Using Web of Science to Analyze Research and Collaborations within the University of Arkansas College of Engineering via Microsoft Excel and VBA Programming

Aubrey Lynn Schultz and Jay McAllister
The University of Arkansas Fayetteville, Ralph E. Martin Department of Chemical Engineering, Fayetteville, AR/ University of Arkansas Fayetteville, Research and Instruction Services, Fayetteville, AR

Abstract

For bibliographic databases such as Web of Science (WoS), metadata can provide a wealth of information with minimal data analysis. Metadata for an article can reveal keywords, research areas, affiliations, and more. When considering the body of literature produced by an entire department or college, a clear view of research trends and multidisciplinary collaboration can be unveiled. The advanced search features of WoS, combined with the ability to export metadata as a Microsoft Excel file, allow for VBA programing to be used to perform a bibliometric analysis. Most engineers are highly proficient in MS Excel, making it an ideal data analytical tool. In this study, the eight departments within the University of Arkansas College of Engineering have been assessed. Using VBA, a program has been designed to take the raw data from the exported WoS file and condense the information into a more meaningful and helpful format. Trends regarding research areas, preferred journals, proficiency, and collaboration will be discussed. Quickly determining these trends would be advantageous to researchers seeking networking, incoming students seeking research areas, or businesses looking for areas excelling in a particular field. While this study only looks at one college within the University of Arkansas, it serves as a model for using WoS and MS Excel for bibliometric analysis.

Keywords

Bibliometrics, Web of Science (WoS), Visual Basic Analysis (VBA), Bibliographic Databases, Student Paper.

1. Introduction

Many engineers know the importance of bibliographic databases to find literature and have their literature found. Still, not many realize the wealth of information hiding in the metadata available on such programs. High-quality scientific databases such as Web of Science (WoS) and Scopus have made bibliometric analysis popular in recent years [1], [2]. Metadata for the articles in such databases include authors, affiliations, keywords, research topics, collaborators, and more. When looking at this information on a university or district level, it begins to paint a picture of the kinds of research and interests being explored by different groups and, excitingly, the connections and developments forming between them. This information could be important to researchers seeking collaborators and networking, incoming students who want to get a quick overview of the academic output of a particular location, or even businesses looking for areas rich in innovation for a specific field. As McAllister et al. write: “Article metadata provided via

databases can be used as a method for accessing content to create stories of the research environment" [3].

WoS, in particular, is an excellent resource for articles in the field of engineering [4]. The WoS Core Collection is one of the most authoritative bibliographic databases [4], [5]. The database contains articles on social and physical sciences, engineering, and medicine. With features that allow for very controlled searches, it is possible to gather almost all the articles from a single department or even college with a single search. WoS also has a unique index named "WoS Categories." Every journal and book in the WoS Core Collection is assigned at least one of the 225 WoS Categories; these records are assigned WoS Categories based on the subject categories of the source publications of the articles [6]. Entire global maps of science disciplines and their connections have been assed using WoS Categories alone [7]. Furthermore, WoS metadata can be exported as an XLS file that can be opened in Microsoft Excel (MS Excel). Users can select from a large number of variables to be included in the spreadsheet (see Fig. 1). Understanding MS Excel is a vital skill for an engineer [8], [9]. MS Excel is used for data logging, complex calculations with built-in functions, visualizing data and creating charts, solving algebraic equations, statistical and economic analysis, and more. Additionally, almost all equipment with any data logging will export as an XLS file. This means that most engineers will be very familiar with the program. While other programs may have greater computing power in specific situations, MS Excel is popular because of its balance between robust analysis and user-friendly controls and interfaces [8]–[10]. Using the built-in developer to write functions and routines in Visual Basic Analysis (VBA) allows for even more complex data analysis. Sophisticated software for bibliometric analysis exists but is likely not as readily available or familiar to engineers as MS Excel and VBA.

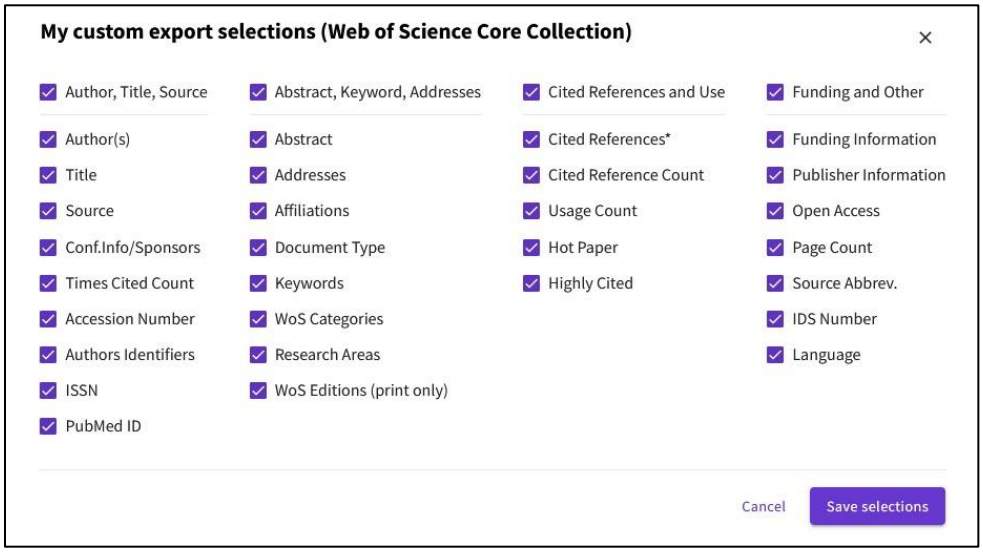


Fig. 1. WoS variables that are available for export as an MS Excel spreadsheet.

