Comparing Engineering Education Research Across Europe: Research Groups, Reward, and Recognition

[1] Natalie Wint, [2, 3] Bill Williams, [4] Andrew Valentine,
[1]University College London, UK
[2] CEGIST, Instituto Superior Técnico, Universidade de Lisboa, Portugal
[3]TUDublin, Ireland
[4]University of Melbourne, Australia
[1] nat.wint@ucl.ac.uk
[2] bwbillwilliamsbw@gmail.com
[4]andrew.valentine@unimelb.edu.au

Abstract - **The past decades have seen the development of engineering education research (EER) worldwide, resulting in the assertion that it has become globally connected as a field of inquiry. Consistent with desires to enhance international EER capacity, this paper reports information about the current state of EER within fourteen European countries. Data were initially gathered during a workshop at the 2022 annual conference of the European Society for Engineering Education (SEFI) and subsequently augmented using an expert elicitation and snowball sampling approach.**

Formal PhD programs and research groups are relatively uncommon in the countries studied. It is rare that EER is valued as highly as disciplinary research, and funding opportunities are isolated and small in scale. The study reveals a landscape which does not always benefit from support infrastructures, and where individual researchers may be isolated within their institutions. Based on this, we identify a need for support infrastructures and career incentives to encourage scholarship in this field and recommend creating position papers outlining strategic priorities aligning with European and national policy.

Keywords: Engineering education research, scholarship, expert elicitation, Europe.

I. Introduction

In recent decades engineering education research (EER) has developed such that there now exists research networks, departments, doctorate programmes, conference series, rigorous research journals, as well as opportunities for funding of large-scale research projects (Beddoes, 2012; Streveler and Smith, 2010). As such, a small body of literature has focused on the emergence of EER in an attempt to understand the impact of such changes (Borrego & Bernhard, 2011; Jesiek, Newswander, & Borrego, 2009). However, this level of growth is not uniform and there are significant differences between EER in different countries, with the most advancement arguably being made within the USA. Work has therefore also focused on understanding EER in different European countries including: Portugal (Sorby, Williams, Oliveira, Duffy, & Brabazon, 2014; van Hattum-Janssen, Williams, & Nunes de Oliveira, 2015); Ireland (Sorby, Williams, Oliveira, Duffy, & Brabazon, 2014); UK (Clark, 2009; Nyamapfene & Williams, 2017; Shawcross & Ridgman, 2013; Wint and Nyamapfene, 2022); and within three Nordic Countries (Edström, Kolmos, Malmi, Bernhard, & Andersson, 2018). Other work has looked further afield including: Australia and New Zealand (Godfrey and Hadgraft, 2009; Klassen et al., 2022). China (Klassen et al., 2022); U.S.A. (Froyd & Lohmann, 2014; Klassen et al., 2022). Comparative studies have considered EER at a European (Bernhard, 2018) and global level (Jesiek, Borrego, & Beddoes, 2010a; 2010b; Streveler, & Smith, 2010).

Such studies highlight differences in the research approaches and perspectives of individuals in different locations (Bernhard and Baille, 2016; Borrego & Bernhard, 2011) and the potential for these differences to result in EER becoming geographically siloed. For example, articles within the Journal of Engineering Education (JEE) and the European Journal of Engineering Education (EJEE), as well as American Society for Engineering Education (ASEE) and European Society for Engineering Education **(**SEFI) conference proceedings have been the subject of citation analysis (Williams, Wankat, and Neto, 2018). The findings demonstrated the global nature of work published in Europe compared to that published in the

Natalie Wint
University College London, UK
nat.wint@ucl.ac.uk

USA, with USA authors tending to cite mostly other USA authors. This has implications for the degree to which the EER community benefit from the work of one another and limits efforts to advance "international capacity for rigorous scholarship in engineering education" (JEE, 2005, p.283).

A variety of contextual factors influence the approaches to EER taken, as well as what is valued. For example, Edström et al. (2018) propose that the absence of significant funding opportunities in Europe compared to the USA, has resulted in the networks and communities playing a more important role in the growth of EER within Europe. This is believed to have resulted in a disjointed and 'bottom-up' approach. It is therefore necessary to understand the existing EER landscapes within a range of countries within Europe, to understand how they may adapt to provide better infrastructure to promote and support EER.

