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Assessment of Professional Competencies and Mobility of Engineers in Europe

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Abstract*: This paper discusses an ongoing concern faced by employers in the engineering sector. Engineering education is faced with new challenges such as lack of student interest at university level, or loss of engineering graduates to other sectors. The impacts of globalisation in terms of movement of people and services, and high competitiveness of the 21st century mean that engineers are required to have a broader set of skills besides their engineering competencies. This poses obstacles in the area of continuing professional development (CPD) of practising engineers; especially when competing for jobs on the European market. The lack of engineers with suitable skills has meant that even small and medium engineering enterprises are recruiting engineers from foreign markets. This research paper will help us understand how the systems within the engineering institutions across Europe are aiming to facilitate mobility of professional engineers in the workforce. While considering the assessment of professional competencies, we aim to achieve more transparency within a system of custom and practice but also promote lifelong learning and performances in this area of research.*

Index Terms – Professional competency, engineering education, Bologna Process, engineering mobility

Introduction

The engineers of today are pressured with having adequate professional competencies to be able to compete on the job market. However, one of the biggest challenges on the engineering job market around the globe is the fast growing number of engineering graduates choosing to work in sectors other than their chosen fields of engineering study (Peacock, 2011). As a matter of fact, during a visit to the Farnborough Airshow in July 2010, the British Business Secretary Vince Cable has expressed strong concern about the chronic shortages of advanced engineers that we currently face in industry (Woodman, 2010). A common perception is that young engineering graduates are motivated by attractive benefits from sectors such as finance, accounting or technical retail. In September 2011 the Telegraph reported further that one in seven graduates who studied science, technology, or engineering subjects have gone into the retail sector (Peacock, 2011). In addition, the declining interest and enrolment of young people in science, technology, engineering and mathematics (STEM) courses is consequently posing greater threat to achieving the Millennium Development Goals (MDGs) set by the United Nations (UN) in 2000, some of which relates to poverty reduction, global education and environmental sustainability (UN, 2000). Besides, our uses of natural resources needs to be sustainable for future generations which implies that we need to introduce more green and sustainable development courses in the engineering curricula. Consequently practising engineers of today have to be highly competent and develop new skills to engage in these challenges.

For engineering to catch the 'seventh wave' of technological revolution (Marjoram, 2010), which is, relating to education for sustainable development, climate change mitigation and adaptation, and new modes of learning, it is essential to attract young people and accentuate these issues in teaching curricula but also most importantly in practice. It is also crucial to eliminate obstacles caused by cultural and national political structures (Charlot *et al.*, 2003) that still limit the mobility of professional engineers across the European Union (EU).

Considering these emerging challenges and the accelerated technological developments that can no longer be ignored, it is important to address and find viable solutions to benefit the future generations. Thus, for the purpose of this paper, we have formulated some research questions that will assist in structuring the issues at hand, for example; what are the perceived challenges in the continuing professional development of practising engineers seeking professional registration? Can UK engineers adopt a successful harmonised and standardised system of qualification recognition when seeking employment on the European job market? Finally, how can we improve the mobility of engineering professionals within Europe?

Drivers for Greater Mobility of Engineering Professionals (Europe)

Mobility has become more common over the last few decades mostly due to the diversity of engineering practices and the varied location of engineering projects. Historically, the Treaty of Rome not only freed economic boundaries, but also allowed the freedom of movement of goods, services and granted employment mobility within the European community. The enlargement of the EU has forecasted noticeable factors of change that have affected higher education (thus the creation of the European Higher Education Area-EHEA) and certainly engineering education. The following identifies the drivers for the concept of mobility (Michel, 2006 and 2010):

- *"globalisation has evidently revolutionised the economy but also directly impacts companies and higher education institutions (affects the EHEA);*
- *virtual networking as well as information and communications technologies are moving at high speed and changing routines, thus forcing the education system to keep up;*
- *professional competencies (especially in engineering) are moving beyond traditional jobs and skills, making their recognition and evaluation more prominent to embark upon real global issues;*
- *in the evolution of engineering activities and education, mobility triggers the minds of young engineers during their study placements abroad, and recognising and integrating these experiences within their "local" degree.*[1]

Continuing Professional Development (CPD) and its Challenges

Engineering achievements in the twentieth century have rapidly changed the way we now live. These have been made possible by engineers due to the available knowledge of that time. Engineers were able to understand and analyse the principles and think beyond in a creative way (Jones, 2010). It is thus clear that engineering (and science) have been at the core of solving the problems that confront mankind.

