A scientometric study of contributions by African-affiliated authors to engineering education research journals 2004-2023

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Abstract

Engineering education research has grown considerably as a field of inquiry over the last 20 years, particularly in the US, Europe and Australia. This study applies a scientometric approach to the contributions from Africa-affiliated authors to 19 engineering education research journals, 2004 - 2023.

In the 385 journal articles published, South Africa was notably the most prolific contributor with 147 articles, followed by Egypt, Nigeria, Botswana and Tunisia. While this research output is comparable with that of other regions in the Global South, it remains significantly lower than that of regions in the Global North. It was noted that the annual average article output was 11 in the period up to 2015 whereas from that year onwards it rose to 28 per annum.

Authors from South Africa and Botswana tended to co-author with colleagues from the US whereas those from Tunisia partnered with Saudi Arabian co-authors. The most common keywords were students, engineering education and E-learning. Three engineering education research centres were identified, two in South Africa and one in Nigeria. We believe that these findings can serve as a useful baseline to allow scholars to monitor the evolution of research in engineering education by African educators over future decades.

Keywords: Engineering education research; scientometric; research output; authors

1. Introduction

Although there has been a growing recognition in the Global North that effective education requires sustained attention and research, until recently, few institutions in Africa have recognised this as a valid research focus in engineering (Winberg et al., 2018). This has resulted in a lack of capacity for engineering education research (EER) and it is claimed that many African educational innovations are not represented in the research literature (Wolff et al., 2022, Inglis and Matemba, 2021). Matemba and colleagues point out that "African engineering education teachers and researchers are thus informed by studies from elsewhere in the world, and find themselves seeking support from colleagues from different educational contexts to develop their educational expertise (Matemba et al. 2023).

There have however been recent initiatives to combat this situation such as the creation of the Engineering Education Research Network in Africa (EERN-Africa) in 2020 (Matemba et al. 2023), the launch of the Southern Journal of Engineering Education (SJEE) in 2022 (Kloot, 2022) and the partnership between the South African Department of Higher Education and Training (DHET), the UK Royal Academy of Engineering (RAE) and University College London to launch the Innovative Engineering Curriculum (IEC) project in 2023 (IEC, 2023).

While it is hoped that initiatives such as these will facilitate EER in the African context in the near future, it will be important to be able to measure progress in the evolution of the field by having data from the recent past to serve as a benchmark and to help provide an overview of the current landscape of African engineering education research publication. With this in mind, this paper presents a scientometric analysis of contributions by African-affiliated authors to eighteen English language engineering education research journals over the 20-year period from 2004 to 2023.

1.1 Literature Review

While scientometric analysis of general scientific publication output has shown that the number of scientific papers published by researchers in Africa has been rising faster than the total world scientific output in recent years (Confraria and Godinho, 2014) there has been little published scientometric data focussing specifically on the EER field. A general scientometric study of EER journal publications between 2014 and 2023 (Kondrashev et al., 2024) shows that the US, EU + UK, Australia and China dominate output in the field as shown in Table I.

TABLE I: COUNTRIES AND REGIONS THAT HAVE THE MOST PUBLICATIONS AND CITATIONS, 2014 - 2023 (KONDRASHEV ET AL., 2024)

Country	Articles	Country	Citations
USA	1924	USA	28,949
China	543	UK	6,948
Spain	493	Australia	6,612
India	329	Spain	6,025
UK	322	China	3,927

Those authors noted that in general “researchers from countries in South America, the Middle East, and Africa had limited contributions to scientific literature” (Kondrashev et al., 2024).

1.2 Research Questions

As there has been relatively little published literature studying the topic of African EER we opted for a broad exploratory approach in our original research question:

What can a scientometric analysis of twenty years of publication in English language journals tell us about the EER landscape in the African context?

