# REEdI: Rethinking Engineering Education in Ireland

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## Abstract

*The REEdI project offers an agile and innovative learning programme providing personalised, flexible and tailored options to diverse learner cohorts; from school leavers to graduating apprentices, to upskilling industry professionals and mature students. Building on the success of world-leading cutting-edge models of engineering pedagogy, we combine an innovative method of content delivery with new immersive technologies to deliver a transformative programme of self-directed and self-scheduled learning for the next generation of engineers. Learners will navigate an online learning map and complete subject paths, in their own time, at their own location, choosing material to suit their individual and unique needs. The framework will be truly innovative, drawing on international best practice in the field of engineering education. The programme enables a student-centred, project-centric and technologically innovative approach to undergraduate programme provision, equipping graduates with the skills and knowledge required to ensure they are capable of navigating the future challenges and disruptive technologies faced by the manufacturing sector in Ireland. In terms of structure, we have designed the framework to have three central pillars: eLearning, projects, and performance planning and review; all bracketed by innovations in pedagogies and technologies. We have modelled REEdI on a world-leading model of self-directed, project-centric learning developed by Charles Sturt University. Our novelty and additions include the use of Virtual Reality and Augmented reality (VR/AR) in supporting the education of student engineers along with student access to world class Science Foundation Ireland research centres (CONFIRM, LERO, and IMaR). This affords a wealth of advantages in undergraduate engineering education provision. It is also becoming increasingly important to involve employers in the development and provision of learning to ensure its relevance to the needs of the workplace. We have appointed Industry champions to a steering committee and industry are actively involved in curriculum design. Our approach aims to be positively disruptive and transformative, with a vision to set the agenda for engineering education nationally.*

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## 1. Introduction

This paper describes the rationale and appetite institutionally, regionally and nationally for a new way of designing, developing and delivering engineering education in Ireland, drawing on expertise and experience internationally in the field of engineering education reform. There is an increasing argument that engineering education in Ireland is risking being a barrier to economic growth in the country. Universities are coming under increasing pressure to re-invent the way that engineering is taught to students, with the ultimate aim of producing engineering graduates that are capable of meeting the skills needs of the countries industries now and into the future. A recent report by Engineers Ireland, the representative body for engineering professionals in Ireland has outlined that 91% of engineering employers identified skills shortages as a significant barrier to growth within the Industry [1]. The skills shortages identified were not only in the technical areas of engineering, but also in the areas of transversal skills. Engineering employers struggle to fill roles in the mechanical and manufacturing engineering professions, which has an annual growth rate of 16.6% [1].

Therefore, Higher Education Institutes (HEIs) in Ireland are required to become more agile and innovative in the design, development, delivery and continuous improvement of engineering education. Our REEdI initiative is to provide an alternative option for engineering education and indeed, other undergraduate disciplines across higher education in Ireland. The ultimate aim is for any HEI to be able to adopt our approach utilizing the roadmap and framework developed and tested through REEdI.

## 2. Engineering education frameworks – The Global context

The pressure on Universities to produce engineering graduates capable of meeting the needs of Industry is not solely an Irish problem. Many institutions across the globe have developed different frameworks and initiatives to tackle the issue. Demands placed on Universities in relation to engineering education output does not stem solely from Industry/employers. The changing demands come from a variety of different cohorts: students, society, and science [2].

Some of the most reported innovators in global engineering education and the methodologies/ frameworks they have developed and proposed to meet these demands are presented here:

- Massachusetts Institute of Technology (MIT) conceived and have spear-headed the CDIO initiative (**C**onceive-**D**esign-**I**mplement-**O**perate), which is a framework that enables the systematic development of engineering programmes, with 12 standards available to guide engineering programme development [http://www.cdio.org/about]. CDIO promotes course/ modular learning and project learning combined, aimed to both ensure technical skills and professional engineering skills are embedded in engineering programmes. [3]. Currently there are >120 institutes involved in the CDIO initiative globally.
- University College London (UCL) has created and driven the Integrated Engineering Program (IEP) framework [4]. This is a cross disciplinary initiative across all engineering disciplines. All programmes follow a core structure across all disciplines. Students in UCL from different engineering disciplines come together at different stages throughout the programme to work on multidisciplinary project teams. The IEP utilizes Problem Based Learning (PBL) as part of the multidisciplinary experience and this is embedded throughout engineering courses at UCL [4].
- Charles Sturt University (CSU) is a multi-campus regional University in New South Wales Australia combining on-campus project-based learning with online learning and off-campus work-based learning. CSU are seen as an emerging leader in engineering education on a global scale [5]. The CSU engineering programme was particuarlly interesting in the REEdI context, as MTU is also a regional university.

