

## Innovations and Challenges in Engineering Education for the Future: Contributing to the UN Sustainable Development Goals (SDGs)

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**Abstract:** Our paper explores exemplary educational practices in engineering education from Ireland and Austria, focusing on their contributions to fostering sustainability mindsets among students. By examining initiatives such as miniXplore at the Technical Museum Vienna and educational programs at TU Wien, as well as Green Schools initiatives in both countries, we demonstrate how early education plays a crucial role in shaping engineers committed to addressing global challenges. Through these case studies, we illustrate the intersection of technology, culture and international stability, offering insights into how engineering education can advance the UN Sustainable Development Goals.

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### 1. INTRODUCTION

In an era marked by rapid technological advancements and global challenges, the role of engineering education has taken on profound significance (Elfert and Ydensen, 2023), particularly concerning its impact on international stability. Our paper, titled 'Innovations and Challenges in Engineering Education for the Future: Contributing to the UN Sustainable Development Goals (SDGs),' addresses this pivotal theme within the context of the 22nd IFAC Conference on Technology, Culture and International Stability (TECIS). By exploring innovative approaches to engineering education in Ireland and Austria, we aim to demonstrate how early education fosters a mindset prioritizing sustainability, thus contributing to the broader discourse on technology, culture, and international stability.

Engineering is often regarded as a driving force behind innovation and progress. It holds immense potential to contribute to the attainment of the United Nations Sustainable Development Goals (SDGs) (FEANI WG SDG, 2021). These goals encompass a wide range of critical issues, from clean energy and infrastructure development to quality education and reduced inequalities, all with the ultimate aim of creating a more sustainable and equitable world for present and future generations. However, the path to achieving these ambitious objectives requires a fundamental shift in the way we educate our future engineers and problem solvers.

Recognizing that education plays a central role in shaping the values, knowledge and skills of individuals, it is essential to foster a culture of sustainability and responsibility from the earliest stages of learning (Federico, 2003). The educational journey towards engineering excellence and sustainability must begin early, extending from Kindergarten through the entire spectrum of schooling. By doing so, we lay the



Figure 1. Map showing the organizations that operate the Eco-Schools program in the different member countries. <https://www.ecoschools.global>

groundwork for a generation of engineers who not only possess the technical proficiency required for their field but also embrace a profound commitment to sustainability, ethics and the welfare of all.

This paper explores the innovative approaches to engineering education adopted by institutions in Ireland and Austria, highlighting the transformative potential of early education in fostering a mindset that prioritizes sustainability. By offering insights into exemplary educational practices in both countries, we aim to demonstrate the importance of integrating sustainability principles into engineering education at various levels. These initiatives not only enhance the attractiveness of science and engineering disciplines but also ensure that future engineers are equipped with the knowledge and values necessary to address the challenges outlined in the UN SDGs.

Doyle-Kent and Watson state in 2021 that “globally prepared engineers with international experience needs to be an intrinsic

components of the engineering education programme.” (Doyle-Kent and Watson, 2021)

In the subsequent sections, we will delve deeper into the specific educational strategies employed in Ireland and Austria, emphasizing how these initiatives contribute to building a sustainable mindset among students. Furthermore, we will explore the broader implications of such educational innovations, emphasizing their alignment with the overarching objectives of the UN SDGs.

## 2. BEST PRACTICE EXAMPLE I: MINIXPLORE @ TECHNICAL MUSEUM VIENNA, AUSTRIA

The "miniXplore" activity, offered at the Technical Museum Vienna is an example for early engineering education designed to make STEM subjects (science, technology, engineering and mathematics) engaging and accessible for children aged three and above (Technical Museum Vienna, 2021). This interactive exhibition, launched on March 26, 2021, focuses on fostering playful exploration, emphasizing that there are no "right" or "wrong" approaches to learning. It encourages children and accompanying adults to embark on a journey through STEM subjects without fear of failure while having fun and excitement. With a sprawling 500 m<sup>2</sup> adventure playground featuring multiple stations, miniXplore stimulates the joy of experimentation, promoting communication, cooperation, creativity, and problem-solving skills.

