EXPLORING ENGINEERING SKILLS DEVELOPMENT THROUGH A COMPARISON OF INSTITUTIONAL PRACTICES IN MEXICO AND SCOTLAND

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ABSTRACT

The future of engineering education does not depend only on the curricula designed by universities, but increasingly on the needs of society and the complex requirements of Industry 4.0. Now there is an urgent need to work on an educational approach based on the close collaboration of three stakeholders: the university, which facilitates authentic learning opportunities for students and professionals and ensures the quality of learning outcomes; the industry, which establishes the skill sets and competencies it requires of its workforce; and finally, governments and professional associations, which can influence, provide global collaboration frameworks to support transformation and funding for reskilling, upskilling, as well as institutional responses. This study presents an analysis and comparison of the engineering skills "eco-system" that considers not only the technical education in

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response to the Fourth Industrial Revolution, but also the problem-solving needs of society and the human factors that shape the transition to the labour market in global contexts.

1 INTRODUCTION

According to the recommendations of international educational organisations in their recent reports, the new curricular programs for engineering education should arise from a collaborative dialogue between academia and industry, based on a multicultural, sustainable, and socially oriented perspective. Examples are the reports of the World Economic Forum (WEF) [1] for general skills, and the Sky 4.0 Project [2] for specific skills. The review of the international literature shows how higher education institutions are beginning to incorporate the lessons learned during the COVID-19 crisis and to implement the most successful strategies, to end the state of educational contingency and move towards achieving the objectives education planned for 2030 [3]. From this review it became evident a gap has formed between Higher Education Institutions (HEI) from different regions of the world, related to the economies of the institutions, the level of digital transformation, and their technological infrastructures [4]. In this communication, we present the preliminary findings of the ongoing project in which Glasgow Caledonian University and Tecnologico de Monterrey collaborate on their institutional practices, programs, and initiatives in engineering, for the promotion and development of the new skill sets required by Industry 4.0. A desktop-based analysis and comparison of the policies and practices in the two countries/universities that have shaped current approaches to such skills development -the eco-system- and the impact that these are having on teaching, learning, and assessment approaches are presented.

2 ENGINEERING SKILLS "ECO-SYSTEMS"

2.1 The case of Scotland

Glasgow Caledonian University (GCU) is a modern university with a long history of providing education for professionals from Scotland, the rest of the UK and internationally. Its new strategy (Strategy 2030) clearly responds to these future demands through a key priority area around employability and skills, and also through its graduate attributes that influence all programme design and delivery with the updated attributes introducing 'Systems Thinking' as a new attribute, and centring learner agency. This new strategy is underpinned by the UN SDGs and is a continuation of previous educational practices to create globally competent graduates. The skills agenda eco-system for Scotland is reflected in Figure 1, where a combination of UK, Scotland-specific and industry influences the future skills requirements. To give examples of educational approaches that develop transversal skills and positive outcomes in engineering, the students are offered international mobility experiences, including Collaborative Online International Learning (COIL). Whilst international mobility dropped during the pandemic, it has recovered strongly for this academic year 2021-2022, with a similar pattern being seen for year-in-industry placements. Additionally, in another module shared across many

programmes, students in teams self-define a future-driven community-focused problem aligned to UN SDGs and design an appropriate solution to this. Such student-centred learning is a growing feature of programmes. Also, GCU is the largest provider of Graduate Apprenticeships (GAs) in Scotland – these are degree-level apprentices in which students gain the required professional competences through university studies and workplace experience to a standard co-designed with industry [5]. Positively, GAs provides opportunities for those who want to up-skill themselves as much as for those starting their careers and produce industry-ready graduates. Importantly, 90% of graduates from all Engineering programmes are in employment or further study after 15 months, with 80% of those in employment in high-skilled graduate jobs.

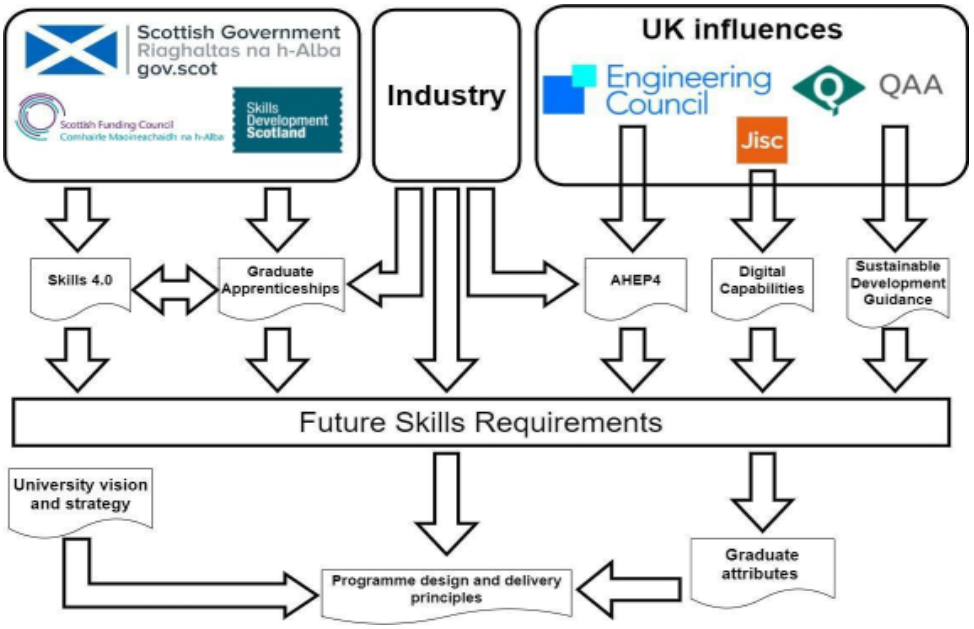

Figure 1: Skills eco-system influence engineering programmes in Scotland [Skills 4.0 defines the set of meta-skills for Industry 4.0; AHEP4: Accreditation of Higher Education Programmes 4th edition]