Within Europe, SEFI facilitates a range of activities which results in countries sharing several common features. The EER track of SEFI, also known as the Working Group for EER (WG-EER), was formed in 2008. From this time there have been an increasing number of submissions at the annual SEFI conference (Bernhard, 2018). There are also claimed to be a number of EER related academic positions (including professorships) across Europe, and numerous EER based PhDs have been granted (Bernhard, 2018). However, funding is not as readily available as it is within the USA (Valentine, Wint, & Williams, 2023) and EER was not well suited to Horizon 2020 funding criteria (Malmi et al. 2018).

With respect to individual countries within Europe, few comparative studies have been completed. Sorby et al. (2014) compare EER within Portugal and Ireland using criteria outlined by Fensham (2004), and which allow for categorization of the fields within science education research. Edström et al. (2018) describe the 'bottom up' formation of the Nordic Network for Engineering Education Research (NNEER), despite individual researchers coming from a range of fields including engineering and educational development. The network was believed to have allowed for the formation of a community who could exchange knowledge and ideas and facilitate research training and identity development. Other work has compared UK EER with EER in Ireland (Wint et al., 2022).

Elsewhere, the publication tendencies of 895 EER authors from different European countries have been investigated using a scientometric approach, to evaluate whether EER authors tend to focus primarily on only EER, or whether they conduct non-educational research. Relevant national policies were used to explain the findings (Valentine and Williams, 2023). There were variations in the extent to which authors focused solely on EER or contributed to both educational and non-educational publications. Authors from both the UK and Spain were shown to publish the most EER. In comparison, authors from France, Germany, and Italy published notably higher numbers of engineering or science-based articles relative to EER. The reverse was true of Portugal, Ireland, and three Nordic countries. In the latter case, with the presence of the NNEER and the fact that there are more PhD programmes in EER (5) available in these three countries than in the rest of Europe combined (2), were proposed as reasons for the findings (Valentine and Williams, 2023).

To sum up this literature review, we note that the existing research on EER in Europe provides a limited and piecemeal picture of the field and shows little evidence of clear national and Europe-level policy relating to this important research field. This is in contrast to the US context where the National Science Foundation has been supporting research in the field for decades (Borrego and Olds, 2011) and more recently China's investment in the New Engineering Education program (Zheng and Wei, 2023) and Malaysia's commitment to Outcome Based Education (Williams and Alias, 2011).

II. Objective

Aligning with the perspective from Edström et al. (2018) that "a sophisticated understanding of and mutual respect for the different perspectives will strengthen the field" (p. 232), the objective of this study is to enhance knowledge within the field by presenting data on the landscape of EER within fourteen European contexts.

Research question: What is the status of EER in European countries from the perspective of research practitioners in these countries?

To this end, we focus on the establishment of research groups, PhD schemes, funding opportunities and reward and recognition at both institutional and national level.

III. Methodology

In mapping the EER landscapes within Europe, we were required to make decisions about the activities to include within our data. Drawing upon the work of Edström et al. (2018), here we focus "on actors who have been visible in the dominant EER communities, either through authorship or participation in projects and network activities" (p. 221). In keeping with that approach, in this work we combine data, triangulating varying viewpoints to ensure a comprehensive picture is created.

We thus made use of an expert elicitation approach (and subsequently, snowball sampling via referrals) to investigate and gather information about the current state of EER within different countries in Europe. Data was initially collected during a workshop entitled "Mapping Engineering Education Research in Europe" which was held at the SEFI 2022 (Wint et al., 2023). The aim of the workshop was advertised as providing "insight into ways to support development of EER in the future".

Workshop participants were asked to provide information pertaining to their own context (at a national level), this including the existence of formalized research groups and PhD schemes they were aware of, as well as financial and non-financial incentives and support available at both a national and institutional level. At the end of the workshop, answers from 14 people from eight different countries were collected. Eight individuals were subsequently contacted following the workshop to confirm their answers and the way in which they had been interpreted by the authors of this study. The eight individuals, who came from a range of six countries, were also asked to make recommendations with respect to those who could provide information about their context. Following this, eight additional participants, representing four contexts were emailed (using a snowball sampling approach), of which five replied, from two different countries. For countries in which participants did not confirm their answers via email, or for which few participants provided data, the authors contacted known actors within that context to validate the responses and provide any additional detail. Initial findings were presented at SEFI 2023 and further data was obtained from attendees who approached the authors following the session. The SEFI 2023 proceedings were also used to identify any countries which were represented at the conference but not included in the sample. A further six countries were identified, and several participants from each country were contacted via email. Data was triangulated using previously published work. The following section presents the data gathered and summarizes the contexts reported for each of the countries.

