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Who Funds Engineering Education Research? Content Analysis Of Funding Sources Described In Three Top-Tier Engineering Education Research Journals

Andrew VALENTINE
The Univeristy of Melbourne, andrew.valentine@unimelb.edu.au

Natalie WINT
UCL, London, UK, natalie.wint.21@ucl.ac.uk

Bill WILLIAMS
CEGIST, University of Lisbon; TUDublin, bwbillwilliamsbw@gmail.com

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A. Valentine[1]
The University of Melbourne
Melbourne, Australia
0000-0002-8640-4924

N Wint
Centre for Engineering Education
UCL, UK
0000-0002-9229-5728

B Williams
CEG-IST, Instituto superior Técnico, Universidade de Lisboa, Portugal
Lisbon, Portugal
TU Dublin
Dublin, Ireland
0000-0003-1604-748X

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ABSTRACT

Engineering education research (EER) is becoming a globally connected field of inquiry but there is a lack of sustained funding opportunities available. Currently, it is not quantitatively known which entities are most prolific for providing funding for EER globally. This study attempted to map which entities were most commonly cited as providing funding for EER. Three top-tier EER journals were chosen, articles published in the journals during 2021 were identified. Metadata about each publication was downloaded from Scopus. Funding information for each publication was qualitatively analysed, then synthesised to provide a quantitative understanding of EER funding sources. There was a notable discrepancy between Europe and the USA. Many USA articles secured funding primarily from the National Science Foundation, whereas European articles were more likely to report funding from a

[1] *Corresponding Author*

A Valentine

andrew.valentine@unimelb.edu.au

range of different sources, including EU programs, state and national governments. This suggests that EER is given a higher priority in the United States and that the majority of this funding is channelled through the NSF. This has implications that growth of EER outside of USA may be restricted by limited funding opportunities.

1 INTRODUCTION

1.1 Background

Despite claims that engineering education research (EER) is becoming a globally connected field of inquiry (Borrego & Bernhard, 2011), the lack of sustained funding opportunities available for those involved has been noted in several locations including Australia (Dart, Trad & Blackmore, 2021; Godfrey & Hadgraft, 2009), Canada (Seniuk Cicek, Paul, Sheridan, & Kuley, 2020), Ireland (Sorby et al., 2014; Wint et al. 2022), New Zealand (Kumar, Gamieldien, Case & Klassen, 2021), Portugal (Sorby et al., 2014, van Hattum-Janssen et al. 2015), South Africa (Kumar, Gamieldien, Case & Klassen, 2021), and the UK (Wint & Nyamapfene, 2022; Wint et al., 2022), as well as within three Nordic Countries (Edström et al., 2016). To this end, the scale and frequency of funding offered by the National Science Foundation (NSF) in the USA does not appear to be replicated in other contexts, where EER has been claimed to fall outside the direct remit of national research funding bodies (Burke et al., 2020; Wint & Nyamapfene, 2022). For example, Malmi et al. (2018) claims that it is difficult to receive support for EER within Europe as it is not a good fit with the criteria defined for EU Horizon 2020 funding.

Such findings are significant, with the lack of EER funding having implications for the EER landscape as a whole. Firstly, funding is both important in attracting new scholars to EER but also in retention of researchers (Xian & Madhavan, 2013). Indeed, Wankat et al. (2002) remind us that the continuing growth of scholarship of teaching and learning in engineering relies on faculty having the same access to funds and support as those engaged in disciplinary research. However, the disparity between funding for technical and education research continues to exist (Dart, Trad, & Blackmore, 2021; Wint & Nyamapfene, 2022). Secondly, the availability of financial support is likely to impact upon the amount of EER publications. Sorby et al. (2014) claim that EER in the USA primarily emerged as a result of consistent funding, with two-thirds of publications within the JEE between 1998 and 2002 acknowledging funding from the National Science Foundation (NSF) (Wankat, 2004). In comparison, it is claimed that the lack of proactive funding on the European level as a contributory factor to the stunted development of EER in Europe (Edström et al., 2016).