The strategic drive to enhance employability and meta-skills across the faculty is reflected in a Royal Academy of Engineering funded Visiting Professorship focused on preparing students for work in innovation-driven workplaces of the future. Considering technical skills, existing programmes emphasised digital and computer-based design and modelling, as well as systems approaches. Future curriculum transformation is underway with new modules with a focus on digital twins, predictive maintenance, and robotics, as well as new postgraduate programmes recognising the role of data science in engineering. Additionally, defining and implementing an Industry 4.0 Skills Taxonomy would better structure future enhancements in skills development.

2.2 The Case of Mexico

Tecnologico de Monterrey (TEC) is within the first 26 positions in the 2022 QS World Employability Ranking and the Top #1 university in Latin America [6], hence the interest to study the strategies that TEC has designed to be successful in terms of employability. The fundamental mission of the TEC is to train professionals and

postgraduates with levels of excellence in the different areas of knowledge through specific educational programs and policies, to promote in students the development of an entrepreneurial and innovative spirit, responsible leadership, honesty, respect for the dignity of the human person, the preservation of the ecology and the appreciation of the historical-cultural values of the community and the country. TEC governs its programs by the Accreditation Board for Engineering and Technology (ABET). Currently, the process of globalisation of the world economy has had an impact on engineering education in four events: rapid technological change; the emergence of a new techno-industrial paradigm (Industry 4.0); the emergence of information technologies; and the worldwide institutionalisation of academic and professional accreditation systems. Faced with these demands, TEC decided in 2015 to progressively begin the implementation of a new educational model with four fundamental pillars: 1) Inspiring teachers, with great preparation; 2) Flexibility with hybrid or fully distance courses to enable learning anywhere; 3) Memorable Experience, with comprehensive physical, cultural, mental and sports development programs; and 4) Challenge Based Learning (CBL) where all courses are designed through a challenge resolution scheme, not problems or projects. These challenges are driven by real-world situations and for this approach to succeed, then the educational model in the design of the challenges involves not only the faculty but also training partners (Companies, industries, civil associations, non-governmental, municipal, or federal authorities, etc). The new paradigm must then be characterised by active learning, centred on the student that solves real challenges [7]. Active learning with the educational model with the CBL didactic technique is the fundamental basis of Socially Oriented Education, that is, developing skills based on the current need, whether labour or social problems [8].

3 METHODOLOGY

The study was designed considering the 2021 report in which the WEF brought together the ideas of ministers of education and labour, chief executive officers, chief human resource officers, chief learning officers, online learning providers and key industry skills experts, to propose a new framework for a global skills taxonomy based on ESCO (European Skills, Competences and Occupations) studies and aligned with the Occupational Information Network (O*NET) framework [1]. The report identifies that the successful adoption of this taxonomy is dependent on both institutional policy and practice. A comparative study focused on the strategies followed by the two universities -TEC and GCU- is being carried out during 2022. Strategies around fostering contemporary and lifelong skills in engineering are being compared: the description of skills frameworks, the how and by whom they were shaped, as well as how institutional policies supported these skills. The taxonomy used in this work integrates additional new skills and emerging attitudes related to the Fourth Industrial Revolution:

- Global Citizenship
- Socially Oriented and Multicultural Perspective
- Challenge-Based Learning

4 DISCUSSION AND FUTURE WORK

Similarities between the two universities include partnership with industry; approaches being influenced by the main industry sectors in the economy; responding to societal challenges (alignment to UN SDGs); and the desire to develop relevant meta- and technical Industry 4.0 skills.

Moreover, at both institutions, the partnership between university, employers and Professional Engineering Institutes nurtures professional engineers through work-based assignments that link module content and the workplace, as well as ongoing reflection.

Additionally, COIL opportunities at both GCU and TEC develop intercultural competencies, international perspectives, and ethical sensitivities, which are essential to develop as responsible global citizens. Companies value these skills as graduates have a more holistic understanding of synergy between engineering and business.

Furthermore, the inclusion of challenges and experiences that are socially oriented and focused on the UN SDGs allow for the robust development of skills (socially conscience and empathy; openness and resilience; creativity and sense-making) which are essential for obtaining jobs that meet the expectations of future engineers.

Some differences in approaches to skills development emerged: particularly the CBL approach present throughout the TEC curriculum allows for dynamic and ongoing engagement with industry, while at GCU it is generally a hybrid approach of project-based and more traditional technical modules. Another difference detected is that the national/government policy in Mexico does not have as much influence in defining the political agenda, so TEC had to develop its own framework, while GCU is being strongly influenced by educational policies at the national level.

The analysis also determined that the Skills Taxonomy, as outlined in [1], at both institutions was being defined. Future work includes the final stages of the study to analyse strategies that respond to the current concern of companies: what are the reasons for the difficulties in finding competent talent within each country? The analysis will focus on the circumstances that relate the difficulty of companies to find talent and the following shortcomings of engineering graduates: soft skills, digital skills, knowledge, and mastery of languages other than their native one, work experience and interpersonal skills.

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