We chose to characterise the landscape using the following indicators:

- global numerical evolution of publications by African-based researchers
- countries and individuals that had the highest number publications,
- co-authorship collaboration patterns with both African and non-African scholars
- the most common key-words assigned to the published journal articles

1.3 Positionality

The authors are based in Europe and Australia respectively. Although the first author worked as an educator in three African countries earlier in his career, neither has direct experience of education in African contexts over the last 20 years.

2. Methodology

The methodological process adopted followed best practice for scientometric analysis (Haghani, 2023; López-Pernas et al., 2023).

The methodology involved two primary stages. The first stage was to identify relevant engineering education journals in the Scopus database, while the second was to search these journals for publications which included authors from countries in Africa.

To identify relevant journals, the Scopus database was searched using the following search string: SRCTITLE ((engineer* OR ieee) AND (educat* OR pedag*)). This identified all source titles in Scopus with the words 'engineer' or 'ieee' in the title' as well as either words starting with 'educat' (e.g. education, educate, educational) or 'pedag' (e.g. pedagogy, pedagogical). Additionally, language was restricted to English, source type was limited to Journal only, while document type was restricted to Article, Editorial and Review. The time period was restricted to 2004-2023 to cover the last 20 years. The year 2024 was not included as at the time of writing not all publications from 2024 had been recorded in the Scopus database, meaning it was incomplete. This resulted in 14487 documents from 23 sources.

Next it was necessary to exclude journals to exclude journals that do not specifically focus on engineering education. Three journals that focused on broader fields were excluded, including (i) World Transactions On Engineering And Technology Education, (ii) International Journal Of Cognitive Research In Science Engineering And Education, and (iii) Energetika Proceedings Of Cis Higher Education Institutions And Power Engineering Associations. The 18 remaining journals were those in Table 2, and included 13,025 publications.

TABLE 2: JOURNALS ANALYZED IN THIS STUDY

Journal	ISSN	Years Covered by Scopus since 2003
Advances in Engineering Education	19411766	2009 to 2024
Australasian Journal of Engineering Education	1325-4340	2013, 2015 to 2024
Computer Applications in Engineering Education	1099-0542	2003 to 2024
Chemical Engineering Education	0009-2479	2003 to 2017, 2024
Education for Chemical Engineers	1749-7728	2006 to 2024
European Journal of Engineering Education	0304-3797	2003 to 2024
Global Journal of Engineering Education	1328-3154	2010 to 2024
IEEE Transactions on Education	0018-9359	2003 to 2024
International Journal of Continuing Engineering Education and Life-Long Learning	1560-4624	2003 to 2024
International Journal of Engineering Education	0949-149X	2003 to 2024

International Journal of Electrical Engineering and Education (formerly International Journal of Electrical Engineering Education)	0020-7209	2003 to 2024
International Journal of Engineering Pedagogy	2192-4880	2018 to 2024
International Journal of Mechanical Engineering Education	0306-4190	2003 to 2024
Journal of Civil Engineering Education (formerly Journal of Professional Issues in Engineering Education and Practice)	2643-9107	2020-2024
Journal of Engineering Education	1069-4730	2003 to 2024
Journal of Engineering Education Transformations	2349-2473	2018 to 2024
Journal of Pre-College Engineering Education Research	2157-9288	2014 to 2024
Journal of Professional Issues in Engineering Education and Practice	1052-3928	2003 to 2019

Following this, the time period was restricted to 2004-2023 to cover the last 20 years. The year 2024 was not included as at the time of writing not all publications from 2024 had been recorded in the Scopus database, meaning it was incomplete.

The publications were then filtered to only include those which included at least one author affiliated with a Country/territory from Africa (as reported by Scopus). As part of this process it was assumed that (i) Mauritius is part of Africa, (ii) Maldives is not a part of Africa, (iii) Malta is not a part of Africa, (iv) Reunion (France) is not a part of Africa (v) Spanish North Africa (Alhucemas, Ceuta, the Chafarinas Islands, Melilla, and Peñón de Vélez de la Gomera) are not a part of Africa. After the results were filtered to only include publications which had at least one author from Africa, 358 publications remained.

