

Teaching Sustainability to Engineers

Some Contemporary Trends and Practices

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

<https://www.engineersireland.ie/Professionals/Communities-Groups/Societies/Academic>



Seek to **Reflect** upon:

- Experience of **Contemporary EESD** trends
- Some initiatives we've tried on our programme **@UCC**

..In the **Context** of:

- Emerging **Professional Body** requirements
- Emerging **EESD** trends
- Wider **Higher Education** and **Societal** trends/imperatives

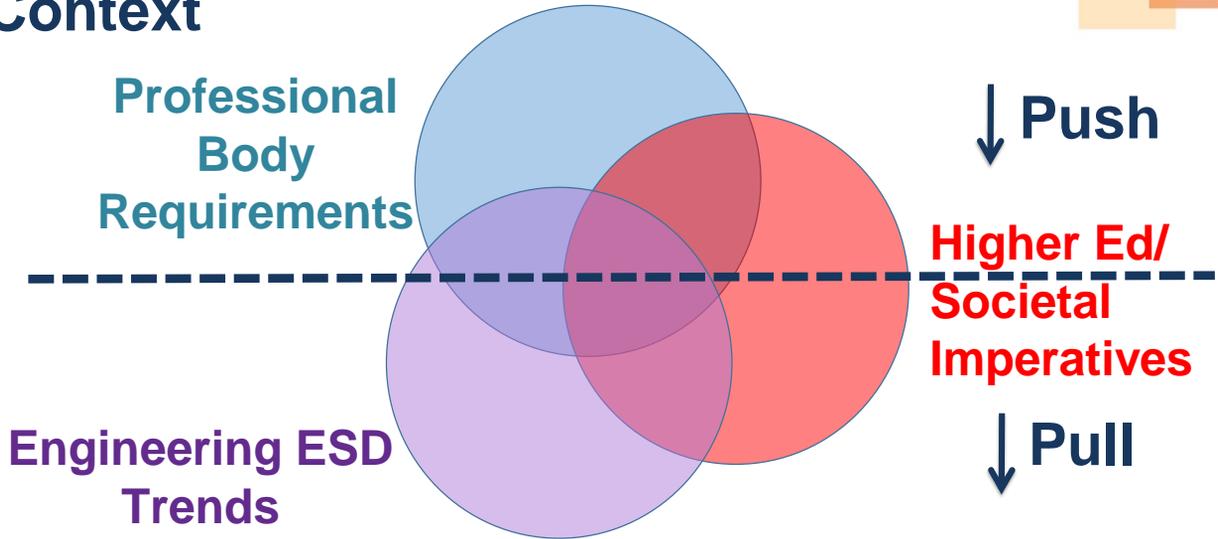


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Engineers Ireland Academic Society: 'Teaching Sustainability to our Students', 17 February 2022



Context



EESD2021
BUILDING FLOURISHING COMMUNITIES

Engineering Education for Sustainable Development Trends



Engineers Ireland Academic Society: 'Teaching Sustainability to our Students', 17 February 2022



10th International Conference on
Engineering Education for Sustainable Development

University College Cork, Ireland

Welcome @EESD2021!

EESD2021 Proceedings

Programme Handbook

Cork Amendment (2021) to Barcelona
Declaration (2004)



EESD2021

BUILDING FLOURISHING COMMUNITIES

Engineering Education for Sustainable Development Trends

- 'Building Flourishing Communities'
- EESD and Contemporary Challenges
- Curriculum Developments
- Novel and Emerging Pedagogical Approaches
- Transdisciplinary Approaches
- Sustainability Competencies
- Non-discipline specific sustainability knowledge & competences in engineering education
- Engineering Ethics
- Global Dimension in Engineering Education
- Innovation, Creativity & EESD

- Teaching Holistic Engineering
- Accreditation Trends and Imperatives
- Technology and Teaching EESD
- Gender and EESD (incl. more broadly: EDI)
- Teaching Green Technologies
- EESD; Industry Imperatives/Implications
- Teaching Uncertainty, Context and Complexity to Engineers
- Design/Planning/Architecture/Engineering Education for Sustainability
- Eng. Education; Incorporating Societal, Economic & Political Dimensions



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EESD Trends:

The Cork Amendment (2021) to the Barcelona Declaration (2004)

In addition to the principles of engineering education set out in 2004's Barcelona Declaration, it is necessary that both engineering students and engineering practitioners are able to **urgently respond to the diverse planetary risks** through an understanding of six imperatives: **values, context, uncertainty, change, limits and vision**, by:

- Actively engaging in rebuttal of **counter-factual information**,
- Anticipatory **future vision** which embraces the **need for restructuring** of how humans live
- Delivering radical change through the **co-generation of solutions across disciplines**
- Seeking **resilient, flexible and adaptive engineered systems** ..operating within **diverse uncertainties**
- Operating **within resource and technological limits** ..go beyond “doing no harm”
- **Challenging orthodoxy** and **honestly assess the risks and impacts**.