In conjunction with MS Excel and VBA programming, Exported WoS metadata can be used to assess an entire college's research interests and multidisciplinary activity. For this study, each program within the College of Engineering at the University of Arkansas, Fayetteville, will be analyzed. Seeing what keywords, research interests, and journals are most common amongst departments will help to "create a story" about the direction the University of Arkansas College

of Engineering is heading in and what multidisciplinary bridges are forming between researchers. This case study shows a model that can be implemented for any institution that regularly publishes articles indexed in WoS.

2. Methods

There are currently eight engineering departments in the University of Arkansas College of Engineering: Chemical, Mechanical, Electrical, Biomedical, Industrial, Biological, Civil, and Computer Engineering. Research articles from all departments were analyzed. After gathering information from faculty websites, a list of professors actively performing research was made. The individuals in each department can be seen in Table 1.

2.1.WoS Query and Export Conditions

Consistent WoS query conditions were used to search for publications to collect a body of literature for analysis. For all searches, results were limited to documents published in the last five years (as of August 2022), document types that were either articles or review articles, no early access documents, and documents affiliated with the University of Arkansas. These constraints ensured that only the articles of interest were exported for further analysis. The professors from each department were then added to a WoS query with the previously described constraints. Alternative names were included in the search for professors with multiple publishing names. For example, a partial screenshot of a query can be seen in Fig. 2.

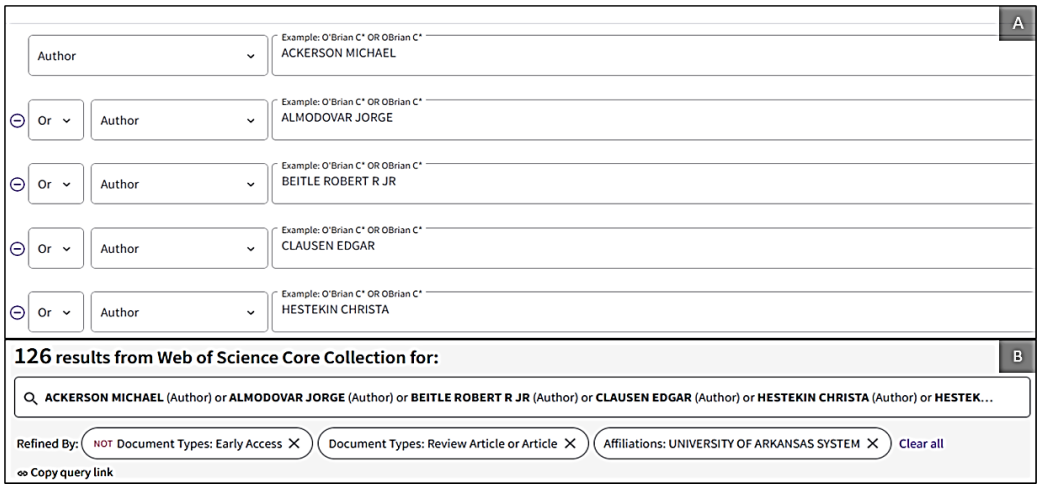


Fig. 2. Example WoS Query Conditions A) The conditions entered directly into the search feature. Boolean conditions can be used to control the variables. B) Additional query control is added through "refining" features.

For each department being considered, a single WoS query would be performed. This was done so that articles could later be linked to authors based on affiliations in future multi-institution studies. The exact queries and search conditions can be seen in Table 1. After performing these searches and exporting the results, eight metadata sets were produced.