Given the apparent relationship between funding of EER and the growth of EER, it is of interest to understand more about sources of funding. Previous work in the area focused on the sources of support acknowledged by the authors of publications within JEE (Wankat, 2004; Wankat, Felder, Smith, & Oreovicz, 2002), and changes in how the NSF has spent money on EER over time (Borrego, & Olds, 2011; Cady, & Fortenberry, 2008). However, there has not been a recent, large scale mapping of the sources of EER funding. As such, in this work we adopt a qualitative content analysis approach to determine the primary funding sources for EER described in three top-tier EER journals.

1.2 Research Question

- What are the primary funding sources for EE research described in three top-tier EE research journals?

2 METHODOLOGY

This study utilised a qualitative content analysis approach. Funding information from relevant EE publications were qualitatively analysed, then synthesised and presented to provide a quantitative understanding of EE funding sources.

2.1 Getting Funding Details of EE Research Publications

We identified engineering education research journals indexed by Scopus that were reported as being top-tier (quartile 1), according to the Citescore 2021 report published by Scopus. This identified the European Journal of Engineering Education (EJEE), IEEE Transactions on Education (IEEEToE), and Journal of Engineering Education (JEE) as being Q1 for the 2021 year.

Using the Scopus web interface, all the articles published by each of the three EE journals during 2021 were identified. The year 2021 was selected as it was the most recent year where it was certain that all the publications for that year had been captured by Scopus (indexing in Scopus may lag behind publishers by several months).

Following this, the Scopus records for each of the publications were downloaded as a csv file (one for each journal), which typically report about 50 data fields for each publication. Each article was uniquely identified by the acronym of the journal and the number of the article in the list (e.g. EJEE-8). This included information about reported funding which was typically captured in the “Funding Details” data field for each publication, or alternatively in the supplementary data fields about during such a “Funding Text 1” and “Funding Text 2”. It was also common that funding details were repeated several times (redundantly) across the “Funding Details” and “Funding Text 1” data fields, as the “Funding Details” data field often included only the names of the funders (and grant IDs) while the “Funding Text 1” data field often reported more details.

It is also important to note that the “Funding Text 1” field often included other information that was not relevant to this study, such as acknowledgements or thanks to reviewers. This is likely due to processes regarding how funding and other information is reported by each journal and indexed by Scopus. An example of reported funding information for several publications is shown in Table 1 for clarity purposes.

Table 1. Example excerpts of funding information reported about publications indexed by Scopus, showing selected relevant data fields

Article Title	**Text in the “Funding Details” Scopus Data Field**	**Text in the “Funding Text 1” Scopus Data Field**	**Text in the “Funding Text 2” Scopus Data Field**
Increasing gender diversity in engineering using soft robotics	National Science Foundation, NSF: DRL-1513175	This material is based on work supported by the National Science Foundation under Grant Number DRL-1513175.	National Science Foundation, Grant/Award Number: DRL-1513175
Constructive alignment between holistic competency development and assessment in Hong Kong engineering education	Research Grants Council, University Grants Committee, RGC, UGC: 17200720	General Research Fund of the Hong Kong Research Grants Council, Grant/Award Number: 17200720; University Grants Committee Teaching and Learning Fund, Grant/Award Number: HKU9/T&L/16-19	The research in this article was funded through the General Research Fund of the Hong Kong Research Grants Council (Project Reference Number 17200720) and the University Grants Committee Teaching and Learning Fund.
Faculty wide curriculum reform: the integrated engineering programme	UCL Engineering, University College London	We would like to thank all the staff and students of the UCL Faculty of Engineering Science for their commitment and dedication to the Integrated Engineering Programme.	

2.2 Analysis of Funding Details

The information about funding reported for each publication in the corresponding Scopus record (see Table 1) was then qualitatively coded with NVivo, using an inductive approach. Several coding themes emerged, which corresponded to different types of funding sources, or types of funding information. The coding themes were University Name, University Department Name, and Agency/Foundation/Funding Scheme.