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Professional Body Requirements:

- /// Engineers Ireland
- /// Institution of Chemical Engineers



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Professional Body Requirements: Engineers Ireland

Programme Areas [2014]

- Sciences and Mathematics
- Discipline-specific Technology
- Software and Information Systems
- Creativity and Innovation
- Engineering Practice
- Social and Business Context

Programme Areas [2021]

- PA1 Science and Mathematics
- PA2 Discipline-specific Technology
- PA3 Software and Information Systems
- PA4 Creativity and Innovation
- PA5 Societal and Business Context
- PA6 Engineering Practice
- PA7 Sustainability**

“The main changes made to the previous edition (2014) are: a new Programme Outcome on ‘Engineering Management’; a new Programme Area on ‘**Sustainability**’; coverage of data science, analytics and the **ethical usage of technology and data**; coverage of **equality, diversity and inclusion** in professional practice, **teamwork and communication**”

Professional Body Requirements: Engineers Ireland

2014 PROGRAMME OUTCOME 3: DESIGN

- (ii) the ability to apply design methods to **unfamiliar**, problems;
- (iii) the ability to investigate and define a need and identify constraints including **environmental and sustainability limitations**, health, safety and risk assessment issues;

PROGRAMME OUTCOME 5: ETHICS

- (ii) knowledge and **understanding** of the **social, environmental, ethical**, economic, financial, institutional, **sustainability** and commercial considerations affecting the exercise of their engineering discipline;

[Sustain*: 5 mentions]

2021: PROGRAMME OUTCOME 3: DESIGN

- (i) knowledge and understanding of design processes and techniques and the ability to apply them to **unfamiliar, ill-defined** problems;
- (ii) the ability to design innovative solutions such as novel systems, components or processes, involving **other disciplines** as appropriate;
- (iii) the ability to investigate and define requirements considering professional **responsibilities towards people and the environment**

PROGRAMME OUTCOME 5: ETHICS

- (i) an **understanding and appreciation** of the **environmental, social** and economic impacts of their **judgements** and to **promote the principles and practices of sustainable development**;
- (iii) knowledge and understanding of the importance of **equality, diversity and inclusion**, and their **impact** on professional practice;

[Sustain* 15 mentions; Diversity: 5 mentions]

Professional Body Requirements: Engineers Ireland

PA7. Sustainability

- The engineering profession has a **critical role** to play in sustainability and climate change mitigation & adaptation.
- Students need to be familiar with the **impact of their work on the three pillars of sustainability** (environmental impact, social impact and economic impact) and should **aspire to be leaders in engineering climate action**.
- Students should be introduced to **specific sustainability concepts** such as **net zero carbon, resource efficiency, circular economy and whole-life cost**.
- Engineers also need to be aware of the **global and multi-cultural context** of their work.
- Students should be exposed to, for example, the **UN Sustainable Development Goals** ..also **develop competences for achieving the SDGs**.



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Professional Body Requirements: Engineers Ireland

PA7. Sustainability

Five core competences for achieving the SDGs [attributed to Programme Outcomes]:

- **Critical thinking and reflection [Problem Analysis]**
- **Envisioning [Design]**
- **Systemic thinking [Knowledge & Understanding, Investigation]**
- **Building partnerships [Teamwork, Communication]**
- **Participation in decision making [Professional & Ethical Responsibilities, Engineering Management]**



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Higher Education/Societal Imperatives

Campus

Research & Innov.



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Coláiste na hOllscoile Corcaigh

Learning and Teaching

Organization



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Campus



UCC

University College Cork, Ireland
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Celebrating 10 Years as a Green Campus

Watch Now →

What makes a good committee?

7 Steps: 1. Shared Responsibility, 2. Agree, 3. Spectrum Lines, 4. Disagree, 5. Shared Responsibility, 6. Shared Responsibility, 7. Shared Responsibility

6 Themes: 1. Travel, 2. Litter & Waste, 3. Energy, 4. Biodiversity, 5. Water, 6. Global Citizenship

Achievements: Creating our own organic fruit & veg, Students' Green Week, More Business, 10 Second Cup!