## 3. The Irish context

When looking at engineering education in the Irish Context, it is important to understand that manufacturing is a central pillar of Irish economy and is a high productivity growth sector [7]. According to Mulligan (2019), Ireland's manufacturing sector is facing "significant" skills shortages in engineering disciplines. Our education programmes need to be more accessible, flexible, open to diverse learner cohorts, applied and tangible. Irish HEIs therefore need to respond in order to generate the Human Capital required for our manufacturing sector. Further to undergraduate engineering skills needs, the manufatcuring industry requires flexible means for continuous professional development (CPD) for staff [7]. Irish manufacturing employers require the following transversal skills of graduates to supplement required improvements in technical engineering knowledge: creativity, innovation, entrepreneurship, critical & analytical thinking, team work, communication and business acumen [9, 10,11]. Therefore, the manufacturing sector in Ireland was selected to pilot the REEdI framework.

## 4. The REEdI framework - Methodology

The pilot programme selected is a BEng/ MEng in manufacturing engineering, with Industry-led content designed and developed throughout the programme.

We have designed our REEdI engineering programme to be comprised of core elements surrounded by innovations in pedagogy, technology and the REEdI Ways of Thinking (REEdI-WoTs), embedding excellence into engineering programme design. The REEdI-WoTs are a cognitive approach which

provide a framework for students on how to think and how to learn more effectively by themselves, so that they are better equipped with the transversal skills, personal effectiveness, academic and workplace competencies required once they graduate.

The following is an outline of our framework:

1. **Significant Work-Based Learning (WBL)**: pedagogically based on project-centric, experiential learning. The student applies learnings from eLearning micro-modules from their learning map and performance planning, review and self-reflection to ensure the competencies WBL are met and demonstrated. A recent review by Rouvrais, S *et al*. 2017 [6] recommended the CDIO model be broadened to include more formal integrated work-based placement/learning (WBP/L) elements and frameworks. Again, the WBP/L model is particularly relevant to our work in REEdI-designing a framework in order to support students, industry partners/employers and HEIs. This activity will ensure that employers' requirements are met, that student competency, learning and professional experience is optimized, and a robust partnership is created between HEIs and industry in terms of WBP/L models.

2. **Student Performance Planning and Review:** building self-awareness and planning skills for student engineers. The purpose of this pillar is for the student (along with a core support team) to take ownership of their learning journey. This core part of our programme design enables the student to gain valuable time management skills, ability to identify individual contributions made to group projects, identify successes and spot opportunities for improvement.

3. **eLearning - Flexible and Personalised**: The REEdI e-Platform will support a flipped classroom approach. This platform will act as the students' learning map from course commencement to graduation as a professional engineer. Although students are free to complete any elements of the learning map as they wish, a number of minimum requirements will be stipulated.

4. **Bracketing the Pedagogy:** REEdI will embed emerging technologies including VR/AR simulations into undergraduate programmes. The simulations will be developed with the ability to track a student's progress as they progress through the scenarios, providing a detailed report of tasks completed successfully and those that were not. Benefits of the application of this technology include, but not limited to: practice of real world skills with rich feedback in a safe environment, mastery of a technique, behavior or method through guided rehearsals again and again, or as many times as is needed, an emotional connection of the learning event to the learner because of the realistic and immersive nature of the environment, the learning to be embedded in the proper context by providing a simulation of the actual environment and individualized instruction as a person progresses through the simulation at his/her own pace.

## 5. Conclusion

Our approach offers an agile and innovative learning framework for engineering education, providing flexible and tailored options to diverse learner cohorts. We will combine an innovative model of content delivery with new immersive technologies to deliver a transformative programme for the next generation of engineers. Immersive technologies such as eLearning and VR/AR are transforming how we learn with digital content. These disruptive technologies impact on academia and indeed many industries, including manufacturing. Applying these technologies to the development of a cutting-edge programme of engineering pedagogy has the potential to impact and transform engineering education across the Higher Education sector in Ireland.

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