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TOWARDS BUILDING A FRAMEWORK FOR CONTINUING ENGINEERING EDUCATION IN HIGHER EDUCATION INSTITUTIONS: A COMPARATIVE STUDY

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ABSTRACT

Continuing engineering education (CEE) is becoming an attractive notion of continuously enhancing and upgrading the engineering skills required by the Fourth Industrial Revolution. Current developments in science and technology and the challenges to address the United Nations Sustainable Development Goals (UN SDGs) of the 2030 Agenda require updating theoretical knowledge, skills, and specific practical work. Even though higher education institutions (HEIs) can provide CEE or CPD (Continuing Professional Development) within or external to degree programs, CEE focuses on training engineers as lifelong learners to meet societal and industrial needs. A comparative study was conducted among eight universities to analyse the strategies used to provide CEE services at an institutional level. This study aims to investigate approaches and practices in CEE offerings to learn lessons and adjust CEE programs and policies in the HEIs involved in this research. The study followed an adapted version of a Comparative Case Study (CSS) as a suitable framework to map the CEE strategies and approaches of the participating universities. Preliminary results indicated differences in the organisational structures, e.g., traditional courses within existing programs. At the same time, other institutions provide flexible mechanisms such as short courses, modules, or micro-credential activities leading to qualifications. Similarities are found in institutional policies aiming at developing postgraduate programs aligned to industry demands. This study reflects the importance of learning programs as resources provided by HEIs applying a framework for engineering education and the engineers' further professional development.

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1 INTRODUCTION

There are many drivers for change in engineering education, such as Industry 4.0, Artificial Intelligence, Digital Transformation, or responding to the Global Grand Challenges, such as the UN Sustainable Development Goals (UNESCO 2021a). Quite rightly, research is focused on how we develop the required competences for emergent engineers through university studies, including a mixture of technical

expertise, such as in reconfigurability (Andersen & Rösiö 2021), digital skills and data management (Sharipov et al. 2021) and transversal skills, such as socio-cultural/intercultural competency (Boyadjieva &Ilieva-Trichkova 2023), as well as in leadership, interpersonal skills, ability to work efficiently in teams, managing interdisciplinary teamwork, communication skills and change, amongst others. However, these challenges equally require examination of the developmental needs of practising engineers and engineering educators, so that Continuing Engineering Education (CEE) practices are developed to meet these needs. Therefore, for this study, CEE is considered to be the additional education of a practising engineer or technologist/technician after an initial recognised phase of education, typically an undergraduate degree (Uhomoibhi & Ross 2019).

The area of CEE is comparatively under-researched, and there is a lack of contemporary publications around the practices and models within institutions concerning CEE. It is this gap in the extant literature that this research seeks to address, by comparing the institutional practices of eight Higher Education Institutions (HEIs) in eight different countries. This comparative case study will outline what institutions are doing and how they are approaching this. The objective is to capture how CEE is developed and implemented within differing institutions to determine any similarities and differences with the intention to inform enhancements to institutional policies and practices. Also, the differences among these institutions in the level of CEE offerings and approaches can serve as an inspirational source for others to start developing CEE activities in their own organisations. Moreover, we aim to learn from and inspire each other's developments. Consequently, the research question for this study is 'What are the approaches at institutional level to integrate Continuing Engineering Education policies?' As all institutions offer full, taught postgraduate programmes, this research will focus on other forms of CEE offering.

This paper will first outline the context of CEE in Higher Education, briefly introducing the eight institutions in this study, before detailing the comparative case study methodology adopted for this research. Next, the study offers comparative findings around how CEE is organised and resourced, what do institutions offer as CEE, the level of involvement of industry in what is offered distinctive aspects found in institutions. Finally, we discuss next steps and future directions in this comparative research.

2 CONTEXT OF CONTINUING ENGINEERING EDUCATION IN HIGHER EDUCATION

Continuing Engineering Education is an essential aspect of any professional engineer maintaining the required competences to practice, whether this be to stay current with new emergent technologies, or develop new skills, e.g., around sustainability or in change leadership (International Engineering Alliance 2021). Nowadays, there are a range of learning modalities for engineers to develop such practice - through experiential learning, through non-formal learning or through

formal learning, or learning-on-the-job (Lynch and Russell, 2009). Additionally, there is also a diversity of providers, from internal training courses and mentoring, online courses, to training organisations, to courses from Original Equipment Manufacturers and Technology/System Providers', as well as a range of offerings from educational institutions, both further and higher education (UNESCO 2021b). This complementary eco-system of providers enables the required flexibility for individuals and their organisations to organise their CEE offers.