Table 1. University of Arkansas Faculty and WoS Queries

Department	Faculty	WoS Constraints	Query
Chemical Engineering [11]	Michael D. Ackerson; Jorge Almodovar; Robert Beitle; Edgar Clausen; Christa Hestekin; Jaime A. Hestekin; Tammy Lutz-Rechtin; Karthik Nayani; Thomas W. Smith; Tom O. Spicer; Greg Thoma; Heather L. Walker; Keisha Bishop Walters; Ranil Wickramasinghe	Publication Date: Last 5 years; NOT Document Types: Early Access; Document Types: Review Article or Article; Affiliations: University of Arkansas system	(AU=(ACKERSON MICHAEL) OR AU=(ALMODOVAR JORGE) OR AU=(BEITLE ROBERT R JR) OR AU=(CLAUSEN EDGAR) OR AU=(HESTEKIN CHRISTA) OR AU=(HESTEKIN JAMIE A) OR AU=(LUTZ RECHTIN TAMMY) OR AU=(NAYANI KARTHIK) OR AU=(SMITH THOMAS W) OR AU=(SPICER THOMAS O) OR AU=(THOMA GREG) OR AU=(WALKER HEATHER L) OR AU=(WALTERS KEISHA B) OR AU=(WICKRAMASINGHE RANIL) OR AU=(WICKRAMASINGHE RANIL S) OR AU=(WICKRAMASINGHE SUMITH RANIL) OR AU=(WICKRAMASINGHE S RANIL)) AND ((DT==("REVIEW" OR "ARTICLE") AND OG==("UNIVERSITY OF ARKANSAS SYSTEM")) NOT (DT==("EARLY ACCESS")))
Mechanical Engineering [12]	Han Hu; Po-Hao Huang; David Jensen; James Leylek; Paul Millett; David Huitink; Xiangbo Meng; Arun Nair; Darin W. Nutter; Larry Roe; Wan Shou; Steve Tung; Keith Walters; Uche Wejinya; Wenchao Zhou; Min Zou	Publication Date: Last 5 years; NOT Document Types: Early Access; Document Types: Review Article or Article; Affiliations: University of Arkansas system	(AU=(HU HAN) OR AU=(HUANG PO HAO) OR AU=(HUITINK DAVID) OR AU=(JENSON DAVID) OR AU=(LEYLEK JAMES) OR AU=(MENG XIANGBO) OR AU=(MILLETT PAUL) OR AU=(NAIR ARUN) OR AU=(NUTTER DARIN) OR AU=(ROE LARRY) OR AU=(SHOU WAN) OR AU=(WALTERS KEITH) OR AU=(WEJINYA UCHE) OR AU=(ZHOU WENCHAO) AND AU=(ZOU MIN)) AND ((DT==("REVIEW" OR "ARTICLE") AND OG==("UNIVERSITY OF ARKANSAS SYSTEM")) NOT (DT==("EARLY ACCESS")))
Electrical Engineering [13]	Juan Carlos Balda; Zhong Chen; Samir M. El-Ghazaly; Magda El-Shenawee; Omar Manasreh; Jeff Dix; Chris Farnell; Alan Mantooth; Terry Martin; Roy A. McCann; Hameed A. Naseem; Robert F. Saunders; Silke Alexandra Spiesshoefer; Morgan E. Ware; Jingxian Wu; Fisher Yu; Yue Zhao	Publication Date: Last 5 years; NOT Document Types: Early Access; Document Types: Review Article or Article; Affiliations: University of Arkansas system	(AU=(CARLOS BALDA JUAN) OR AU=(CHEN ZHONG) OR AU=(DIX JEFF) OR AU=(EL GHAZALY SAMIR) OR AU=(EL SHENAWEE MAGDA) OR AU=(FARNELL CHRIS) OR AU=(MANASREH OMAR) OR AU=(MANTOOTH ALAN) OR AU=(MARTIN TERRY) OR AU=(MCCANN ROY) OR AU=(NASEEM HAMEED) OR AU=(SAUNDERS ROBERT) OR AU=(SPIESSHOEFER SILKE A) OR AU=(WARE MORGAN) OR AU=(WU JINGXIAN) OR AU=(YU FISHER) OR AU=(ZHAO YUE) AND OG=(University of Arkansas Fayetteville)) AND ((DT==("ARTICLE" OR "REVIEW") AND OG==("UNIVERSITY OF ARKANSAS SYSTEM")) NOT (DT==("EARLY ACCESS")))
Biomedical Engineering [14]	Kartik Balachandran; Mostafa Elsaadany; Leonard Harris; Ranu Jung; James Abbas; Morten Olgaard Jensen; Timothy J. Muldoon; Christopher E. Nelson; Xianghong Qian; Kyle P. Quinn; Narasimhan Rajaram; Raj Raghavendra Rao; Rebekah Margaret Samsonraj; Young Hye Song; Jeffrey Collins Wolchok	Publication Date: Last 5 years; NOT Document Types: Early Access; Document Types: Review Article or Article; Affiliations: University of Arkansas system	(AU=(BALACHANDRAN KARTIK) OR AU=(ABBAS JAMES) OR AU=(ELSAADANY MOSTAFA) OR AU=(HARRIS LEONARD) OR AU=(JENSEN MORTEN OLGAARD) OR AU=(JUNG RANU) OR AU=(MULDOON TIMOTHY J) OR AU=(NELSON CHRISTOPHER E) OR AU=(QIAN XIANGHONG) OR AU=(QUINN KYLE P) OR AU=(RAJARAM NARASIMHAN) OR AU=(RAO RAJ RAGHAVENDRA) OR AU=(SAMSONRAJ REBEKAH M) OR AU=(SONG YOUNG HYE) OR AU=(WOLCHOK JEFFERY C)) AND ((OG==("UNIVERSITY OF ARKANSAS SYSTEM") AND DT==("ARTICLE" OR "REVIEW")) NOT (DT==("EARLY ACCESS")))
Industrial Engineering [15]	Carol Schubert Gattis; Ralph Rocky Gay; Xiao Liu; Ashlea Bennett Milburn; Kim LaScola Needy; Haitao Liao; Heather Lyn Nachtmann; Leonard Lee Nethercutt; Gregory S. Parnell; Ed Pohl; Tish Pohl; Chase E. Rainwater; Manuel D. Rossetti; Karl D. Schubert; Kelly M. Sullivan; Shengfan Zhang; John R. English; Sandra D. Eksioglu; Burak Eksioglu; Justin Robert Chimka; W. Art Chaovalitwongse; Richard Cassady; Carrie Beam	Publication Date: Last 5 years; NOT Document Types: Early Access; Document Types: Review Article or Article; Affiliations: University of Arkansas system	(AU=(BEAM CARRIE) OR AU=(CASSADY RICHARD) OR AU=(CHAOVALITWONGSE W ART) OR AU=(CHIMKA JUSTIN R) OR AU=(EKSIOGLU SANDRA D) OR AU=(EKSIOGLU BURAK) OR AU=(ENGLISH JOHN) OR AU=(GATTIS CAROL SCHUBERT) OR AU=(GAY RALPH) OR AU=(LIAO HAITAO) OR AU=(LIU XIAO) OR AU=(MILBURN ASHLEA BENNETT) OR AU=(NACHTMANN HEATHER L) OR AU=(PARNELL GREGORY S) OR AU=(POHL ED) OR AU=(RAINWATER CHASE E) OR AU=(ROSSETTI MANUEL D) OR AU=(SCHUBERT K D) OR AU=(SULLIVAN KELLY M) OR AU=(ZHANG SHENGFAN)) AND ((OG==("UNIVERSITY OF ARKANSAS SYSTEM") AND DT==("ARTICLE" OR "REVIEW")) NOT (DT==("EARLY ACCESS")))
Biological Engineering [16]	Jin-Woo Kim; Yanbin Li; Marty Matlock; G Scott Osborn; Yi Liang; Benjamin R. Runkle; Ali Ubeyitogullari; Lalit R. Verma; Dongyi Wang; Jun Zhu; Sammy Saber Sadaka; Christopher Garrett Henry; Brian Haggard; Thomas A. Costello	Publication Date: Last 5 years; NOT Document Types: Early Access; Document Types: Review Article or Article; Affiliations: University of Arkansas system	(AU=(COSTELLO THOMAS A) OR AU=(HAGGARD BRIAN) OR AU=(HENRY CHRISTOPHER GARRETT) OR AU=(KIM JIN WOO) OR AU=(LI YANBIN) OR AU=(LIANG YI) OR AU=(MATLOCK MARTY) OR AU=(OSBORN G S) OR AU=(RUNKLE BENJAMIN R) OR AU=(SADAKA SAMMY S) OR AU=(UBEYITOGULLARI ALI) OR AU=(VERMA LALIT R) OR AU=(WANG DONGYI) OR AU=(ZHU JUN)) AND ((OG==("UNIVERSITY OF ARKANSAS SYSTEM") AND DT==("ARTICLE" OR "REVIEW")) NOT (DT==("EARLY ACCESS")))
Civil Engineering [17]	Julian Fairey; Eric V. Fernstrom; Sarah Vavrik Hernandez; Ernie Heymsfield; Micah Hale; Seungtaek Lee; Cameron Murray; Gary Prinz; R. Panneer Selvam; Graham Thompson; Suman Mitra; Richard A. Coffman; Andrew F. Braham; Michelle Lee Barry; Stacy Goad Williams; Clinton M. Wood; Wen Zhang	Publication Date: Last 5 years; NOT Document Types: Early Access; Document Types: Review Article or Article; Affiliations: University of Arkansas system	(AU=(BERNHARDT-BARRY MICHELLE L) OR AU=(BRAHAM ANDREW F) OR AU=(COFFMAN RICHARD A) OR AU=(FAIREY JULIAN) OR AU=(FERNSTROM ERIC V) OR AU=(HALE MICAH) OR AU=(HERNANDEZ SARAH V) OR AU=(HEYMSFIELD E) OR AU=(LEE SEUNGTAEK) OR AU=(MITRA SUMAN) OR AU=(MURRAY CAMERON) OR AU=(PRINZ GARY) OR AU=(SELVAM R PANEER) OR AU=(THOMPSON GRAHAM) OR AU=(WILLIAMS STACY GOAD) OR AU=(WOOD CLINTON M) OR AU=(ZHANG WEN)) AND ((OG==("UNIVERSITY OF ARKANSAS SYSTEM") AND DT==("ARTICLE" OR "REVIEW")) NOT (DT==("EARLY ACCESS")))
Computer Engineering [18]	Thi Hoang Ngan Le; Wing Ning Li; Khoa Luu; Ukash Nakarmi; Yanjun Pan; Qinghua Li; Alexander H. Nelson; Brajendra Nath Panda; Pat Parkerson; Matthew J. Patitz; Yarui Peng; Lora Streeter; Dale R. Thompson; Xintao Wu; Justin Zhan; Lu Zhang; Kevin Jin; Miaoqing Huang; Susan E. Gauch; John Michael Gauch; Jia Di; David Andrews	Publication Date: Last 5 years; NOT Document Types: Early Access; Document Types: Review Article or Article; Affiliations: University of Arkansas system	(AU=(ANDREWS DAVID) OR AU=(DI JIA) OR AU=(GAUCH JOHN M) OR AU=(GAUCH SUSAN E) OR AU=(HUANG MIAOQING) OR AU=(JIN KEVIN) OR AU=(LE NGAN) OR AU=(LI WING NING) OR AU=(LI QINGHUA) OR AU=(LUU KHOA) OR AU=(NAKARMI UKASH) OR AU=(NELSON ALEXANDER H) OR AU=(PAN YANJUN) OR AU=(PANDA BRAJENDRA) OR AU=(PARKERTON PAT) OR AU=(PATITZ MATTHEW J) OR AU=(PENG YARUI) OR AU=(STREETER LORA) OR AU=(THOMPSON DALE R) OR AU=(WU XINTAO) OR AU=(ZHAN JUSTIN) OR AU=(ZHANG LU)) AND ((OG==("UNIVERSITY OF ARKANSAS SYSTEM") AND DT==("ARTICLE" OR "REVIEW")) NOT (DT==("EARLY ACCESS")))

