Cahiers
#Costech

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Educating engineers to contribute to a regional goal of net zero carbon emissions by 2030

> #Numéro 5
> Colloque Ingenium 2021 : le développement durable dans la formation et les activités d'ingénieur
> Working papers
> Développement durable - > Didactique

Citer cet article

Fogg-Rogers, Laura., Bakthavatchaalam, Venkat., Richardson, David., Fowles-Sweet, Wendy. "Educating engineers to contribute to a regional goal of net zero carbon emissions by 2030.", 25 avril 2022, *Cahiers Costech*, numéro 5.
DOI https://doi.org/10.34746/cahierscostech133 -
URL https://costech.utc.fr/CahiersCostech/article133.html

Abstract

The environmental and health impacts of climate change and biodiversity loss are now apparent and yet cohesive policymaking to mitigate emissions is moving too slowly. The UK's target for carbon neutrality has been set for 2050, but this has been superseded by regional leadership in the West of England aiming for Net Zero by 2030. This has been incorporated within the University of the West of England (UWE Bristol) 2030 Strategy through the declaration of a Climate and Ecological Emergency, with direct (scope 1), indirect (scope 2), and implicated (scope 3) emissions included. In order to meet these goals, sustainability education is embedded through all levels of the Engineering Curriculum, aiming to support the regional goal of Net Zero 2030. Current modules incorporate education for Sustainable Development Goals alongside citizen engagement challenges, where engineers find solutions to real-life problems. All undergraduate engineers also take part in immersive project weeks to develop problem-based learning around the Engineers without Borders international challenges. A new Climate Action Hub aims to showcase staff and student sustainability projects and individual actions. Finally, the initiative for Digital Engineering Technology and Innovation aims to embed sustainability throughout the engineering lifecycle, with UWE Bristol providing skills development leadership for the region to enable the future transition.

Keywords : Carbon emissions ; climate emergency ; city health citizen engagement ; Net Zero.

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Plan

1 - The Climate and Ecological Emergency

The environmental and health impacts of climate change and biodiversity loss are now being felt around the world, from record high temperatures, drought, wildfires, extreme flooding, and even disease pandemics (Ripple, Wolf, Newsome, Barnard, & Moomaw, 2020). Concurrently, we are living through a sixth mass extinction event, with human activities destroying biodiversity at a rate significant enough for the current epoch to be named the Anthropocene (Pievani, 2014). In 2018, the Intergovernmental Panel on Climate Change (IPCC) indicated that humanity urgently needs to cut carbon emissions by 2030 in order to stay below 1.5C of global heating (IPCC, 2018). This led highly respected global institutions such as the United Nations (UN), and the European Parliament to declare a Climate and Ecological Emergency (European Parliament, 2019 ; UN Environment Programme, 2021).

The UK Government has pledged to reach net zero emissions by 2050, with a 78% drop in emissions by 2035 (UK Government, 2021). Following IPCC guidance, some regional councils such as Bristol City Council and the West of England Combined Authority, have pledged to reach Net Zero at an earlier date of 2030 (Bristol City Council, 2019). Many other regional institutions have therefore also pledged to become carbon neutral by 2030 ; the University of the West of England, Bristol (UWE Bristol) is a Higher Education Institution which has embedded this target within its strategic plan (UWE Bristol, 2019). Linked to this goal is UWE Bristol’s leadership of the Environmental Association for Universities and Colleges (EAUC), an Alliance for Sustainability Leadership in Education (UWE Bristol, 2021c).

1.1 - Engineering and the Sustainable Development Goals

In order to reach carbon neutrality, everything we make and do will need to be reimagined and re-engineered ; engineering therefore has a huge role to play in the transition away from fossil fuels (DETI, 2021). It is therefore vitally important that future engineers are educated about climate change impacts, global sustainability, and developing technologies which are not harmful to the world's biosphere. The Sustainable Development Goals (SDGs) were developed to outline the social, environmental, and economic actions needed to ensure humanitarian development, whilst also staying within planetary boundaries to support life on earth (Ramirez-Mendoza et al., 2020).