The name of each university, university department name, agency, foundation, or funding scheme was coded as a separate sub-nodes within the overarching themes, so that it was possible to code repeated mentions of an entity to that same node. Examples of agencies, foundations or funding schemes include the National Science Foundation, European Commission, and Spanish Ministry of Science and Innovation. When the name of an agency, foundation or funding scheme was reported in a language other than English, the name of the entity was coded using the original naming given (i.e. names were not translated to English).

The coding that had been completed for every article by the first author was then checked by the second author, who used a separate spreadsheet to record possible issues in the original coding. Following this, the first author then reviewed the notes made by the second author and made minor changes to the original coding. Subsequent areas of remaining unclarity were discussed amongst the authors until a consensus was reached. All entries were then recoded to ensure consistency amongst the sample.

It is necessary to clarify that university names or departments were only coded when these were specifically reported in the relevant funding data fields within Scopus. When a university name was explicitly stated within the funding data fields within Scopus (like in row 3 of Table 1 above), it was assumed that the university had specifically provided funds for the purpose of conducting the research (i.e. it was assumed that this did not just reflect the salaries of the authors who were paid to conduct the research as part of their work at the university, otherwise every single publication would list all the universities that all the authors worked at). However, it is possible that authors' normal salaries paid by universities may have been inadvertently reported as funding for some publications. This is a limitation of the study.

3 RESULTS

3.1 Ratio of articles that received funding

Table 2 shows that approximately half of EJEE (47.4%) and half of IEEEToE (50.0%) publications report funding. In contrast, a higher percentage of JEE articles report funding (73.0%). The most common types of funding for all journals were agencies or entities other than universities (Table 3). Numerous articles also reported receiving funding from universities but often it was unclear if this was funding dedicated to the project or indirectly (such as through staff salaries).

Table 2. Number of articles published by each journal, and how many reported funding sources

Journal	Number of Articles Published in 2021	Number of Articles Which Reported Funding
EJEE	59	28
IEEEToE	54	27
JEE	52	38

Table 3. Most common sources of funding explicitly reported by publications in each journal

Journal	Agency Entries (total count)	University Name Entries (total count)
EJEE	28	20
IEEEToE	58	8
JEE	43	16
Total	128	43

3.2 Sources of funding from each country

Table 4 shows the origin of funding sources, based on country or international organisation (only the European Union). There was a mix of funding from agencies and universities across many countries. Spain and the United States included the highest number of agencies (12 each). The United States and Spain had the highest number of universities which funded research, at 18 and 6, respectively.

Table 4. Number of unique universities and agencies which provided funding for EE research from each country

Country/Region	Number of Unique Universities Named	Number of Unique Agencies Named
Argentina	1	N/A
Australia	2	N/A
Brazil	1	4
Canada	1	N/A
Chile	N/A	1
China	2	7
Colombia	1	N/A
Croatia	0	N/A
Denmark	1	N/A
European Union	N/A	7
France	N/A	1
Germany	N/A	1
Hong Kong	N/A	2
Ireland	N/A	1
Japan	N/A	1
Malaysia	1	N/A
Netherlands	1	1
South Africa	1	1
Spain	6	12
Sweden	3	N/A
UK	4	2
USA	18	12
Total	43	53

3.3 Most common sources of funding

Table 5. Most common sources of funding reported (excluding universities)

Funding Country/Union	Agency or Program	Number of Articles Which Mentioned Agency or Program As Funding Source
USA	National Science Foundation	47
European Union	All others	5
European Union	European Regional Development Fund	5
European Union	Erasmus+	5
Spain	Spanish Ministerio de Ciencia e Innovación	3

Table 5 shows the agencies which were named the highest number of times amongst all the articles published in the three journals in 2021. As shown, the NSF in the United States provided funding for the highest number of articles by far, at 47. The next highest was the European Commission, which provided funding for 15 article, though various sub-programs (e.g.Erasmus+, European Regional Development Fund). Moreover, there were a large number of articles which were funded by more than one NSF grant. Table 6 shows that 11 articles were funded by 2 NSF grants, while 4 articles were funded by 3 NSF grants.