HEIs have played a long-standing role within this CEE landscape, particularly in the provision of postgraduate/Masters qualifications, at the research-teaching and research-praxis nexus. However, the greater diversity of learning options and immediacy of access to some forms of learning, makes it important to examine how HEIs are responding to those demands, and to see if there are similarities and differences between the different forms of HEI: public university, private university, technical universities, commercial (for profit) providers. This research adds insight into how HEIs are organising themselves in response to these needs, as well as highlighting how the different types of courses and how these educational offerings are developed (e.g., driven by market, knowledge sharing by HEI, or in collaboration). As all institutions offer taught postgraduate programmes, then the research will focus on other forms of Continuing Engineering Education offering. The focus on just a sample of HEIs is acknowledged as a limitation of this research.

The eight (8) institutions involved in this research are from eight different countries, seven of whom are European (see authors' institutions above), with examples of CEE offered (Table 1). They represent a range of different HEIs across the forms outlined in the paragraph above, and all engage within a range of CEE activities, whether that be offered internally (to students and staff) or for external provision. The fact that the participating institutions are from different countries provides a breadth of approaches. However, it is acknowledged that the institutions are not necessarily representative of these countries. Additionally, the institutions also are at different points in the lifecycle of adapting their CEE provision; this research is not focused on evaluating competitive positioning rather to determine if there are shared aspects that are influencing the decisions on policy and practice.

Table 1. Participating Institutions and code use for results below

Institution	**Code**	**Example of CEE provision offered**
Aalborg University www.aau.dk	A	Short courses/modules, Master programs (MBA) eg within Cyber Security and Privacy, Management of Technology, Building physics, Circular economy, Energy efficiency
Aalto University https://www.aaltoee.fi/en	B	E/MBA programs, long and short courses, micro-credentials, modules, customised programs, online programs. Themes from all six Aalto University schools are represented.
TU Berlin www.academy-tu.berlin	C	Degree programs (MBA, MBL, MSc) and short courses in the areas of Data Science, Sustainability, Management & Leadership, Engineering & Mobility

Tecnológico de Monterrey https://tec.mx/en	D	Degree programs (MBA, MBL, MSc) and short courses in the areas of Business Analytics, Cybersecurity, Biotechnology, Data Science, Applied Artificial Intelligence
Glasgow Caledonian University https://www.gcu.ac.uk/study/part-timestudy	E	Short courses, e.g. in Data Analytics & AI Machine Learning; Renewable Energy Technologies; Climate Change & Carbon Management.
Uppsala University - The Faculty of Science and Technology https://www.uu.se/en	F	Short courses in, e.g. Industrial analytics, Sustainable energy transition, Biomaterials, Additive manufacturing in metallic and ceramic materials, Application of augmented reality in industry, Data mining, Statistical machine learning, Self-leadership etc.
EPFL https://www.epfl.ch/education/continuing-education/	G	Degree programs (COS, CAS, DAS, MAS) and short courses around science, technology and engineering (i.e., Data Science, Machine Learning, Supply Chains, Fintech, IOT, Geoengineering, Risk Management, Urbanism, etc.)
TU Eindhoven https://www.tue.nl	H	Short courses on a variety of topics, e.g. mechanical engineering, etc.

3 METHODOLOGY

The nature of the research question is descriptive and exploratory, so is best suited to a qualitative methodology. Specifically, a comparative case study approach has been taken, adapted from Barlett and Vavrus (2017). A purposive sample of institutions was selected to participate in the study with inclusion criteria being that each institution had some involvement in Continuing Engineering Education; this sampling strategy is recognised as a limitation of the paper, but in this exploratory research a purposive sample is appropriate, as the study seeks to identify factors that influence policy and practice around CEE.

Data collection was achieved through each institution completing information against a standardised set of criteria. These criteria were generated based on factors that covered meso (institutional) level and micro-level (programme and course) factors. Meso factors covered: how policies supported CEE; organisational structure; ease of CEE operating within regulations; permitted offerings (type of courses & provision areas); university systems to support; resourcing (staffing) approaches; teaching, learning and assessment methods. Subsequently, each institution summarised the pertinent aspects that related to the research question into a short (one to two page) institutional summary.

An inductive, group analysis of the detailed and summarised institutional cases was conducted to determine shared practices, similar factors influencing policy, practice and decision making, as well as potential differences. The findings of this comparative analysis are presented below.

4 FINDINGS AND DISCUSSIONS

Based on the collective and comparative analysis of the eight cases, then three main aspects were identified: 1) how each institution organised the provision of CEE, including how it resourced such courses; 2) what courses were offered and how did these fit into any flexible qualification provision, and 3) how strongly were the offerings aligned to the needs of the market (including whether the courses were co-designed between a HEI and another organisation).

4.1 Organisational structure and resourcing

Seven of the institutions arrange some (or all) of their CEE offerings from within the institution's existing organisational structure, whereas in one institution (#C – TU Berlin) then this is solely arranged through an associated private company (APC) (Table 2). As an APC is also a form of centralised offering (owned subsidiary of one or more than one institutions), then seven institutions use a centralised approach, reflecting the importance of having strategic vision and policy enactment for CEE, and seeking to use centralised services (such as finance). De-centralised offerings reflect either ad-hoc opportunities, or a decision for continuing education to be more focused in particular schools and faculties. Drivers for different forms of supporting organisational structure relate to national legislation, flexibility, and building from a school/department outwards, with macro factors (legislation, government policy) being a significant driver of institutional policy and decisions.