3. Results

Figure 1 shows the distribution of publications over time. Publications increased after 2016 to more than 20 per year (averaging approximately 28 per year), a number which has been continuously maintained until 2023. This contrasts to the annual publications before 2015 which averaged approximately 11 per year. This increase may be due to greater importance being accorded to EER in South African institutions as Table 4 shows that researchers from South Africa make up a major part of the authors of papers in our sample. In addition the launch of the first Biennial Conference of the South African Society for Engineering Education in 2011 may have laid the foundations for the higher number of journal articles published in the last ten years.

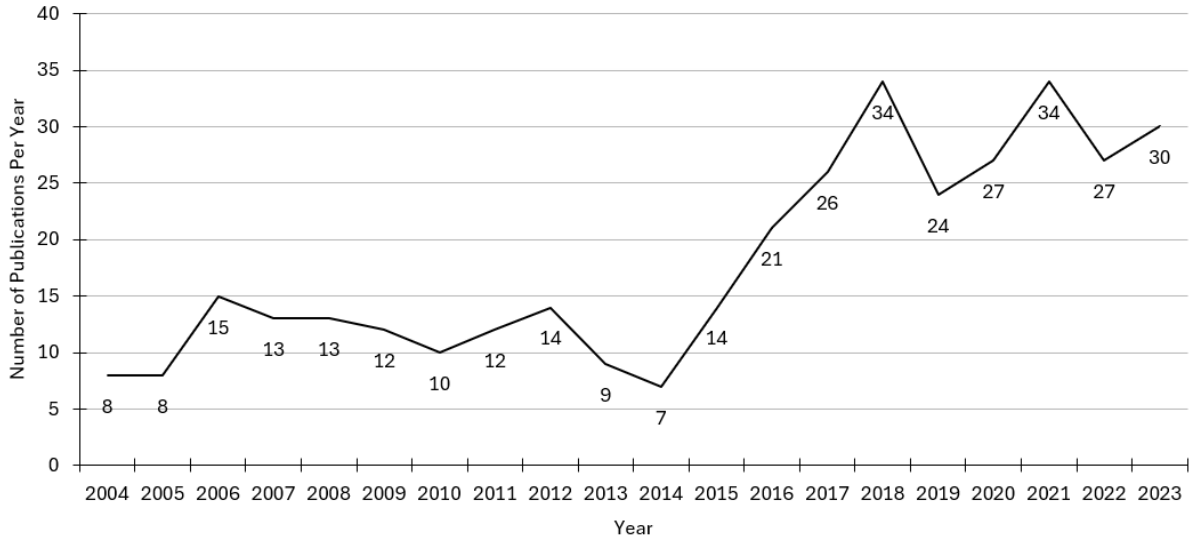

Figure 1: Number Of Publications Per Year By African Authors In English Language EER Journals (2004-2023)

Table 3 shows the number of publications by African-affiliated authors in each of the respective journals between 2004 and 2023. The European Journal of Engineering Education, International Journal of Engineering Education and Computer Applications in Engineering Education had the highest number of publications.

TABLE 3: NUMBER OF PUBLICATIONS BY AUTHORS FROM AFRICAN COUNTRIES IN ENGLISH LANGUAGE EER JOURNALS 2004-2023

Journal	Count
European Journal of Engineering Education	56
International Journal of Engineering Education	55
Computer Applications in Engineering Education	48
Global Journal of Engineering Education	31
International Journal of Engineering Pedagogy	27
International Journal of Electrical Engineering and Education (International Journal of Electrical Engineering Education)	26 (2)
Journal of Professional Issues in Engineering Education and Practice	22
International Journal of Mechanical Engineering Education	22
IEEE Transactions on Education	21
Education for Chemical Engineers	13
International Journal of Continuing Engineering Education and Life Long Learning	11
Chemical Engineering Education	9
Journal of Engineering Education Transformations	5
Australasian Journal of Engineering Education	5
Journal of Engineering Education	4
Journal of Civil Engineering Education	1
Advances in Engineering Education	0