To understand the challenges young engineers face at the beginning of their career, we have to start from the root of the problem, that is, tertiary education. For many years, there has been a concern about the shortage of professional engineers across many European countries. According to European Commission figures, the number of engineering vacancies rose by 30% in 2007 to around 23,000 in Germany (EurActive, 2007). This is to some extent due to the declining number of

[1] Michel, J. (2010) *"Mobility of engineers: the European experience"* section 7.5 - Engineering accreditation, standards and mobility, in Engineering Capacity: Education, Training and Mobility, UNESCO;
Michel, J. (2006) "*Globalisation and the mobility of engineers,"* Integrating the international education of engineers in the curriculum, the European experience, 7th World Congress on Engineering Education , Budapest, March 2006, published in IDEAS (WFEO) - N°13 - pp. 45-52.

students studying an engineering discipline at universities for multiple reasons; either lack of interest, complexity of engineering core subjects (notably mathematics) or rigorous exams. In the national context, we are have to account the high drop-out rates of engineering students; for example, Baillie and Fitzgerald found that students quit Imperial College engineering degrees because; they either lacked mathematical skills, found engineering dreary, or were unprepared for the learning styles of higher education (Baillie and Fitzgerald, 2000).

Across Europe, Science, Technology, Engineering and Mathematics (STEM) subjects are also rapidly declining at tertiary education levels, with gaps being filled by students coming from across Asia. Whilst an ageing population will only aggravate the situation further. However another issue is competency. Some companies recruiting graduate engineers fear that they do not possess the required competences for industry, and lack practical job skills that are critical for *"the complex interactions of real-world engineering"* (Walther *et al.*, 2007). Therefore, CPD is an important aspect on the journey to becoming a professional engineer regardless of having a solid foundation of engineering knowledge and skills.

Engineers bring a very varied set of skills that have been fundamental to the success of many large and small enterprises. Unfortunately, in addition to the chronic shortage of engineers over the last three decades, there is an increasing need for engineers with the right skills in certain niche areas including manufacturing (Walther *et al*, 2011). This could potentially be as a result of the erosion of the UK education sector by having 'less demanding GCSE and A-level exams' as was reported by the Office of Qualifications and Examinations Regulation - Ofqual (Paton, 2012). Engineering companies are struggling to recruit engineers with the *'requisite knowledge of different engineering disciplines'* (Professional Engineering, 12 March 2012). Despite having potential solutions to mitigate this issue, some might only be effective over a long period of time. The declining interest by undergraduate students to study an engineering discipline at a time of increasing business need signifies that there is a direct correlation with shortages of professional engineers with the right skills in the workforce. In the UK however, the main deterrence is the recent university tuition fee increase. In fact, recently published UCAS figures showed a drop of 8.7% in the number of total UK applicants in all university subjects, of which engineering undergraduates' intake declined by 1.3% (2012 entries) compared to 2011 entries (Vasagar, 2012; UCAS, 2012). The United Nations Educational, Scientific and Cultural Organisation (UNESCO), recognises the global engineering quandary and the crucial importance to further the development of engineers, including that of the engineering profession. Because of the changing nature of engineering challenges, it is becoming more common for engineers to accumulate a wider set of skills on top of their engineering expertise. The engineering discipline has undergone a sustained transformation because of the unprecedented challenges of the twenty-first century (Walther *et al.*, 2011). This prompts the need to put more thought in the choice of subjects/topics during an initial education. We must not forget that a first degree can only build the engineering foundation, therefore Continuing Engineering Education (CEE) or Continuing Professional Development (CPD) is also vital.

One of the competences defined in the Enhancing Engineering Education in Europe (E4 Thematic Network) report was to *'identify prerequisite knowledge (background)'* (Montesinos and Romero, 2003). This means that an engineer will need prior competences in order to achieve some competences. Evidently, existing research has also proposed that many engineering students possess some sort of 'subconscious' informal educational experiences, skills and even similar ways of thinking to that of practicing engineers (Anderson and Courter, 2010). However, professional proficiency and/or competences are largely developed and improved on the job despite having a K-16 education. Furthermore, the Engineering Professors' Council (EPC) report about the assessment of the output standards and professional body accreditation states that engineering programmes must demonstrate that their graduates have a varied set of competency skills known as the 'Ability to...Statement' (EPC, 2002). Some of which are related to having technical skills that are essential for engineering practice, and recognise the need to engage in lifelong learning.