UWE Bristol has pledged to embed the SDGs within all curricula, so that higher education degrees prepare graduates for working sustainably (Gough, 2021). This is particularly important for student engineers, as engineering is traditionally taught as an empirical subject isolated from social and environmental contexts, despite having so much impact on society (Lawlor, 2016 ; Ramirez-Mendoza et al., 2020). The UK Standard for Professional Engineering Competence (UK SPEC) (Engineering Council, 2021) requires engineers to gain an understanding of the ethical and environmental impacts of technology, in order to achieve professional certification. However, introducing social contexts into engineering curricula is viewed as a novel concept, with some resistance from traditional engineering educators.

1.2 - Real-world problems and project-based learning

'Real-world' problems can inspire and motivate learners (Loyens, Jones, Mikkers, & van Gog, 2015), while the use of group projects is considered to facilitate collaborative learning (Kokotsaki, Menzies, & Wiggins, 2016). With terminology often used inter-changeably in engineering education, both problem-based learning and project-based learning share characteristics such as collaboration and group work, the integration of knowledge and practice, and foregrounding problem analysis as the basis of the learning process (Du, de Graaff, & Kolmos, 2019). This experiential active learning can provide opportunities for students to consider sociological and environmental systems thinking in engineering, alongside the traditional scientific-engineering aspects (Frank, Lavy, & Elata, 2003). It also validates different skills and competencies other than technical knowledge, which is often constructed as more of a male domain, and is thus important for females developing an engineering identity (Du, 2006). This enables the development of communities of practice, which are useful for female students due to differentiation in technical experience (Du, 2006 ; Du & Kolmos, 2009). Furthermore, working with the community

acts as service learning, which can enhance the employability of student engineers (Duffy, Moeller, Kazmer, & Barrington, 2008 ; Oakes et al., 2002).

Engineers without Borders are an international charity which have drawn on this evidence to develop a model of project-based learning, called the Engineering for People Design Challenge (Engineers without Borders, 2021a). The global scenarios enable university students to “work on real-world problems without real-world pressures and risks”, giving them “the opportunity to learn and practice the ethical, environmental, social and cultural aspects of engineering design”. The programme first ran in 2011, and is now operated by 30 universities across the UK, Ireland, South Africa, USA and Australia. The programme develops an awareness of the Climate and Ecological Emergency, alongside endorsing the ‘Engineers Declare’ movement (Engineers without Borders, 2021b). This international petition brings together all forms of the engineering profession to “declare their commitment to create engineering outcomes that have a more positive impact on the world around us” (Engineers Declare, 2021). This paper outlines UWE Bristol’s efforts to educate engineering students on the SDGs, alongside working towards the regional goal of Net Zero 2030.

2 - Engineering Education for Net Zero Transition

2.1 - SDGs in Curricula

The first aim for our curricula transformation was to assess where SDG relevant topics were already being taught in the engineering curricula. A departmental-wide mixed methods survey was designed to assess which SDGs were already incorporated, and which teaching methods were being utilized. The survey was emailed out to all staff in 2020, with 27 module leaders responding to highlight pedagogy in 60 modules, covering the engineering topics of : Aerospace ; Mechanical and Automotive ; Electrical, Electronic, and Robotics ; Maths and Statistics ; and Engineering Competency.

Two sub-themes were identified : ‘Direct’ and ‘Indirect’ embedding of SDGs ; direct being where the engineering designs explicitly reference the SDGs as providing social or environmental solutions, and indirect being where the SDGs are achieved through the engineering education e.g. quality education and gender equality. Direct inclusion of the SDGs tended to focus on reducing energy consumption, and reducing weight and waste, such as through improving the efficiency of the machines/designs. Mitigating the impact of climate change through optimal use of energy was also mentioned. The usage of lifecycle

analysis was implemented in several courses, especially for composite materials and their recycling. The full analysis of the spread of the SDGs and their incorporation within different degree programmes can be seen in Figure 1.