Ethical approval was obtained from University College London. Workshop participants were informed their answers may be used for the purpose of this research, and those not consenting were asked not to submit answers at the end of the workshop. They were also reminded in follow up emails when answers were validated.

IV. FINDINGS

The data obtained are presented by country in Table 1.

TABLE 1
COMPARISON OF THE DEVELOPMENT OF EER WITHIN DIFFERENT EUROPEAN NATIONS

European Country	Formal EER Groups	PhD Schemes	Incentives University Based	Incentives (Nation-wide)	Other relevant sources
Belgium	1 centre, namely LESEC, as well as informal groupings based within individual departments	One PhD scheme (within Science and Technology). None associated with specific engineering disciplines	Lack of funding	Few exist at a national level. European funds focused on either engineering or education.	Valentine & Williams, 2023
Czechia	No groups identified	No programmes identified	EER not considered a traditional research field within technical universities	Some opportunities for funding when working within university alliances or under Horizon funding.	Valentine & Williams, 2023
Denmark	Two large research group at Aalborg: the UNESCO Centre for PBL in Engineering, Science and Sustainability and the Centre for Design, Innovation and Sustainability	The two Aalborg groups have PhD programs.	Often achieved via publication. Status of EER similar to disciplinary research. CDIO membership important in some institutions.	Funding allocated according to output. Philanthropic funding	Edström et al., 2018 Sorby et al., 2014; Valentine & Williams, 2023
Finland	PGL Research Group (Tampere University). Computer Education Research groups. Individual researchers.	Some individual doctoral students in areas of computer science or engineering education.	None identified	None identified	Edström et al., 2018; Valentine & Williams, 2023
France	FPI research group (ENSTA Bretagne) Networks for researchers from social sciences and humanities involved in EER.	Few opportunities for PhDs in EER.	Some funding for PhD and Post Doctoral researchers.	Funding available at European level. No specific EER funding from ANR (Agence National de Recherche projects)	Valentine & Williams, 2023
Germany	Various groups and a collaboration between universities identified	No dedicated PhD programmes; Majority of PhD dissertations still produced as individual projects.	Few EER faculty positions. Focus on SoTL which was presented regionally. Common for publication in German only. Awards for excellence in teaching.	National incentives considered not to exist. The German Research Foundation (DFG) award majority of its grants strictly by discipline (e.g., technical engineering or education)	Valentine & Williams, 2023
Ireland	CREATE (TU Dublin) as well as other smaller groups..	Existence of some opportunities.	Small incentives. Presence of research output within promotion criteria.	No dedicated funding but some related work obtains funding.	Sorby et al., 2014; Valentine & Williams, 2023; Wint et al., 2022
Italy	Lack of EER groups META and METID (Politecnico di Milano) groups identified	None identified	Awards for innovative teaching practice as evidenced by education based publications.	Publication informs career progression and EER journals not included within specific research areas required. No identified funding opportunities. .	Valentine & Williams, 2023
Netherlands	4TU.CEE formed by four technical universities. Other groups focus on	4TU.CEE host a formal programme. Some PhD students within other research groups, and	Publications part of career track for institutional members of 4TU.CEE, EER Room for everyone's	Knowledge Sector Plans, Comenius Fellowships, as well as funding from. 4TU.CEE. finding available at regional,	Valentine & Williams, 2023