Sustainability is an integral part of the miniXplore experience, extending beyond just teaching STEM concepts. Natural materials like birchwood, sheep's wool, Swiss pine wood shavings, cherry stones and buckwheat chaff are thoughtfully incorporated into the exhibition's design, alongside recycled plastics and environmentally certified furniture. This approach demonstrates a commitment to sustainability in early education, teaching children not only about science and technology but also about the importance of environmentally responsible choices. Regional businesses were prioritized in the selection of external partners, aligning with sustainability principles and promoting local economic growth. Overall, miniXplore stands as a remarkable example of how engineering education can blend learning, fun, and sustainability to inspire young minds and nurture a generation of eco-conscious engineers.

## 3. BEST PRACTICE EXAMPLE II: PROGRAMS AND EVENTS FOR CHILDREN AND YOUNG WOMEN AT TU WIEN

Women's active participation and empowerment in STEM (science, technology, engineering and mathematics) fields (Chowdhury et al, 2022) is essential for achieving the UN Sustainable Development Goals, as it promotes innovation, economic growth and gender equality, ultimately contributing to a more sustainable and equitable world.

TU Wien, also known as Technische Universität Wien, is Austria's largest institution for natural sciences and technology research and education. It is part of the Austrian Universities of Technology consortium, along with TU Graz and MU Leoben, with over 42,000 students and a significant research and financial presence.

TU Wien offers a wide range of STEM initiatives aimed at supporting individuals interested in pursuing careers in technology and natural sciences. These initiatives are designed to help students, newcomers and researchers discover the opportunities in these fields. The university provides various information formats, available centrally, through faculties, institutes and student associations, allowing everyone to explore the options at Austria's largest university in technology and natural sciences. These activities run throughout the year and cater to individuals, school classes and special events for young women. Personalized counseling sessions are also available to address specific questions. Additionally, the TU Wien has established the Network FU[TU]RE.experts and offers resources through the Gender Competence Department, Equal Treatment Working Group and TU Kids & Care Office to support staff members in science communication.

For children and young women, the TU Wien offers several specialized programs and events. These include FIT-Infotage and FIT Botschafterinnen (Women Only, FIT stands for Frauen in die Technik, which means women into technology), BeSt<sup>3</sup> (the major career and study information fair in Austria), Wiener Töchtertag (Viennese day for daughters, Girls Only), Girls Day Mini (for small kids, four-six years old, Girls Only), techNIKE-Workshops (Women Only), Hannspeter Winter-Preis (Women Only), and Young Science-Ambassadors from the TU Wien. These programs aim to engage and inspire young girls and women to pursue careers in STEM fields by providing them with exposure to various aspects of technology and natural sciences. The university's commitment to promoting diversity and inclusivity is evident through these initiatives, which encourage girls and women to explore opportunities in traditionally male-dominated fields.

One specific example shall be highlighted in more detail here: The Transformer Project at TU Wien. In line with the focal themes of climate, future and technology, the project "Transformer" has commenced at TU Wien, in collaboration with the Climate and Energy Fund and the Austrian Research Promotion Agency (FFG). This initiative utilizes an empty space in the city as a platform for creative exploration and learning, with a particular emphasis on engaging children and adolescents in hands-on research and education related to the topic of climate change. The new innovative and creative learning space that is emerging in an old 17th-century orphanage with approximately 900 square meters of usable space is being developed collaboratively with scientists from TU Wien to generate solutions related to climate change, climate adaptation and the circular economy. The "Transformer" project involves researchers and staff from six different faculties at TU Wien. The initiative aims to engage children, youth, educators, families and the wider community in addressing these critical issues and encouraging creative solutions.

The project's core team consists of four members, along with nine representatives from the six participating faculties, each contributing unique knowledge and expertise. The project involves repurposing the old building to create spaces for experimentation, learning and interdisciplinary collaboration, with a focus on ecological building materials, recycling and

sustainability. The ultimate goal is to empower children and youth to take action and make a positive impact on the environment and their future. The project's implementation spans three years (starting in 2023) with an emphasis on active participation and practical learning experiences aiming to transform knowledge into tangible solutions and inspiring a sense of optimism for the future.

This initiative has gained substantial support from various partners, including BIG (Austria's federal real estate company), who provided the project with the necessary facilities. The project's broad goals include raising awareness, fostering sustainability, and encouraging concrete actions towards a more sustainable future, all while providing a safe and engaging space for children and youth to explore, experiment, and develop their skills.

#### 4. BEST PRACTICE EXAMPLE III: GREEN SCHOOLS

Eco-Schools is actively embraced in 73 countries through FEE (Foundation for Environmental Education) member organizations and additionally in 26 countries via International Schools.