Problems: Air Pollution, Students' Green Week, Shared Responsibility, Student Engagement, 10 Second Cup!

Some Solutions: Travel (Transit), Energy, Student Engagement/Committee, Money (€), Bike Storage, Safe Two-Way Bike Lanes, Call Special T.D., Better Canteen, On the Road!

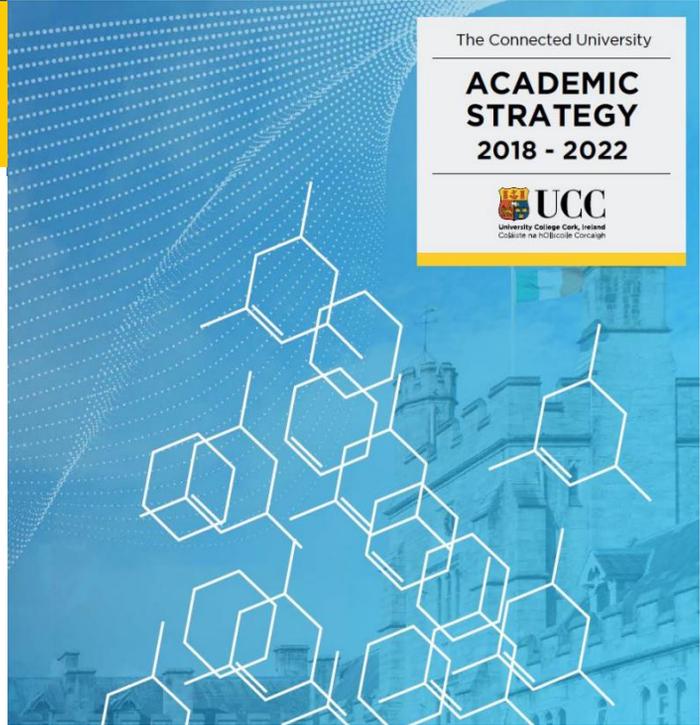
Envirosoc UCC Environmental Society

Welcome Green Schools Committees!

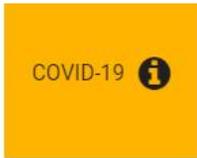


University College Cork
World's First Green Campus

Learning and Teaching



Equality, Diversity & Inclusion Unit
Comhionannas, Éagsúlacht agus Ionchuimsitheacht



COURSES

MY UCC

Organization



Equality, Diversity & Inclusion Unit

Est. Jan 2018
Director (single dedicated role) appointed July 2021

Research & Innovation

Promoting Inter-/Transdisciplinary and EDI Imperatives



UCC2022 Presidents Post-COP26 Doctoral Training Fund:
'Proposals should be inter and trans-disciplinary'

Enhancing awareness & adoption of Digital Inclusion
Strategies in Teaching & Learning Fund

'New Connections' Grant Award:
'New, collaborative ventures are especially welcome'



UCC Process and Chemical Engineering Some initiatives and experiences



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UCC Process and Chemical Engineering

IChemE *Sustainability Teaching Award Winners* (2016) encouraging ‘development of better approaches to integrating sustainability principles and values into undergraduate teaching’.

IChemE: ‘particularly impressed by your integration of sustainability teaching across the curriculum, with good examples of interdisciplinary projects and varied assessment with student comments indicating their appreciation of the approach.’

‘University College Cork demonstrated that they could integrate sustainability teaching principles across the curriculum, which will provide their chemical engineering students with a set of values to apply to their future careers.’

Institution of Chemical Engineers

Sustainability and Education
Special Interest Groups

Sustainability Teaching Award 2016

Awarded for encouraging the development of better approaches to integrating sustainability principles and values into undergraduate teaching.