In the development of professional competences, an engineer is expected to *'analyse, solve problems and evolve innovative solutions in that discipline'* (Jones, 2010) but unfortunately modern day engineers do not necessarily have the fundamental skills and knowledge that present companies look for. An engineering graduate is far from being a skilled and experienced professional and has much training to do to gain skills that would be useful in the workplace. As a matter of fact, engineering graduates tend to not have a wide-ranging set of skills (e.g. managerial, leadership, etc.). Much of these skills would or should have been taught at university to some extent but not to the detriment of learning technical skills (Jones, 2010).

Former research by Walther *et al.* has suggested that there exist non-specific trigger statements that would help students recall a particular experience at university, otherwise known as *"competence anomalies"* (Walther *et al.*, 2011). Furthermore, Walther *et al.* proposed an alternative tool known as the Accidental Competency discourse which was used to support learning from observation based on reflection from significant learning events. In the instance of competence anomalies through *non-specific triggers*, it was found that Accidental Competency discourse phase contributed greatly to the learning experience. Another successful learning style that engineers use is the constructivist method, i.e. building on own knowledge with the guided help of a coach, or constructing new information based on existing knowledge (Wilson and Lowry, 2000).

A. The important attributes of a professional engineer

Because of the changing nature within an engineering career, it is difficult to pin down what specific competences an engineer 'should know'. The UNESCO report on 'engineering issues and opportunities for development' has summarised the important attributes in four simple categories, that is; technical, personal, professional and managerial. It stresses that equal weight should not be put on these categories due to individual career position. To show how these attributes match the overall requirements in the UK Standard for Professional Engineering Competence (UK-SPEC), we have merged the two together in table 1. Of course we have to apply these competences within the context of the individual engineering disciplines and job functionality. These attributes will thus form part of a bigger competency model that will help assess each individual's abilities in order to achieve registration as a professional engineer and move up the competence hierarchy.

Table 1: Important attributes of a professional engineer

Technical - Ability to think mathematically, have background knowledge of basic science and specific discipline, identify factors affecting project implementation, collaborate with key stakeholders, promote new applications when necessary, develop and evaluate continuous improvement systems.	***Professional -*** Show commitment to high standards, comply with the rules of professional conduct of own professional body, demonstrate initiative in and commitment to the affairs of the professional body, appreciate ethical responsibilities, ability to handle uncertainty.
Personal - Ability to communicate effectively, show willingness to learn and identify individual needs. Ability to know and manage own emotions, strengths and weaknesses, create, maintain and enhance productive working relationships and resolve conflicts. Show appreciation of international dimensions.	***Managerial -*** Ability to manage and apply safe systems of work, ensure that systems satisfy health, safety and welfare requirements, develop and implement appropriate hazard identification and risk management systems, appreciation of management concepts and issues. Ability to lead and manage personal, financial and technical resources.

Source: M. Jones, *"Continuing Engineering Education and Professional Development,"* Engineering Capacity: Education, Training and Mobility, UNESCO report 2010, UK-SPEC, Engineering Council, 2010.

Furthermore, if we consider the global engineering competences expected of engineering graduates, the ABET criteria (Accreditation Board for Engineering and Technology) stipulate very similar competency requirements as that of the UK-SPEC (ABET, 2012 - 2013 criteria). Comparatively, the EUR-ACE criteria (European Accreditation Board for Engineering Education) give much in-depth description of the objective and outcomes expected of engineering graduates in Europe. In the 'Transferable Skills' section, some of the skills that should be developed within the engineering programme are summarised as follows:

- *function efficiently as an individual and demonstrate team workmanship;*
- *communicate effectively (with engineering community and society at large);*
- *ability to demonstrate knowledge of engineering practices and consider environmental impacts, and commit to professional ethics, responsibilities and norms of engineering practice;*
- *demonstrate awareness of project management and business practices, such as risks and change management;*

- *ability to recognise the need for and engage in independent, lifelong learning.*

We can clearly spot the similarities between the EUR-ACE standards framework, ABET criteria and that of the UK-SPEC (i.e. societal impact & ethical responsibilities, effective communication, etc) which suggest that there is a globally mutual consensus when it comes to our expectations of engineering competences.