2.2. MS Excel and VBA Programming

The windows system used during the analysis was Office 2019. The software version used was Excel 2019. All eight exported WoS results were consolidated into one sheet to analyze the entire engineering college. In the worksheet designed around the VBA program, the consolidated WoS exports remain unedited from their original state. Any worksheet manipulations are done to a copied worksheet that updates each time the program is run based on user input (see Fig. 3). This prevents any data from being lost between runs. In the active worksheet, duplicate articles that may have been introduced during the consolidation of the queries were subsequently removed. Of the 71 variables present in WoS metadata, nine were identified as vital to analysis; these variables are "Author Full Names," "Source Title," "Author Keywords," "Keywords Plus," "WoS Categories," "Research Areas," "Publication Year," "Article Title," and "Times Cited, All Databases." These nine variables are critical for the program to carry out the standard routine. Still, any of the 71 variables can be kept in the sheet via a user interface (see Fig. 3C). The departments and institutions being analyzed can also be selected by the user (see Figs. 3A & 3B). Additional measures were taken so that the program would identify and consolidate most acronyms and alternative spellings of keywords. For example, "Life Cycle Assessment (LCA)," "Life-Cycle-Assessment," "Life cycle assessments," and "LCA" would all be converted to and counted as "Life Cycle Assessment."