##### 4.1 Vienna International School

Vienna International School is dedicated to promoting Education for Sustainable Development. The aim is to cultivate responsible global citizens who embrace sustainable lifestyles and thinking (Andreou, 2020). The school is accredited as the first International Eco School in Austria by Eco Schools (Fig. 1), Global Schools, and Umweltzeichen (Austrian Eco Label) organizations. They integrate the Eco School Program and Sustainable Development Goals into the curriculum to educate students about global sustainability issues. By becoming an international Eco School, they encourage students to understand and champion sustainability on a global scale, fostering a commitment to a sustainable world. The school also holds the Umweltzeichen label, emphasizing its dedication to environmentally friendly education.

##### 4.2 A Green-Schools in Ireland

Most young people care deeply for the environment and aspire to make a positive impact on their surroundings. Green-Schools is operated, and coordinated by, the Environmental Education Unit of "An Taisce." It is described as Ireland's leading environmental management and education programme for primary and secondary schools. It links positive environmental impact with the core school curriculum. It aims to push the learning beyond the classroom by developing responsible attitudes and commitment, both at home and in the wider community.

Green-Schools has the ambitious aim of promoting long-term, whole school, positive actions to improve the local environment. To ensure that this programme is a success it is student-led but has engagement and involvement from the wider community.

Green-Schools' mission is to protect planet Earth, our shared home, and this means everyone must play a part in this

challenging project. Participants from all backgrounds, cultures, races and ethnicities, religions and belief systems, abilities, sexual orientations and gender identities are part of the global team. Equity, diversity and social justice are fundamental to the Green-School's value system.

The core themes of the programme are:

*Litter and Waste*, focusing on litter and waste issues by encouraging a sense of responsibility for all.

*Energy* looking at the steps that can be taken at school level to reduce energy consumption and raise awareness of climate change.

*Water*, developing awareness around water conservation as well as how to effectively manage this important resource in schools.

*Travel*, increasing the number of students walking, cycling, scooting, using public transport or carpooling to school can have a very positive effect.

*Biodiversity*, looking at increasing the awareness in schools of the importance of native plants, animals and habitats.

In addition, *Global Citizenship* in the following areas are considered: *Litter & Waste*, *Energy*, *Marine Environment*, *Travel* and *Biodiversity*.

In order to enhance the activities in schools, Green-Schools offers many free resources to Teachers on their website. It also has a calendar of events that the students and staff can take part in, including clinics to ensure that the participant get the maximum from each initiative. Newsletters and competitions keep the community informed and motivated.

##### 4.3 The Sustainable Energy Authority of Ireland school's initiatives

The Sustainable Energy Authority of Ireland (SEAI) interacts with the Irish educational communities, from preschool to primary and post primary, providing workshops to bring energy and sustainability into the classroom in a fun, interactive way. These energy workshops are for both teachers and pupils at primary and post-primary levels. SEAI have also Early Childhood Ireland to bring the "Guzzler" energy programme to pre-school children. Here pre-school children develop an understanding about energy and sustainability, and the values built when they are young children will stay with them for the rest of their lives and, ultimately, they are more likely to be empowered citizens in the future (SEAI.IE, 2024).

## 5. IRISH EDUCATIONAL POLICIES FOR SUSTAINABLE DEVELOPMENT

Ireland has taken a very active interest in building sustainability into Irish education at all levels. The Irish Government, through the Department of Education in 2014, launched 'Education for Sustainability.' The National Strategy on Education for Sustainable Development in Ireland states its main objective is to "ensure that (Irish) education contributes to sustainable development by equipping learners with the relevant knowledge (the 'what'), the key dispositions and

skills (the ‘how’) and the values (the ‘why’) that will motivate and empower them throughout their lives to become informed active citizens who take action for a more sustainable future. (GOV.IE, 2014).