Table 6. Articles funded by more than one National Science Foundation Grant

Number of National Science Foundation Grants	Count	Article IDs
2 National Science Foundation Grants	11	EJEE-12, EJEE-13, IEEETOE-20, IEEETOE-40, IEEETOE-54, JEE-7, JEE-27, JEE-38, JEE-41, JEE-43, JEE-44
3 National Science Foundation Grants	4	IEEETOE-3, IEEETOE-14, JEE-24, JEE-36

3.4 Contribution of funding source agencies, based on geographic region

The funding sources in Europe were quite scattered and not uniform. There were 49 articles published that were funded by 28 European Agencies. But the funding sources in the USA were a lot more concentrated. There were 54 articles published that were funded by 12 USA Agencies, Foundations, and Research Schemes. Of these 54 articles, 42 were funded by the NSF.

Table 7. Most common sources of funding reported, aggregated by regions (selected – not all shown)

Region	Number of Unique Agencies, from Region	Number of Published Articles Funded by Agencies from Region
Europe (all)	27	49
USA	12	54
China	7	12
Brazil	5	6

4 DISCUSSION

4.1 Reflections on findings

From a European perspective it is notable from Table 5 that while 47 papers in our sample reported funding from the US federal funding agency, only 17 were supported by European Union level funding. This suggests that EER is given a higher priority in the United States and that the majority of this funding is channelled through the NSF.

Furthermore, it is important to note that our data only allows us to compare how many papers were funded and who were the funders but does not provide information on the actual values of financial support provided by each grant. The only study we have found that presents comparative figures for the financial support provided by NSF grants compared with national funding in the EU is a 2015 study on Portugal that observes that funding for a typical NSF- supported project in the period 2000 to 2010 was more than 25 times higher than that for projects funded by the FCT, the equivalent Portuguese government agency. This could be a fruitful area for collaborative data gathering within SEFI to identify the scale of national funding awards in EU countries.

Within the European context, Table 4 shows that Spain is the most cited as providing support via national or institutional funding (18 reported sources in our sample). This aligns with a previous study that showed that Spanish authors were prolific in the field of EER in the period 2018 - 2019 (authors 2021). The UK is the next with 6 reported sources which again aligns with data in a previous study (authors 2022).

From a historical perspective, we have not found prior data on EER funding for Europe, South America or China but there is a study on the US context from 20 years ago that suggests that at that time NSF funding was at a notably lower level there. Wankat et. al (2002) examined 72 of the articles published in JEE during 1999. At that time, only 35% of articles reported receiving financial support, and 19% reported funding from the NSF. Comparing the findings of Wankat et. al (2002) with the findings in this study demonstrates that during the previous 20 years, the percentage of JEE articles which report funding (from any source) increased from 35% to 73%, and the percentage of articles which specifically reported NSF funding increased from 19% to 50%.

4.2 Limitations

There are several limitations of this study which must be noted. First, the sample of funding information was drawn from limited years, focusing only on publications from 2021. The sample of publications also was limited to top-tier EER journals, and did not include all EER journals or other publication venues such as conference proceedings or book chapters (although funding information for conference papers is often not recorded in Scopus). Some authors may also publish in languages other than English (also being in journals outside the 3 selected), which would also mean that potential sources of funding were not included in the sample of evaluated articles. The data relies on self-reporting by the authors. In some cases, it was unclear whether authors were supported financially and it is possible that authors forgot to mention any support they received. For example, in some cases it is plausible that authors acknowledge their own institution as their employer, as opposed to them providing specific funding for the research. The amount of monetary support may also vary significantly between sources.

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