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“Integration of Sustainability Teaching across the Curriculum”

Year 1:

NE1001 Intro. to Energy Engineering and Engineering Ethics
PE1003 Intro. to Process and Chemical Engineering

Year 2:

AE2004 Ecology for Engineers
PE2004 Communication and Ethics in Engineering

Year 3:

PE3011 Sustainability and Environmental Protection I
NE3002 Energy in Buildings (/elective)

Year 4:

PE4021/PE6060 BE(Hons)/ME Work Placement
PE4050 Design Project

Year 4 (BE(Hons)) electives:

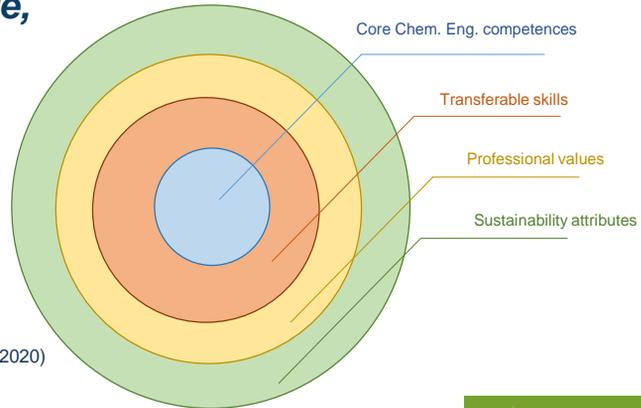
NE3003 Sustainable Energy (/also ME elective)
CE4016 Energy Systems in Buildings
NE4005 Sustainability, Bioenergy and Circular Economy Systems
CE3012 Materials and Sustainability
CE4024 Progressing Towards Sustainable Industry
FE4002 Global Food Policy
MG2003 Consumer Behaviour and Sustainable Consumption

Year 5 (ME):

PE6031 Carbon Geocycles and Capture Utilisation and Storage
PE6033 Sustainability and Environmental Protection II
NE6004 Sustainability, Bioenergy and Circular Economy Systems (/elective)

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Sustainability Attributes Transcending core knowledge, skills and values



Source: Gutiérrez Ortiz, F.J., Fitzpatrick, J.J. & Byrne, E.P. (2020)
European Journal of Engineering Education, 46 (3), 441-456.



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Sustainability Attributes (Gutiérrez Ortiz *et al.*, 2020):

- **Sustainability (core) knowledge and understanding**, including around the issues and challenges, as well as a deep appreciation of the importance of the social, ethical, ecological and economic dimensions of sustainability, and the interconnectedness of each.
- **Sustainability skills**: ability to develop appropriate greener technologies, processes and approaches.
- **Sustainability values**: e.g. concern for the environment, commitment to sustainable development, empathy, equality, diversity, commitment to social justice, flourishing communities, human well-being, etc.

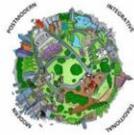


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PE2004 *Communication and Ethics in Engineering*
Wicked Problem Assignment (includes seeking alternative framings)



Wicked Problem:
Group 8
L: Atmospheric Carbon

Rising Sea Levels & Protecting Ourselves From Floods

An Outlook from the four worldview perspectives

PE2004 Group 6

Safety in a chemical plant, a wicked problem?



Computers and Artificial Intelligence

Wicked Problems Group 3



PE2004 *Communication and Ethics in Engineering*
Wicked Problem Assignment (includes seeking alternative framings)

“Who I am is defined by my **social position** and/or my **achievements**”

“I feel more like a **citizen of the world** than a citizen of a country”



“Who I am is defined by my **religion** and **upbringing**”

“I feel part of the vast, **interconnected whole** that is life and the universe”

Annick de Witt's Worldviews model

PE3011 Sustainability and Environmental Protection I
Sustainability Book Review

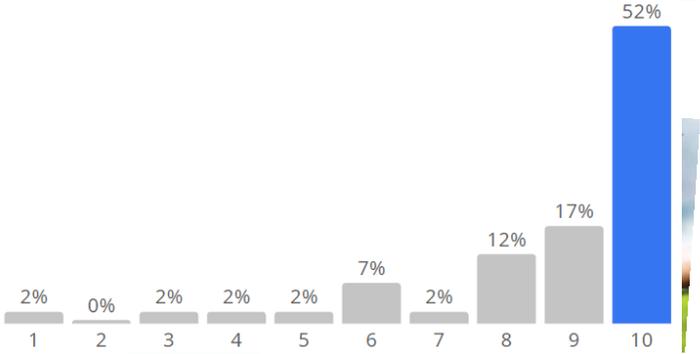
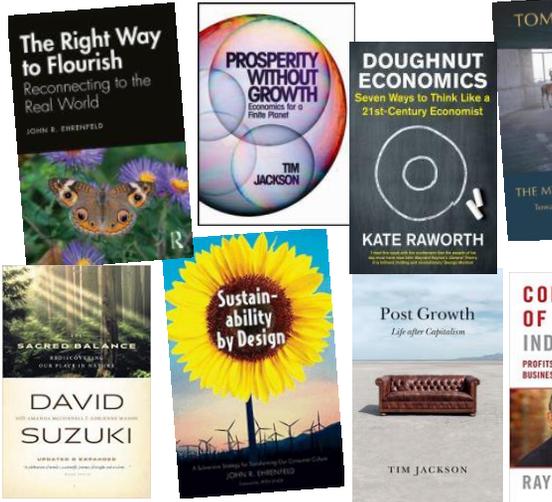
TRANSDISCIPLINARY PERSPECTIVES ON TRANSITIONS TO