B. The Benefits of Skills Acquisition

Getting the right skills or development training is not only important for oneself but is advantageous for everyone – for society, for employers, and mostly for the individuals themselves (see figure 1). We can observe that each stakeholder is dependent on each other and hence form an interconnectedness that is strengthened further by having highly qualified individuals no matter the job sector (EC – New Skills for New Jobs: Action Now, 2010). It is proven that if you are highly qualified the more you earn on average (EC – New Skills for New Jobs: Action Now, 2010). From the point of view of independent experts, the report stated that there has been in increase in higher level skills employment in Europe (83.9% in 2010), whilst the number of people with low level skills has decreased (48.1% in 2010).[2]

Nevertheless, employing people with adequate skills is a very important factor in not only the working life, but also in social and civic life. The economy certainly benefits from a highly skilled work-force as this increases competitiveness in the job market. According to Collier *et al.* (2007), companies that provide adequate skills training are 2.5 times less likely to go bankrupt compared to those that do not. Higher skilled employees will also increase their chances of competing on foreign markets, possibly making employers more flexible in terms of mobility.

Additionally, from ongoing project at Northumbria University as part of the Global Dimension of Engineering Education Project (GDEE)[3], a questionnaire entitled 'Thinking about your business' had been sent out targeting employers of Northumbria graduates in local engineering industries. The aims were to explore what attributes or competences they believe their 'global engineers' should possess when thinking about mobility in engineering. According to the employers' opinions, our research findings suggest that developing skills is important to *create an engineer with confidence in working in different cultures.*

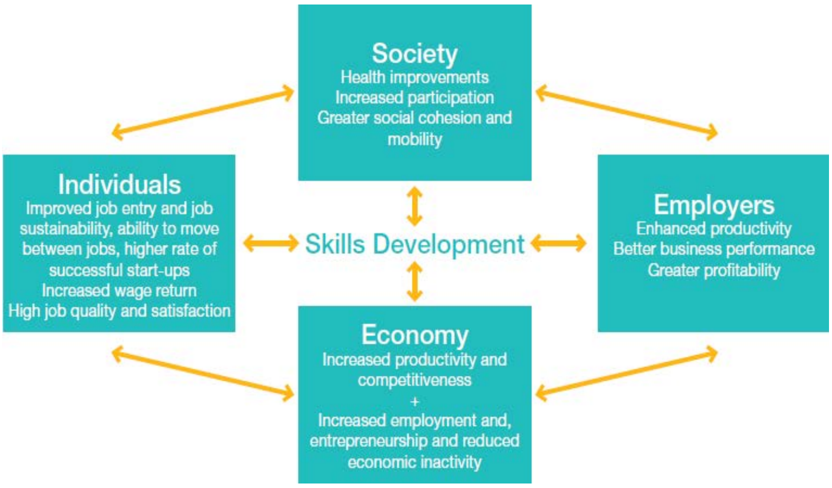

Figure 1: Benefits of Skills Development ("*New Skills for New jobs: Action Now*," A report by the Expert Group on New Skills for New Jobs prepared for the European Commission, February 2010)

2 "New Skills for New jobs: Action Now" A report by the Expert group on New Skills for New Jobs prepared for the European Commission, ©European Union, February 2010. Eurostat 2010

3 The Global Dimension of Engineering Education Project is run by Engineers Against Poverty in collaboration with the Engineering Council, Higher Education Academy, Engineering Professors' Council, Institute of Education, Engineers Without Borders and six UK HEIs. www.engineersagainstpoverty.org/eaps_programme/engineering_education.cfm

European mobility systems for engineers

Skills which support mobility are a key concept that is becoming increasingly mandatory for professional development, essentially for a better career outlook (Michel, 2010). Due to the diversity of their professions and their multiple project locations, engineers constitute one of the most mobile professions in the world. The trend is obvious in Europe as there has been legislation set up to facilitate professional qualification recognition of in all Member States thus enabling a person to practice a regulated profession in any EU country (Docampo, 2005). The obvious aspect of mobility here is of course geographical. The dimension of mobility in this context is however not only limited to the physical or geographical sense, but it can be professional mobility, trans-disciplinary mobility or even technological mobility – see below (Michel, 2010).