	different areas and levels of STEM education.	other standalone PhDs.	talent framework improved recognition.	national and European level.	
Portugal	No formal groups. There are individual researchers in many engineering schools. EER group within SPEE (Portuguese Society for Engineering Education) hosts international CISPEE conference.	No formal programs. Some candidates have been able to include EER research within other PhD programs. Several Portuguese have emigrated and enrolled in PhD programs in other European countries or in the US.	Some small grants typically related to pedagogical initiatives	Difficult to apply for national funding agency (FCT) grants as EER does not fit within recognised areas. Approximately 6 projects funded by FCT this century. Gulbenkian Foundation does provide small grants for educational initiatives.	van Hattum-Janssen, Williams, & Nunes de Oliveira, 2015; Valentine and Williams, 2021; 2023
Spain	EduSTEAMa research Group in STEAM Education formed between UPC and UOC.	The Engineering, Science and Technology Education Doctoral Programme at UPC. Industrial PhD scholarships also exist.	High number of EER journal articles published. EER publications rewarded as those of any other disciplinary area within the national ANECA framework.	Although competitive regional, national and European level funding was available, it was not specifically allocated for EER.	Valentine and Williams 2021; 2023 Lopez, 2019
Sweden	At KTH, Uppsala, Chalmers and Linkoping. National network for EER active since 2007	Programs at KTH, Uppsala, Chalmers and Linkoping	CDIO has had a central role at KTH and other institutions.The need for pedagogical development courses at technical universities has also provided an incentive.	by Swedish research Council. The funding is for education research in all subjects and at all levels, with no dedicated fund for EER.	Crawley et al. 2014; Edström and Kolmos 2014 Edström et al., 2018 Valentine & Williams, 2023
Switzerland	CAPE, CEDE, LEARN and CCTC at EPFL as well as individuals within faculties. The Future Learn Initiative (ETHZ, Zurich)	Lack of specialised EER PhD programmes, but PhDs focused on EER topics do exist (for example, the Joint Doctoral Programme on Learning Sciences (JDPLS) at EPFL).	Awards for teaching.	Experience of obtaining money from BeLEARN, the Swiss National Science Foundation and private foundations. In all cases the funding was for education or digital education, not explicitly for EER.	
UK	Presence of a small number	No formal schemes identified.	EER acknowledged as part of career progression for teaching based roles. Small 'pots' of funding	Limited funding. Existence of some prizes for teaching	Shawcross & Ridgman, 2013; Nyamapfene & Williams, 2017; Valentine & Williams, 2023; Wint and Nyamapfene, 2022

V. Discussion

Formal PhD Programmes and Research Groups

Few EER groups were identified across most European countries with the exception of the Netherlands. Dedicated PhD programs were rare, with doctorate opportunities identified as being isolated and situated within engineering departments. In a few cases, PhDs were obtained via publication, something which was said to drive levels of publication. Such findings hint at a lack of sustainability of efforts. EER was considered as interdisciplinary, this being considered as problematic in some cases, particularly if researchers were associated with a disciplinary-specialized department. Similar points have been made previously in relation to the difficulties associated with switching from technical research to EER, these being compounded by a lack of opportunities to expertise in research methods (Beddoes 2012; Borrego & Bernhard, 2011; Dart, Trad & Blackmore, 2022), something which has been linked to EER quality (Malmi et al., 2018).

Although typically unfunded, national networks, for example the EERN (UK and Ireland), NNEER (Denmark, Finland and Sweden, with minor participation from Norway, Estonia and Lithuania), SPEE (Portugal), as well as CDIO (member institutions globally) appear to be instrumental in fostering community and collaboration.

Institutional and National Recognition and Reward

Institutional support varies between countries and in most cases EER career routes (which are more common in the USA) were not identified. Establishing such options may thus act as a catalyst for EER development within Europe, a phenomenon which has been reported within Australia, in. which appointments (including professorships) are claimed to have validated EER (Godfrey and Hadgraft, 2009), with "engineering education" and "computer science education" being adopted as codified Fields of Research by the Australian government on 2020 (Australian Bureau of Statistics, 2020).