The Irish government facilitates this in practice by organizing an annual national forum on Education for Sustainable Development, the most recent taking place on December 1<sup>st</sup>, 2023. (GOV.IE, 2024)

This forum discussed in depth the following topics:

- Progress on ESD to 2030
- Transforming Learning
- Partnerships for ESD
- Sustainable and Inclusive Learning Environments
- Creative thinking for Climate Action and Sustainability

The priority action areas pinpointed were; transforming policy in Ireland, transforming the Irish learning environments, building the capacity of educators, empowering and mobilizing youth and accelerating local actions. Updates on each of these actions were described in detail and the following plan was proposed for building capacity of the Irish Educators:

- National Forum – Strategic Alignment of Teaching and Learning (SATLE) - funding with ESD actions (transforminglearning.ie, 2024).
- National Technological University Transformation for Recovery and Resilience national project (NTUTORR) project – Sustainability focus (NTUTOR, 2024)
- Mapping of ESD Continuous Professional Development (CPD) for teachers
- Inclusion of sustainability as criteria for teacher summer courses
- Peer Learning Activities – Learning for Sustainability
- SDSN Ireland launched, Feb 2023 – UCC and Queens (sdsnireland.org, 2024).

Actions at a policy level will mean that all stakeholders will be actively involved in change making throughout the Irish education system.

## 6. NTUTORR

Engineers and scientists play a critical role in the use of global resources and need to be educated with the tools to make a positive difference. Engineering education at third level is greatly enhanced by the use of the NTUTORR tools in the classroom.

NTUTORR is described as an innovative collaboration across the technological higher education sectors in Ireland to transform the student experience through technology and staff-student collaboration, in alignment with the UN sustainable development goals. (NTUTOR, 2024).

It is composed of seven third level technological universities and is funded by the European Union initiative

NextGenerationEU. (NextGenerationEU, 2024) NTUTORR has five themes and these themes are streamed into three areas: Student Empowerment, Staff Capabilities and Digital Ecosystem.

The first theme addressed is *Digital Transformation*, and here transformation in the local educational partners is enabled by implementing digital ecosystems which support teaching, learning and assessment. The second theme is *Universal Design for Learning*. This focuses on improving the student experience by promoting more flexibility in the methods used in teaching and assessing the work. The third theme is *Education for Sustainability*. The objective here is to develop a culture of change across the sector by the integration of the UN Sustainable Development Goals in the delivery of the overall project. The fourth theme is *Academic Integrity*. This looks at equipping our academic staff and students with the appropriate tools to ensure “honesty, trust and fairness in teaching, learning and assessment in the context of rapid technological advancements.” The fifth theme is *Equality, Diversity and Inclusion*. This focuses on establishing an inclusive, safe, equitable and respectful culture across the technological higher education sector. Finally, the sixth theme is *Employability*. This area is concerned by the enabling our students to be successful after graduation and throughout their working lives.

The themes are transformed into streams, one of which is student empowerment stream, which changes the learners experience in a positive manner. In order to do this nine work packages (WP) are made available, and an example of one is WP 1.3: The Academy for Sustainability, Leadership & Employability. In essence, this provides opportunities for students to develop skills and literacy in sustainability and global citizenship, digital identity and transformation, EDI and mental health and well-being. It is flexible, accessible and self-directed learning pathways for students to earn a "digital backpack" of credentials.

## 7. CONCLUSIONS

In conclusion, our paper underscores the transformative potential of early engineering education in fostering sustainability mindsets among students, thus contributing to the broader discourse on technology, culture and international stability. By highlighting best practices from Ireland and Austria, we provide insights into how educational initiatives can shape future engineers committed to addressing global challenges. Our findings not only enrich the literature on engineering education but also offer practical implications for advancing the UN Sustainable Development Goals and promoting international stability. We believe that our research aligns with the objectives of the TECIS conference, and we look forward to further discussions on this vital topic.

In an increasingly complex world, where the pursuit of sustainability and global well-being stands as a paramount objective, reimagining engineering education becomes imperative. The transformative power of education in shaping the engineers of tomorrow, who will drive innovation and address the world's most pressing challenges, cannot be overstated. This paper seeks to shed light on the vital role that

early education plays in realizing a sustainable future and how nations like Ireland and Austria are at the forefront of this transformative journey. Through their innovative practices, these nations may serve as best practice examples for others, showing potential paths toward a more sustainable and prosperous world for all.

It is acknowledged and recognized in this paper that positive influence starts at the preschool stage, and the value systems can be enhanced and encouraged throughout the educational journey. Governments can play a pivotal role by providing a sustainable strategy in education as well as practical guidance and fanatical support in the classroom. Connecting SDG to everyday life and empowering students to make a positive difference throughout their education in a holistic way, as part of their community, will naturally facilitate them in their quest to make a positive difference and become Global responsible leaders of the future.

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