Professional mobility: How many times should engineers change jobs or take on various projects to be considered 'global engineers'?
Trans-disciplinary mobility: Should engineers develop other skills besides scientific or technological ones?
Technological mobility: Engineers need to be up-to-date with essential tools that are rapidly changing.

Going back to our research findings from the project afore mentioned, when questioned about mobility, one of the responses suggests that some employers expect that their engineers are *able to develop solutions and lead projects across national boundaries*. Furthermore, one company expressed that they expected all their engineers to *participate in multi-site regional or global initiatives*. This clearly demonstrates that being mobile is becoming increasingly important and considered a must for any professional engineer.

Europe has a long history of cross border mobility, thus understanding the concept of mobility in all its form. The signing of the Treaty of Rome in 1957 made freedom of movement possible for every European citizen and secured the right to seek employment within the European Community. Globalisation has positively helped push forward new ideas for cross-border mobility. The treaty was the first step towards European integration and cooperation. Consequently, the implementation of the Bologna Process within the higher education system has helped strengthen the mobility of engineering students and that of engineers in Europe through the creation of a European Higher Education Area (EHEA). The primary aims of the process are (i) to harmonise the education system (between bachelor and master degree programmes), (ii) whilst successfully re-organising the higher engineering education system in Europe, and (iii) enhancing the recognition and evaluation of competency (Michel, 2010). Despite recent criticism about its 'democratic legitimacy', the Bologna Process has positively facilitated the movement of students within the 47 participating countries since its signing in 1999 (Times Higher Education – T.H.E., 29 March 2012).

Nevertheless, regardless of tensions surrounding the Bologna Process, there are systems set up and dedicated to promote the standardisation of qualification and improve mobility of engineering professionals. The main organisations responsible for engineering education in Europe are the European Society for Engineering Education (SEFI) and the International Society of Engineering Education (IGIP). SEFI strengthens ties between higher engineering education institutions and other scientific and international bodies on issues of research and development in engineering education (De Graaff and Kolmos, 2010), thus participating in projects such as the Socrates Thematic Network - Teaching and Research in Engineering Education in Europe (TREE). On the other hand, the harmonisation of higher education degrees (through the European Credit transfer System – ECTS), aims to effectively encourage more students to take advantage of European exchange programmes (Erasmus, Tempus, Socrates or Alfa) as part of their university study. As a result this will boost "European" participation, mobility and diversity of students, staff, graduates and finally the work force (Heitmann *et al.*, 2003). These exchange programmes have been very successful in promoting lifelong learning in the last few years. Erasmus trends show a year-on-year total increase of student exchanges by 7.4% during the academic year 2009-2010 (of which the engineering/manufacturing/construction share of study courses is 12% and a share of 13 % for company placements/traineeships). Erasmus could well reach their target of supporting 3 million students by the end of 2012-2013 if this tendency is kept steady. As for staff exchanges, which includes teaching assignments and training, the trend represents an increase of 3.8% for the academic year 2009-2010.[4] Thus more young engineering professionals are progressively viewing Europe as a single area for higher education and employment opportunities.

Heitmann also suggests Europe should have a "global" education; as he predicts that the future will allow more engineering projects involving ad hoc combinations of specialist international companies to collaborate to solve one single project and then dismantle once complete (Heitmann *et al.*, 2003). This can be confirmed as, from our research project, 83% responded positively when asked whether their engineers would collaborate on projects with foreign engineers, where the majority said that their engineers *regularly travel overseas on business*. These 'global engineers' will strengthen partnerships between engineering businesses and academia but also with engineering institutions.

Furthermore, at an academic level, the European Accreditation of Engineering Programmes (EUR-ACE) aims to develop a Framework Standards for the Accreditation of Engineering Programmes within the EHEA. The framework allows the comparison of educational qualifications in the EHEA which will promote the mobility of engineering graduates. During a periodical assessment of a programme of engineering education, a peer review panel will thoroughly scrutinise data about the programme and meet with the Higher Education Institution (HEI) running the programme (EUR-ACE, 2008). The panel comprises appropriately trained and independent practicing engineers coming from both industry and academia.