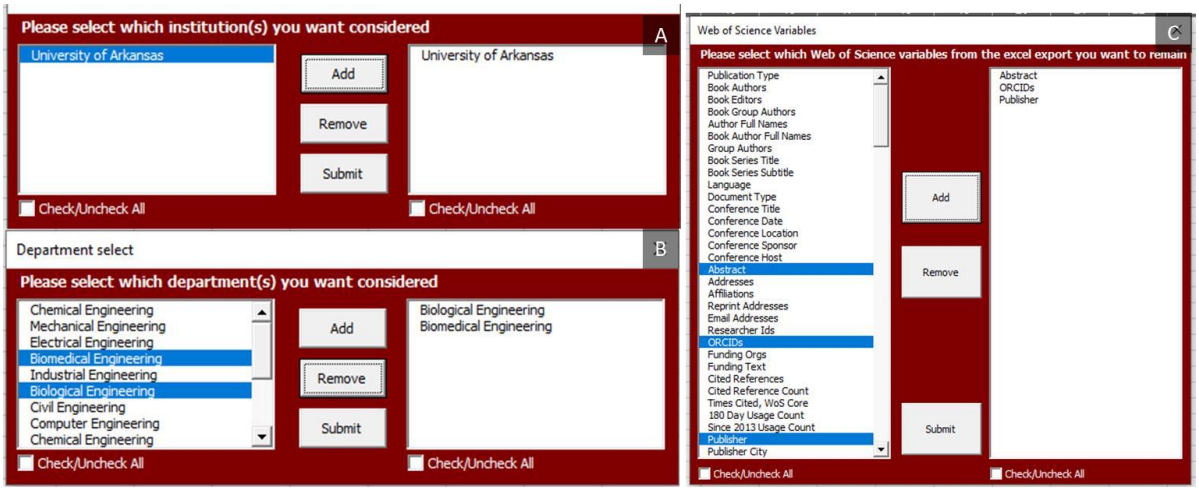


Fig. 3. User interfaces for the VBA program. A) An input box to select institutions. B) An input box to select departments. C)An input box to WoS variables

The names of the faculty members and which department and university they belong to are entered into a series of arrays (see Fig. 4). These arrays hold five values for each author: [Full Name], [Last Name, First Name], [Last Name, First Name (Alternative Spelling)], [Department], [Institute]. The [Full Name] is used to print the authors' names in a way that is easy to read. The two [Last Name, First Name] values are used to identify articles authored by the faculty of interest and direct the program from there. These variables are formatted to match the metadata of the list of authors in the WoS file, allowing for easy identification by the program. The extra value for alternative spellings enables the program to account for authors who have published under multiple names. The [Department] value is important for comparing different engineering programs and finding collaborations. Currently, the [Institute] value does not affect the current

analysis focused on the University of Arkansas. Still, its presence allows for further analysis based on different institutions to be implemented in the future.

```
Option Compare Text 'this tells the program to ignore capitalization when comparing text

Global WoSExport As New Collection 'this holds all possible WoS Variables
Global Department As New Collection 'This holds the names of the different departments
Global Institute As New Collection 'this holds the names of the institutions

Global CHEG(1 To 14, 1 To 5) As String 'Chemical Engineering
Global MEEG(1 To 16, 1 To 5) As String 'Mechanical Engineering
Global ELEG(1 To 17, 1 To 5) As String 'Electrical Engineering
Global BMEG(1 To 15, 1 To 5) As String 'Biomedical Engineering
Global INEG(1 To 23, 1 To 5) As String 'Industrial Engineering
Global BENG(1 To 14, 1 To 5) As String 'Biological Engineering
Global CVEG(1 To 17, 1 To 5) As String 'Civil Engineering
Global CSCE(1 To 22, 1 To 5) As String 'Computer Engineering
```

Fig. 4. VBA code showing collections and arrays required for metadata analysis.

The final program finds and catalogs keywords, research areas, and journals based on the authors. It then counts the number of occurrences for each of these to determine the authors' most common variables. An overall analysis is done as well. The publishing year is preserved for all entries. Additionally, collaborations (articles authored by multiple authors of interest) are flagged and reported.

3. Results

In total, the current faculty of the University of Arkansas College of Engineering had 815 articles listed on WoS. These articles were created between 138 faculty members across eight departments. These articles have amassed a total of 7444 citations.

3.1. WoS Categories

Being an index unique to WoS, the WoS Categories were an obvious metric to consider during analysis. The top 30 WoS Categories for all the articles published (Fig. 5) show a curious trend. Even when accounting for all eight departments, Electrical and Electronic Engineering is the WoS Category that is repeated the most. This is interesting, given the heavy focus that much of the engineering college places on biomedical and biological research. However, this is not the only trend visible in the data. Overall, the College of Engineering has research leaning towards polymers, biomaterials, nanotechnology, electronics, environmental sciences, and medical technology.