A Third Window

0 4 2

In terms of supporting engagement and learning, how would you rate the following: Sustainability Book Review Exercise

Score: 8.6



PE3011
'Perusall' Peer-to-peer readings

Perusall® > 2021-PE3011:Susta

In terms of supporting engagement and learning, how would you rate the following: 'Perusall' Paper Readings and Commentaries

0 3 9

- Comments
- Questions
- Responses
- Upvotes

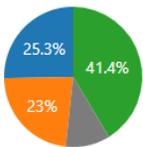
- 2021-PE3011:S... X
- EB
- My Courses
- Course home
- Settings
- Gradebook
- Student view
- 93 Notifications
- Notes
- Add to my calendar

Content
Library
Bradshaw et al (2021) A G...

Fl
W

Score: 8.5

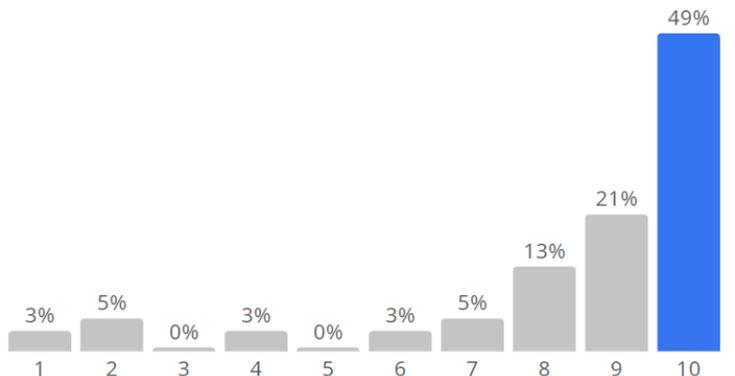
Overall assignment progress



- Completed with maximum score (41.4%)
- Completed but not maximum score (25.3%)
- Some work submitted (23.0%)
- No work submitted (10.3%)

1156 comments, 107 questions, 42 unanswered questions

4 hours, 19 minutes average reading time



models of modern and integrative ie we need the

PE3011 Sustainability and Environmental Protection I

Transdisciplinary Group Sustainability

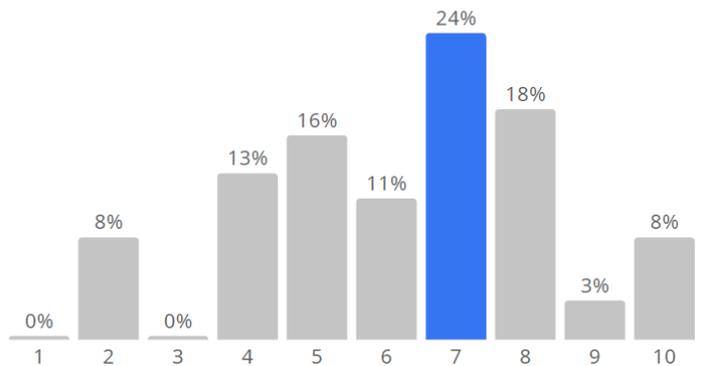
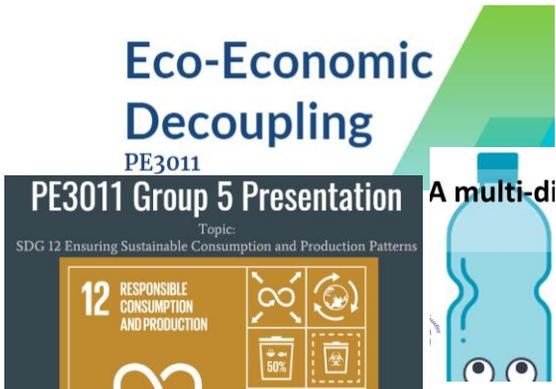
In terms of supporting engagement and learning, how would you rate the following:
Group Sustainability Presentation

0 3 8

1] Research, critically examine, and suggest **organization or process** which makes claim
OR

2] Research and critically reflect upon **any as**

Score: 6.3



Student Feedback PE3011; Seen as positive/valuable

- ‘Good to **promote critical thinking**. But I found it a bit **challenging**. Not what I was used to or familiar with.’
- ‘A major learning point of this was taking on board **alternative perspectives** of problems, **outside of engineering solutions**.’
- ‘[The] **transdisciplinary approach was enlightening** – an engineering solution isn’t always the only option.’
- ‘Working in a team with **vastly different opinions is hugely valuable** to our careers in the future.’