In addition, there are various enterprises that have been set up to create networks that would enable young engineering professionals and students to exchange knowledge and experience and/or to foster mobility. The European Young Engineers (EYE) and the Council of Association of Long-Cycle Engineers of a University or Higher School of Engineering of the European Union (CLAIU-EU) are two such platforms available to promote free circulation of professional engineers based on equivalent qualifications. The CLAIU-EU is fairly new and seeks to maintain good relationships with other world-wide associations with similar aims and also monitors the progress of legislation regarding the formation and profession of engineers in Europe. EYE on the other hand, offers a forum for new students to create links and find prospective jobs on the European job market.

Despite numerous efforts to ease transferability on the higher education system and to harmonise qualification recognition of professional engineers across Europe, there still exist mobility barriers on the job market that prevent successful recruitment. According to a study by Charlot *et al.*, some restrictions to mobility are in part, due to its legality and institutionalisation of the engineering profession within the national political structures, and others are cultural. Some employers may not be willing to recruit a foreign national outside of their own educational system, or they are uncertain that (s)he would stay long enough to cover the cost of professional training and relocation (Charlot *et al.*, 2003). Albeit, UK employers are fairly open to recruit engineers from abroad. However, some national institutions may not be eager to accept changes unless they are certain of their efficiency and purpose. In that context, the EngC have recently announced that they have deferred their participation that would promote engineerING card (European professional card designed for increasing transparency and mobility of European professional engineers) until they are clear of the real benefits the professional card would bring (EngC newsletter issue 53, Jan 2012). From the employers' viewpoint, the difficulty is that there is not much clarity in understanding what real competences and capabilities are brought out by a particular qualification (Charlot *et al.*, 2003).

Proposed Solution

It is clear that there is a need for standardisation in regard to professional registration within wider Europe so that the mobility of professional engineers is not attenuated. The processes involved for professional registration are more onerous in some European member states than others, for example, the strict language requirement including training and an admission exam to be able to practice in Portugal or passing a State examination in Italy (Docampo, 2005). Despite international agreements such as the Washington Accord, the Sydney Accord or the Dublin Accord, it may be

[4] "Erasmus – facts, figures and trends," the European Union support for student and staff exchanges and university cooperation 2009/2010, Education and Culture DG, Lifelong Learning Programme, European Commission, Luxembourg: Publication Office of the European Union, © European Union, 2011.

that a lack of confidence from some employers (Charlot *et al.*, 2003), as well as national political structures still deter applications from foreign engineers into these countries.

The introduction of the Directive 2005/36/EC aims to regulate the professional recognition of qualifications since the Lisbon Strategy. Its purpose is to allow the same rights for an individual to pursue a profession from one member state to a 'host' member state. Following this, the engineerING card was introduced as a FEANI policy paper for the engineering profession within Europe. The professional card aims to unify the existing system as well as bring transparency of qualifications thus solving mobility issues for the engineering profession. The issue is, how well are these initiatives being received in member states? We have identified the cautionary measures taken by the EngC UK before adopting such practice, or perhaps the long standing history of the engineering profession in each state which would potentially delay the unification of professional registration of engineers. Thus a fair and efficient 'implementation framework' will need to be adopted by employers including engineering institutions to reduce the amount of red tape that professional engineers go through before being able to practice in a different member state. To be successful such a framework would thus require a change in attitude and culture from both employers and national professional bodies.

Concluding remarks

In summary, the challenges that professional engineers face have been identified and we can appreciate the increasing demand for professionals to be mobile within the global economy. In the engineering job market, this means developing new skills for the purpose of mitigating the factors affecting climate change. Additionally, the skill shortages in the European engineering job market are an emerging concern to enterprises both large and small. The search for highly skilled, competent engineers is thus crucial for companies looking to exercise the continuing professional development of their practising engineers. Obstacles to the mobility of professional engineers within Europe might be caused by national political and embedded cultural traditions, as well as onerous registration procedures. To some extent, these may reduce the confidence of some employers in recruiting professional engineers from neighbouring member states. However, we have seen some breakthroughs in the form of European higher education exchange programmes, the engineerING card and organisations (e.g. EYE or CLAIU-EU), which aims to enhance the mobility of engineering professionals and students in Europe. Nonetheless, much has to be done at national levels, especially in adopting an efficient implementation framework enabling simpler routes to professional registration that would improve transparency, advocate international recognition that would ultimately sanction mobility on the European engineering job market.

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