Journal of Pre-College Engineering Education Research	0
TOTAL	**358**

Table 4 shows the number of publications by each country between 2004 and 2023. The total shown in Table 2 is 372 instead of 358, as some publications have authors from different African countries. South Africa notably has the highest number of publications at 147, followed by Egypt, Nigeria, Botswana, Tunisia and Morocco who each have approximately 30 publications. There are numerous countries which also have single digit publications, with five countries having only one publication each.

Also in Table 4 it can be seen that the countries with the highest number of co-authorship collaborations with other African countries are Kenya, South Africa, and Uganda. The countries with the highest number of collaborations with non-African countries are South Africa, Egypt, and Tunisia.

TABLE 4: NUMBER OF PUBLICATIONS FROM EACH AFRICAN COUNTRY THAT PUBLISHED IN ENGLISH LANGUAGE EER JOURNALS 2004-2023.

Country	Number of Publications	Number of Collaborations with Other African Countries	Number of Collaborations with Non-African Countries
South Africa	147	11	41
Egypt	37	0	18
Nigeria	36	5	12
Botswana	30	1	12
Tunisia	29	0	15
Morocco	25	1	3
Algeria	19	1	7
Ghana	12	0	7
Kenya	7	12*	3
Ethiopia	5	5	3
Mauritius	4	0	1
Uganda	4	9*	3
Libyan Arab Jamahiriya	4	0	2
Malawi	3	5*	3
Tanzania	3	2	2
Cameroon	2	0	0
Zimbabwe	1	0	1
Zambia	1	0	1
Sudan	1	3*	1
Rwanda	1	1	0
Mozambique	1	0	1
TOTAL	**372**	**21**	**136**

* NOTE: THE NUMBER OF COLLABORATIONS MAY BE HIGHER THAN THE NUMBER OF PUBLICATIONS IF THERE ARE MULTIPLE COLLABORATIONS PER PUBLICATION.

Table 5 shows the most common country collaborations between African and Non-African countries. As shown, the countries with the highest number of collaborations are South Africa-United States, Tunisia-Saudi Arabia, and Botswana-United States. Considering collaborations between all authors from Africa and non-African countries, Table 6 shows that authors from Africa most often collaborate with the United States, Saudi Arabia and the United Kingdom.

TABLE 5: NUMBER OF COLLABORATIONS BETWEEN AFRICAN COUNTRIES AND NON-AFRICAN COUNTRIES PUBLISHED IN ENGLISH LANGUAGE EER JOURNALS 2004-2023 (ONLY THOSE WITH A MINIMUM OF 5 COLLABORATIONS SHOWN)

Country A	Country B	Count
South Africa	United States	13
Tunisia	Saudi Arabia	10
Botswana	United States	9
South Africa	United Kingdom	6
Algeria	France	6
Egypt	Saudi Arabia	5

TABLE 6: NUMBER OF COLLABORATIONS BETWEEN ALL AFRICAN COUNTRIES AND NON-AFRICAN COUNTRIES PUBLISHED IN ENGLISH LANGUAGE EER JOURNALS 2004-2023 (ONLY THOSE WITH A MINIMUM OF 5 COLLABORATIONS SHOWN)

Country A	Country B	Count
All Authors from Africa	United States	36
All Authors from Africa	Saudi Arabia	17
All Authors from Africa	United Kingdom	12
All Authors from Africa	France	11
All Authors from Africa	Spain	6
All Authors from Africa	Australia	5

Table 7 presents the most common keywords between 2004-2013 and 2014-2023. The purpose of this is to observe how the most prevalent themes changed or remained constant during the two decades. 'Students' and 'Engineering Education' remained the most common keywords, while the next three remained in similar rankings. An observation is that 'Computer Simulation' which was ranked sixth between 2004-2013 disappeared from the rankings in the following decade, although 'Computer Aided Instruction' appeared. 'E-learning' became more prominent in the second decade.