Table 2. Organisational approach to offering CEE.

	A	B	C	D	E	F	G	H
Associated private company/ foundation		X	X	X	X		X	
Centralised CE offering	X	X	X	X	X		X	X
De-centralised CE offering	X	X				X	X	X

An interesting aspect of CEE between the institutions is differing practices around how these offerings are resourced (Table 3). Six institutions are able to use institutional staff within their existing contracts, but for two institutions (#B – Aalto University, #C – TU Berlin), then they have to remunerate lecturers additionally for their involvement. These two institutions also use APCs, reflecting policy and legal requirements within their institutions/countries. Discussions highlighted that resourcing is a key area of policy and enactment of that policy that enables effective CEE offering.

Table3: how CEE offerings are resourced

	A	B	C	D	E	F	G	H
Institutional staff - within contract	X			X	X	X	X	X
Institutional staff - paid		X	X	X	X	X	X	
External to institution staff - paid	X	X	X		X	X	X	
Partnership with external institution		X		X			X	

Of note, all institutions do not subsidise the running of courses, with the costs being met through a variety of means, including government, commercial or individual funding; the balance of sources of the above funding varies between institutions.

4.2 Types of CEE Offering

All institutions offer full taught postgraduate programmes (as outlined above), so these are not considered in these findings. Table 4 indicates that all partners are engaged in a range of courses – from stand-alone Continuing Professional Development (CPD) modules, to up- and re-skilling, up to full Masters programmes (delivered through APCs, or through credit stacking in a more flexible way). These offerings can be non-credit bearing, or carry credits. For those offerings with credits (for example micro-credentials), then these could be stand-alone or institutions may offer a structure or flexible pathway to a university qualification. Some institutions (#B – Aalto University, #C – TU Berlin) have to clearly distinguish between what their institution offers as Masters degrees and CEE offerings, due to legal frameworks in their respective countries.

Table 4: Types of CEE offering

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Masters (EQF7) programme	X	X	X	X	X		X	
Open course	X	X		X	X	X	X	X
Closed course	X	X	X	X	X	X	X	
Bespoke (*tailor-made*) course	X	X	X	X	X	X	X	X

The majority of the courses offered are to those outside the institutions, such as practising professionals. However, in the discussions (and not reported here) was also the importance of CEE to support staff development, and this is a potential area for future research.

4.3 Engagement with industry and organisations

All institutions have a strong market alignment (Table 5) that demonstrate market awareness and offering relevant qualifications, either through partnership (through co-creation) or through being market-responsive are essential aspects of successful CEE offerings. Additionally, as would be expected within a university, then all institutions offer courses driven from their expertise. Courses are not just for commercial organisations, but are offered for public organisations, and can be commissioned. Amongst institutions co-created courses are still less frequent, reflecting the enhanced co-ordination and co-operation to generate such courses.

Table 5: Market alignment of CEE offerings

	A	B	C	D	E	F	G	H
Market-driven/specified	X	X	X		X	X	X	
University-driven/specified	X	X	X	X	X	X	X	
Co-created	X	X	X	X	X	X	X	X

5 SUMMARY AND FUTURE DIRECTIONS

This comparative study has compared how eight different Higher Education Institutions are approaching Continuing Engineering Education using a comparative case study framework approach. Whilst, the institutions are at various stages of evolution in terms of offering CEE, some have done so for decades, whereas others are newer in this area, then key similarities emerged: broadly a centralised, approach to CEE, with a clear strategic vision that creates clear CEE offerings that are aligned to the marketplace. Differences, such as Associated Private Companies and types of offering and resourcing, emerge often due to macro factors (legislation and government policy). It is clear that these changing drivers are encouraging, or in some cases mandating, an enhanced approach to CEE within institutions, and an approach that is responsive to changing market and societal expectations, that consequently requires a balance between organisational agility and sustaining quality and building on central services.

This initial comparison has highlighted a number of key areas for further research and discussion: 1) what are models to resource CEE offerings, and how can an institution choose the most appropriate option? 2) what are the best practices and models around co-creation of CEE offerings? 3) developing a conceptual framework around developing and implementing a CEE strategy; 4) developing a taxonomy for CEE (as had to be partially done for this research to allow consistency in comparison); 5) What CEE offerings should institutions create for their own staff (to meet changing needs of their profession)? 6) expand this initial exploratory research to survey a wider range of institutions to understand practices, drivers and policies to enable CEE; and 7) What is the role of fixed courses/programmes compared to collecting micro credentials, and how are the micro credentials evaluated (for instance given EQF level)?

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