3.2.Keywords

When complied, keywords can provide an excellent overview of research areas. In the 815 articles assessed, there were 5125 unique keywords listed. The top 20 keywords between all departments can be seen in Fig. 6. Model, the most used keyword overall, is also in the top 10 keywords for the Biomedical, Biological, Mechanical, Civil, Industrial, and Computer Engineering departments. Given the appearance of other keywords in the top 30 list, such as "optimization," "simulation," "life cycle assessment," and "deep learning," it is fair to assume

that the College of Engineering relies heavily on software and computer programing. The top keywords for individual departments show department strength and interconnections between departments (see Figs. 7 & 8). The findings are consistent with what one would expect given the top WoS Categories.

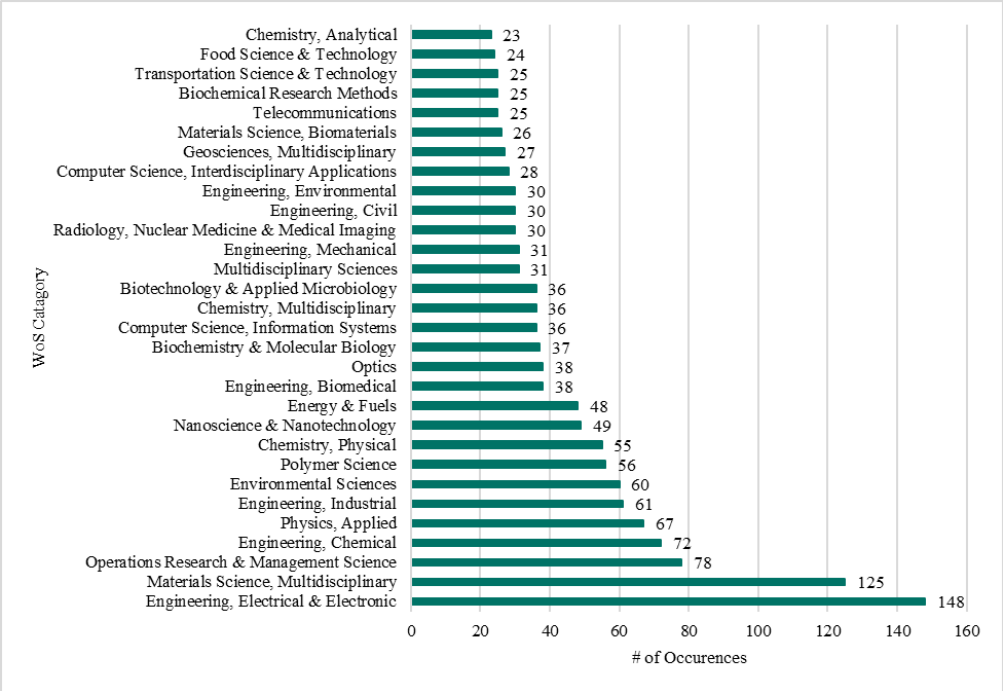


Fig. 5. The top 30 WoS Categories for all articles in the study

Keyword	Count
Model	92
System	50
Performance	48
Optimization	41
Life Cycle Assessment	40
Design	36
Temperature	32
Growth	31
Impact	30
Management	29
Nanoparticles	29
Dynamic	27
Silicon Carbide	26
Mechanism	24
Waste Water	23
Flux	23
Breast Cancer	23
Reliability	22
Greenhouse Gas Emission	21
Cancer	20
Simulation	19
Power Electronic	19
Deep Learning	18
Soil	18
Behavior	18
Surface Modification	18
Energy	18
Switches	18
Sensor	17
Water	17