PE4050 Year IV Design Project

'Embedding Sustainability' into the 4th year capstone Design Project (rather than as 'bolt on')

Traditional 'end of pipe' approach:

Do the design first



Then perform sustainability assessment at the end

Revised approach to placing sustainability as context of design project requires:

- Considering sustainability throughout a (semi-open ended) design process**
-Thus feed into design decisions from start, including framing
- Environmental aspects**
-Employ scientific/engineering tools & methods which can directly influence the design (e.g. LCA, EIS, material and energy balances)
- Socio-economic aspects**
- More difficult but could be argued that the key sustainability 'game-changers' lie in this domain; consider/identify key problematic issues? (e.g. community engagement /contribution, staff transportation/health/wellbeing, EDI promotion, etc.)

UCC's student entry won IChemE Macnab-Lacey Award 2021*

*Jointly with University of Manchester
Award made annually for '*undergraduate student design project team whose design project submission best shows how chemical engineering practice can contribute to a more sustainable world.*'

University College Cork
Macnab-Lacey Design Project Prize Submission 2021



Food Waste to Bio-Products:
Food Waste to Biogas

Ross Dunphy, Sarah Kelleher, Daniel Maguire,
Anshul Nama, Sarah O Leary, Malik Zaidan



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Sustainable Development Goals Toolkit

COVID-19

INPUT DATA HERE

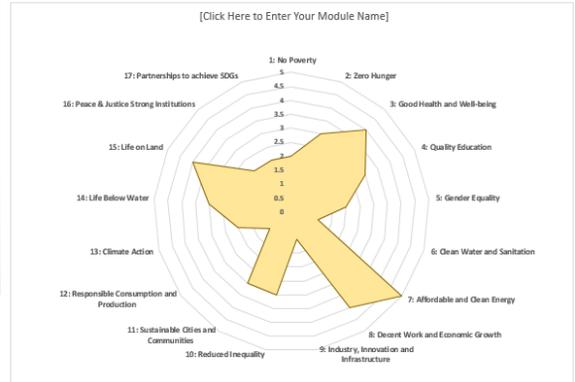
Individual SDGs (click link for more)	SDG Pillar	Score (0-5)
1. No Poverty	Social	2
2. Zero Hunger	Social	3
3. Good Health and Well-being	Social	4
4. Quality Education	Social	3
5. Gender Equality	Social	2
6. Clean Water and Sanitation	Environment	1
7. Affordable and Clean Energy	Social	5
8. Decent Work and Economic Growth	Economy	4
9. Industry, Innovation and Infrastructure	Economy	1
10. Reduced Inequality	Economy	3
11. Sustainable Cities and Communities	Social	3
12. Responsible Consumption and Production	Economy	1
13. Climate Action	Environment	2
14. Life Below Water	Environment	3
15. Life on Land	Environment	4
16. Peace & Justice Strong Institutions	Social	2
17. Partnerships to achieve SDGs	Social	2



Sustainable Development Goals Toolkit

Read on to learn about the SDG Toolkit and how this can be used to create awareness around sustainability within your curriculum.

VIEW RESULTS IN THE GRAPHS BELOW



by Dr John Barimo, UCC (National Forum Funded)



Teaching and Learning for Sustainability



SYNTHESIS REPORT

Some Key Findings:

- ESD: Involves developing requisite **Knowledge, Skills and Values**
- Need for HE **Sustainability Standard** identified (SDG role?)
- **Students engagement** in developing ESD integral (often lacking)
- **Staff skills and confidence** sometimes lacking

4 Key Challenges:

- Lack of **Time** (for students and staff)
- Insufficient **Resources/funding/training**
- **Inadequate HE higher level support/leadership**
- Difficulty engaging with **uninterested staff**

EDUCATION FOR SUSTAINABLE DEVELOPMENT

CO-CREATING COMMON AREAS OF NEED AND CONCERN

FEBRUARY 2022

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UCC GREEN CAMPUS



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