TABLE 7: MOST COMMON KEYWORDS FROM PUBLICATIONS FROM TIME PERIODS 2004-2013 AND 2014-2023 ACCORDING TO SCOPUS

2004-2013		**2014-2023**	
Keyword	***Number of Occurrences (N=114)***	***Keyword***	***Number of Occurrences (N=244)***
Students	35	Students	108

Engineering Education	29	Engineering Education	90
Teaching	20	Education	42
Education	17	Curricula	31
Curricula	10	E-learning	30
Computer Simulation	8	Teaching	25
E-learning	8	Learning Systems	18
Technical Presentations	7	Professional Aspects	16
Professional Aspects	7	Education Computing	14
Engineering	7	Higher Education	13
Societies And Institutions	6	Computer Aided Instruction	13
Project Management	6	Surveys	12
Construction Industry	6	Engineering	12
Undergraduate Courses	5	Graduate Attributes	11
Higher Education	5	Problem Solving	9

TABLE 8: AUTHORS WHO PUBLISHED 5 OR MORE PUBLICATIONS IN ENGLISH LANGUAGE EER JOURNALS 2004-2023 WHILE ASSOCIATED WITH AFRICAN INSTITUTIONS. NOTE IT IS POSSIBLE AUTHORS MOVED LOCATION DURING THIS TIME PERIOD.

Author	Scopus ID	Number of Publications	Country of Affiliation (during 2004 - 2023)
Swart, Arthur James	8502923800	22	South Africa
Uziak, Jacek	6506665129	20	Botswana
Binous, Housam	6508118336	17	Tunisia
Bellagi, Ahmed	6602233624	10	Tunisia
Case, Jennifer M.	7103347500	10	South Africa
Kloot, Bruce Charles	33667766700	7	South Africa
Oladiran, Moses Tunde	6603525896	7	Botswana
Collier-Reed, Brandon I.	7202456093	5	South Africa
Engelbrecht, Johann	55244523100	5	South Africa
Wolff, Karin Elizabeth	55587842800	5	South Africa

From Table 8 we see that in terms of output per author, South African based scholars were in the majority, followed by those from Botswana and Tunisia.

The process of analysing the affiliations of the authors in the sample also identified three research centres that have a particular focus on engineering education:

- Africa Center of Excellence on New Pedagogies in Engineering Education, Zaria, Nigeria
- Centre for Research in Engineering Education, and Academic Support Programme for Engineering, University of Cape Town, Cape Town, South Africa
- Engineering Education, Faculty of Engineering and the Built Environment, Univ. of Johannesburg, Johannesburg, 2006, South Africa

4. Limitations

One limitation of our methodology is that it involves the use of affiliation data in Scopus to identify African authors. This means that the work of African-born researchers with affiliations in other parts of the world such as Esther Matembe (Australia), Abel Nyamapfene (UK) and Jennifer Case (US) is not fully included.

The study presented here is also constrained by limitations in the scope of the data available in Scopus. The authors appreciate the need for a more critical and nuanced interpretation of the emerging metadata to provide more actionable insights for future research in the field and to better engage with the perspectives of the African papers and their authors. Indeed "a proper scientometric method can not be complete without a nuanced qualitative view inspired by the other methods." (Lopez-Pernas et al., 2023, pp 80). However, such a content-analysis approach would involve the presentation and application of an additional qualitative methodology that is not possible within the page constraints for IRSPBL2025 conference submissions.

A further limitation is that we focus on the total number of journal publications without applying a quality criterion to measure their impact.

5. Future research

Future work aims to complement the data reported in this paper by introducing a quality criterion where we apply citation analysis to provide a measure of the impact of the publications in our sample. In addition, a content-analysis of the articles in our sample is expected to provide more actionable data for African scholars.