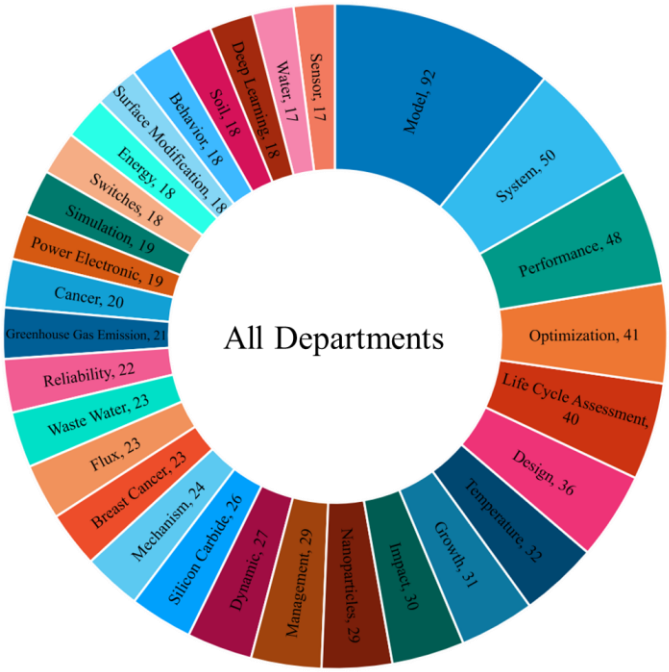
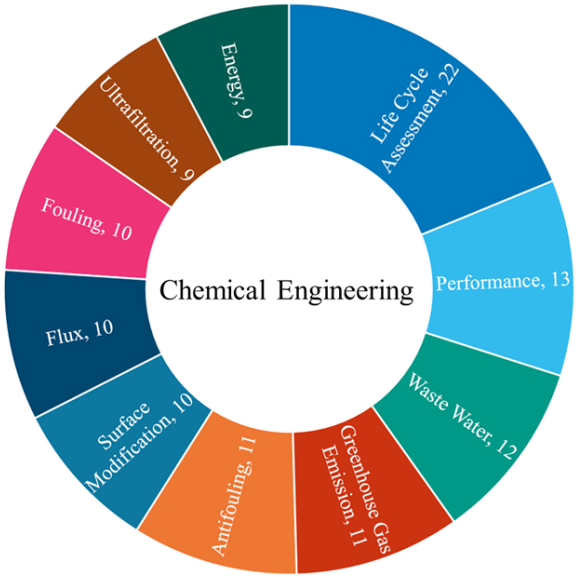
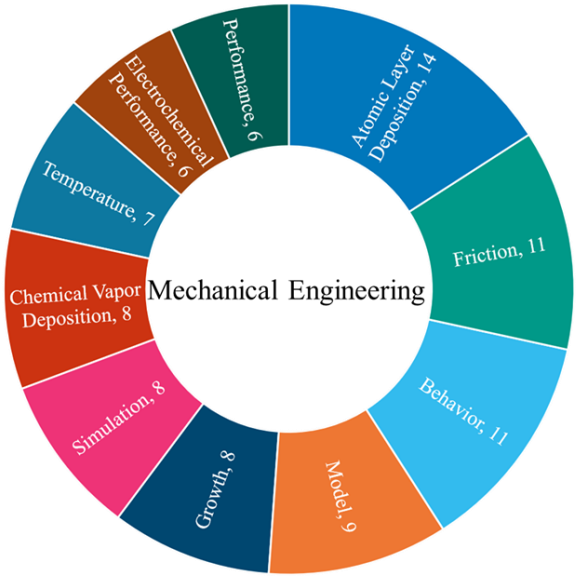


Fig. 6. The top 30 keywords for all articles in the study

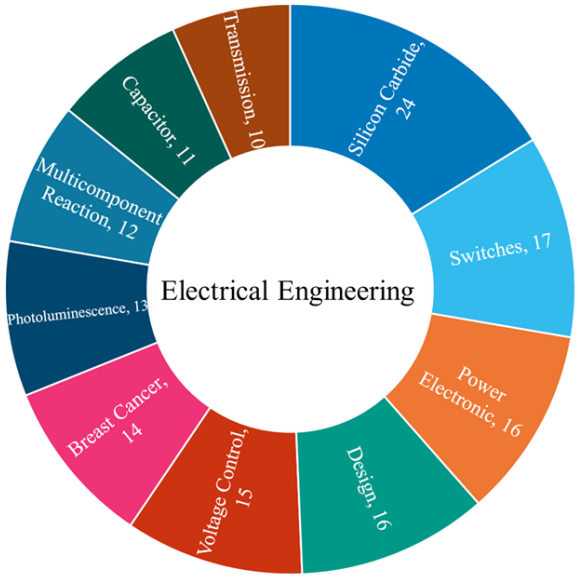
Keyword	Count
Life Cycle Assessment	22
Performance	13
Waste Water	12
Antifouling	11
Greenhouse Gas Emission	11
Fouling	10
Flux	10
Surface Modification	10
Energy	9
Ultrafiltration	9



Keyword	Count
Atomic Layer Deposition	14
Behavior	11
Friction	11
Model	9
Chemical Vapor Deposition	8
Simulation	8
Growth	8
Temperature	7
Performance	6
Electrochemical Performance	6



Keyword	Count
Silicon Carbide	24
Switches	17
Design	16
Power Electronic	16
Voltage Control	15
Breast Cancer	14
Photoluminescence	13
Multicomponent Reaction	12
Capacitor	11
Transmission	10



Keyword	Count
Nanoparticles	14
Biosensor	14
Life Cycle Assessment	12
Sensor	9
Sensitive Detection	9
Metal Organic Framework	9
Soil	9
Immunosensor	8
Nanocomposites	8
Model	8