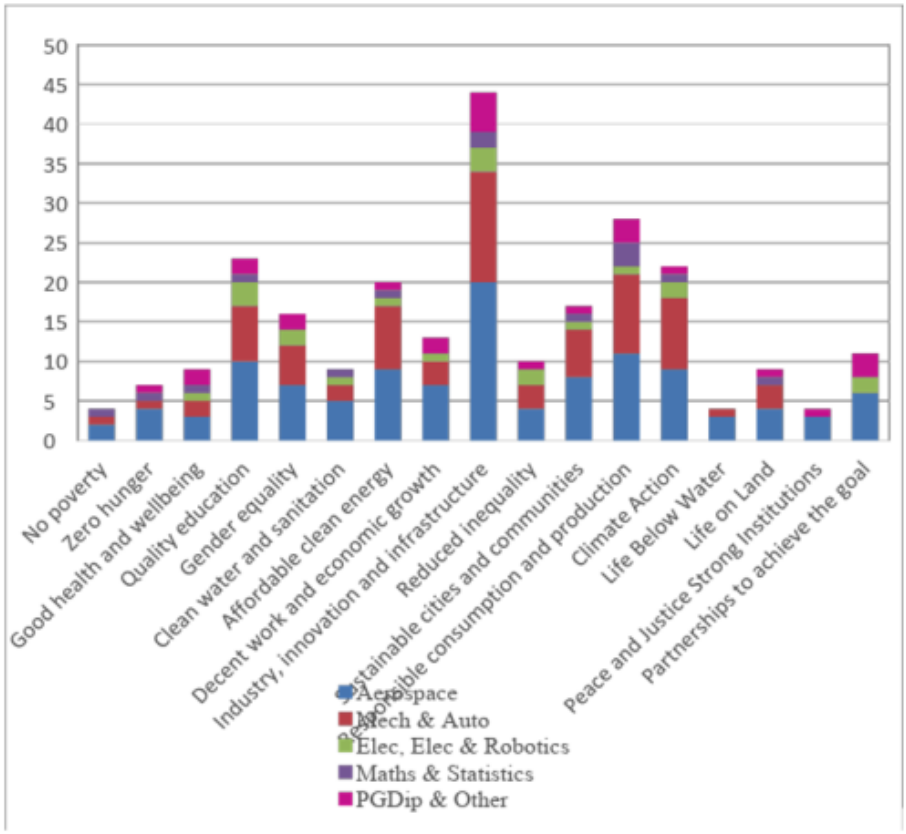

Figure 1 Number of Engineering Modules in which SDGs are Embedded

2.2 - Community action

Universities occupy a vital role in the community ; thus undergraduate education incorporating active service learning provides opportunities to influence communities now and in the future (Direito, Pereira, & Duarte, 2012). The Department for Engineering Design and Mathematics at UWE Bristol aims to develop socially engaged and aware graduate engineers, and so incorporated the Engineers without Borders challenge into its curricula in 2019. All undergraduate engineers now take part in immersive project weeks, where the students present their solutions to the design challenges (UWE Bristol, 2021a). Local speakers are brought onto campus to outline similar problems occurring in the region, and to showcase their environmentally conscious engineering career development.

Masters level engineers also take part in a service-learning module called ‘Engineering in the Community’ (UWE Bristol, 2020). Local community groups suggest real-life problems, and students then act as

consultants to develop and implement solutions locally. This is being expanded into a Climate Action Hub in our new sustainably built School of Engineering building (UWE Bristol, 2021b), where communities can come for advice from the student and staff community. Students and staff taking individual or engineering climate action will also showcase their projects, aiming to inspire momentum around the UN Climate Change Conference in 2021 (COP26, 2021).

Finally, UWE Bristol is leading the Skills programme in the initiative for Digital Engineering Technology and Innovation (DETI), which aims to embed sustainability throughout the engineering lifecycle through greater utilization of digital technologies (UWE Bristol, 2021d). We are taking a comprehensive approach to skills development, providing regional leadership on sustainability and STEM education for primary, secondary, further, higher, and lifelong learning. We aim to develop the awareness, skills and capacity for action for current and future engineers, to enable transition away from fossil fuels. This will be enhanced ahead of COP26 through holding a Youth Engagement with Engineering for Sustainability Summit (YEESS) in October 2021, with young people discussing ideas for 'How Might We Reach Net Zero emissions by 2030 ?' (I'm an Engineer, 2021). The regional government for the West of England has responded to this work by citing DETI as a key actor in its Climate Action plan for 2030 (WECA, 2020).

We believe that the engineering profession has a crucial role to play in climate education and action, and we hope that other engineering educators also act with urgency to speed up the global transition to carbon neutrality.

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