Small funding opportunities were identified at an institutional level in a number of contexts, with some participants claiming that EER counted toward promotion. However, there was a lack of funding at a national level, with funding being linked to research output and assessment in Denmark, Italy, and the UK. EER was not typically acknowledged within such exercises, which have also been claimed to discourage interdisciplinary research (Higgins, 2020) and which have been linked to an observed increase in Teaching and Scholarship roles within the UK (Locke et al., 2016), thus further strengthening existing divisions between pedagogy and other research. The interdisciplinary nature of EER was also believed to limit opportunities for funding in Ireland, Germany and the UK where grants were claimed to be aimed at educationalists or technical engineering work. These findings are supported by the work of Malmi et al. (2018) who identified a mismatch between EER as Horizon 2020 funding criteria. The lack of financial support poses a risk to the development of EER, with Edström et al. (2018) claiming that a lack European funding contributes toward stunted development of EER in Europe. (p. 219). Conversely, Sorby et al. (2014), attributes the emergence of EER in the U.S to the availability of funding.

Of all the contexts studied within this work, EER appears to be most established within the Netherlands, which is home to 4TU.CEE, a partnership between four technical universities, and which provides both PhD and funding opportunities. The Netherlands also appears to benefit from funding at both a regional and national level, with opportunities focused on the knowledge sector and lifelong learning. Researchers located within the country also appear to benefit from work around career pathways. The collaboration demonstrated by the technical universities could result in the development of clear strategies, informed by national needs, as well as development opportunities. The critical mass which results from such projects likely contributes towards running ambitious and well-designed projects which are likely to have lasting and wider reaching impact. Such outputs attract interest from researchers from different disciplines, as well as other stakeholders such as policy-makers, professional institutes and industry, and are thus likely to result in further growth.

The publication of position papers, outlining such priorities, at both a national and European level, and which could be facilitated by SEFI, would also be beneficial. The existing SEFI position papers on areas such Diversity Equity and Inclusion or Engineering Skills (https://www.sefi.be/publication-category/position-papers/) provide examples of how the society could provide guidance and leadership to national and EU-level policy makers.

Given the clear absence of funding, and considering increased pressures within the higher education sector, it is likely that development of European EER depends upon institutional reward and recognition, for example promotion based on educational research.

In addition, SEFI (and other similar communities including those at a national level) serve a valuable role in allowing individual researchers to get feedback and build collaborations. Such opportunities are important for those at all development stages, for whom conference participation has been shown to be an important activity (Gardner and Willey, 2016). National networks and Communities of Practice (e.g., Pitterson et al., 2020) also help likeminded, but otherwise isolated, individuals to exchange ideas, something which has been identified as being particularly important in countries with limited funding (Edström et al., 2016). Given the lack of formal development opportunities, it is important to take advantage of the benefits associated with collaboration between engineers and education researchers (Borrego and Streveler, 2014; Edström et al., 2016; Streveler and Smith, 2010), which include learning how to do educational research (Borrego and Newswander, 2008). Networking between engineering educators, and with those with expertise within educational and social sciences research, is thus considered necessary to promote the development of EER within Europe.

VI. Limitations

There are a number of countries omitted from this work, and the data obtained only reflects a small number of perspectives from self-selected participants, most of whom were in attendance at SEFI 2022. The work is therefore subject to selection bias. Given the self-selection involved, it seems reasonable to believe that the sample wanted to contribute towards growth in EER,

something which may have resulted in greater emphasis on negative aspects. It would thus be beneficial to increase the sample size and to ensure diversity of participants, including the audience of EER, and stakeholders including funders. The development of EER depends upon the views of newcomers, who may not yet be familiar with opportunities, as much as of those who are already part of the community. Such information is imperative in understanding ways by which to foster community and promote growth nationally. While this study takes an 'insider' view, it would also be interesting to understand the perceptions of 'outsiders' (i.e. EER researchers based outside of Europe). Finally, there is a need to place greater emphasis on relationships between contextual factors (e.g., higher education policy and finding models) as well as on research output, for example via use of scientometric analysis (López-Pernas, Saqr, & Apiola, 2023; Valentine, & Williams, 2023).

Conclusions

The findings from our mapping of EER in 14 European countries from the perspective of research practitioners suggest a consistent picture of a lack of national EER infrastructures within the European context. This contrasts with the situation in the US where this research field has been prioritized for decades and with countries like China and Malaysia that have set out national policies addressing EER.

We identify a need for more support infrastructures for EER at national and European level and recommend that more career incentives be provided to encourage scholarship in this field. We also recommend creating position papers outlining strategic priorities aligning with European and national policy and we see an important role for the European Society for Engineering Education (SEFI) in providing leadership in this process.

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