6. Conclusion

In our sample comprised of 358 articles with African-affiliated authors published in 18 journals from 2004 to 2023, the annual output of research publications in the field of EER was relatively low in the early part of the century, averaging 11 per annum, but more than doubled in the period 2015 - 2016 and it has remained relatively stable since then at an average of 28. We have not been able to attribute specific causes for the increase although we suggest it may be linked to developments in the South African context.

The three most popular publication venues are European Journal of Engineering Education, International Journal of Engineering Education and Computer Applications in Engineering Education. The countries with the highest number of co-authorship collaborations with other African countries are Kenya, South Africa, and Uganda. The countries with the highest number of collaborations with non-African countries are South Africa, Egypt, and Tunisia. the most common partnerships have been South Africa-United States, Tunisia-Saudi Arabia, and Botswana-United States.

According to the keywords listed in Scopus, “Students’ and ‘Engineering Education’ remained the most common keywords over the twenty-year period. ‘Computer Simulation’ was ranked sixth between 2004-2013 but disappeared from the rankings in the following decade, while ‘Computer Aided Instruction’ appeared. ‘E-learning’ became more prominent in the second decade and the pandemic years are likely to have contributed to this development.

Our analysis identified three research centres on the continent that have a particular focus on engineering education. This development, along with the growth in journal publications, is an indication that engineering education research has evolved from the relatively low level suggested by the limited research

output earlier in the century. While this output is comparable with that of other regions in the Global South, it remains significantly lower than that of regions in the Global North.

7. References

Confraria, H., & Godinho, M. M. (2015). The impact of African science: A bibliometric analysis. *Scientometrics*, *102*, 1241-1268.

Haghani, M. (2023). What makes an informative and publication-worthy scientometric analysis of literature: a guide for authors, reviewers and editors. *Transportation Research Interdisciplinary Perspectives*, *22*, 100956.

IEC, "Bringing life to our Engineering Curricula" Accessed 5 December 2024 at https://iecurricula.co.za/index

Inglis, H. M., and E. Matemba. 2021. "Starting the Conversation with African Engineering Educators About Student Success." Paper presented at the Research in Engineering Education Symposium, Perth, Australia, Accessed 5 December 2024.

Kloot, B., 2022, Editorial, *Southern Journal of Engineering Education*, *1*, 1-2

Kondrashev, S. V., Vavulskaia, E. I., Burenina, V. I., Prokopyev, A. I., Ibraeva, G. R., & Nikitina, S. A. (2024). Research trends in engineering education research through bibliometric analysis. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(7), em2476.

López-Pernas, S., Saqr, M., & Apiola, M. (2023). Scientometrics: a concise introduction and a detailed methodology for mapping the scientific field of computing education research. *Past, present and future of computing education research: A global perspective*, 79-99.

Matemba, E., Smith, L., Wolff, K., Inglis, H., Mogashana, D., Jansen, L., ... & Nyamapfene, A. (2023). Reflecting on a community of practice for engineering education research capacity in Africa: who are we and where are we going?. *Australasian Journal of Engineering Education*, *28*(1), 74-84.

Winberg, C., J. Wright, K. E. Wolff, N. Pallitt, V. G. Bozalek, and H. Conana. 2018. "Critical Interdisciplinary Dialogues: Towards a Pedagogy of Well-Being in STEM Disciplines and Fields." *South African Journal of Higher Education* 32 (6): 270–287. https://doi.org/10.20853/32-6-2975

Wolff, K., A. Dalton, D. Blaine, A. H. Basson, and C. Viljoen. 2022. "Engineering Education in the Global North and South: A Comparative Thematic Analysis." Paper presented at the 2022 IEEE IFEES World Engineering Education Forum – Global Engineering Deans Council (WEEF-GEDC), Cape Town, South Africa, November 2022