching.

o Incorporate disciplines of the social sciences and humanities.

o Promote multidisciplinary teamwork.

o Stimulate creativity and critical thinking.

o Foster reflection and self-learning.

o Strengthen systemic thinking and a holistic approach. Train people who are motivated to participate and who are able to take responsible decisions.

o Raise awareness for the challenges posed by globalization.

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

o The links between all the different levels of the educational system.

o The content of courses.

o Teaching strategies in the classroom.

o Teaching and learning techniques.

o Research methods.

o Training of trainers.

o Evaluation and assessment techniques.

o The participation of external bodies in developing and evaluating the curriculum.

o 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:

o A redefinition of institutions' and universities' missions, so that they are adapted to new requirements in which sustainability is a leading concern.

o An institutional commitment to quality.

o 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.

EESD2021

BUILDING FLOURISHING COMMUNITIES