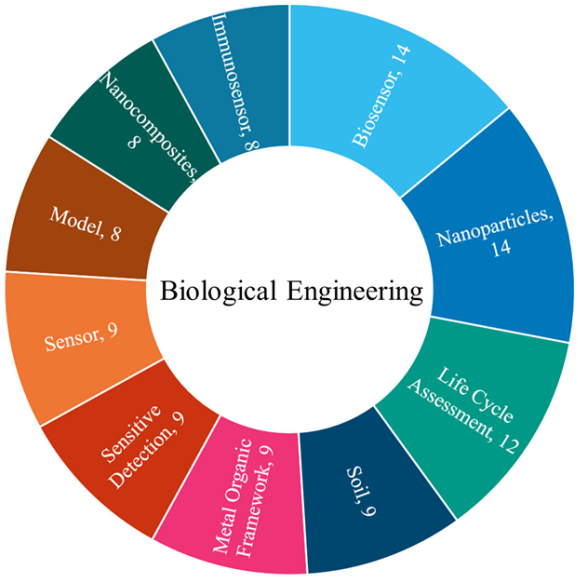
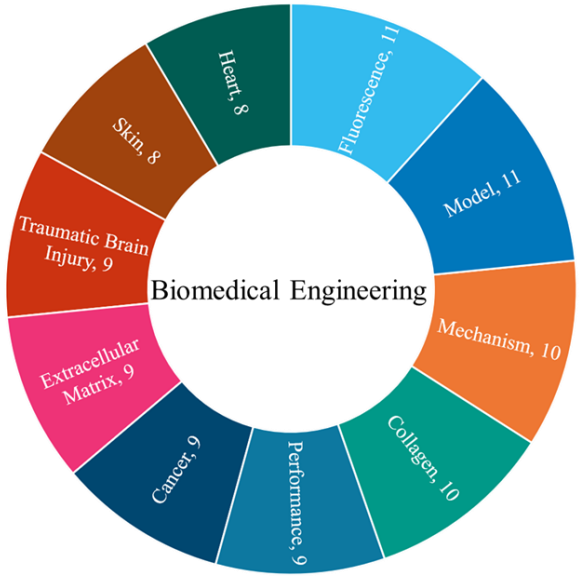
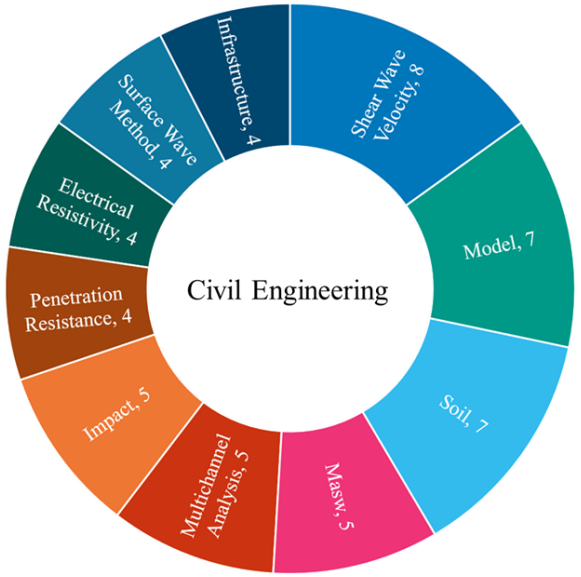


Fig. 7. Top 10 keywords for Chemical, Mechanical, Electrical, and Biological Engineering

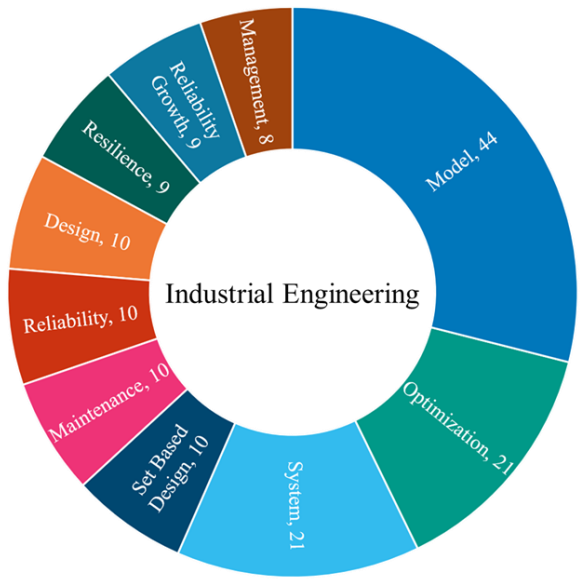
Keyword	Count
Model	11
Fluorescence	11
Collagen	10
Mechanism	10
Traumatic Brain Injury	9
Extracellular Matrix	9
Cancer	9
Performance	9
Heart	8
Skin	8



Keyword	Count
Shear Wave Velocity	8
Soil	7
Model	7
Impact	5
Multichannel Analysis	5
Masw	5
Infrastructure	4
Surface Wave Method	4
Electrical Resistivity	4
Penetration Resistance	4



Keyword	Count
Model	44
System	21
Optimization	21
Design	10
Reliability	10
Maintenance	10
Set Based Design	10
Reliability Growth	9
Resilience	9
Management	8



Keyword	Count
Deep Learning	12
Optimization	7
Convolutional Neural Network	6
Network	6
Security	6
Model	5
Cybersecurity	5
Dynamic	5
Self Assembly	4
Fpga	4

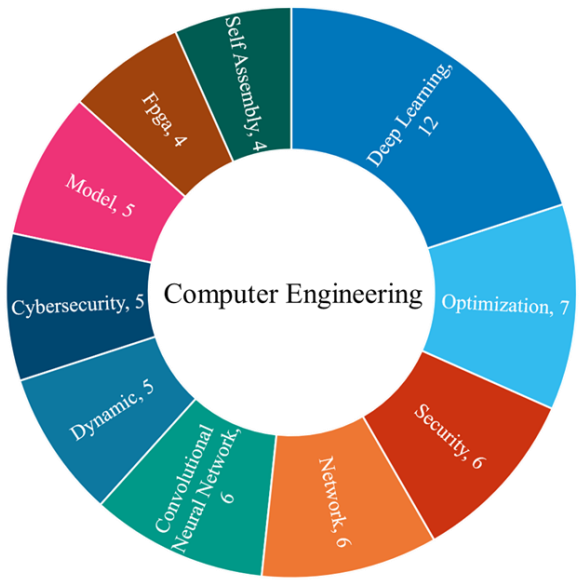


Fig. 8. Top 10 keywords for Biomedical, Civil, Industrial, and Computer Engineering

3.3.Journals

The two journals that the College of Engineering has published the most in the last five years are the *IEEE Transactions on Power Electronics* and the *IEEE Journal Of Emerging and Selected Topics In Power Electronics* (Fig. 9). This is consistent with results from previous sections. These results also show many journal articles focusing on membrane technologies and environmental sciences. Knowledge of what journals are most popular shows what research areas in the college are most represented in academia.

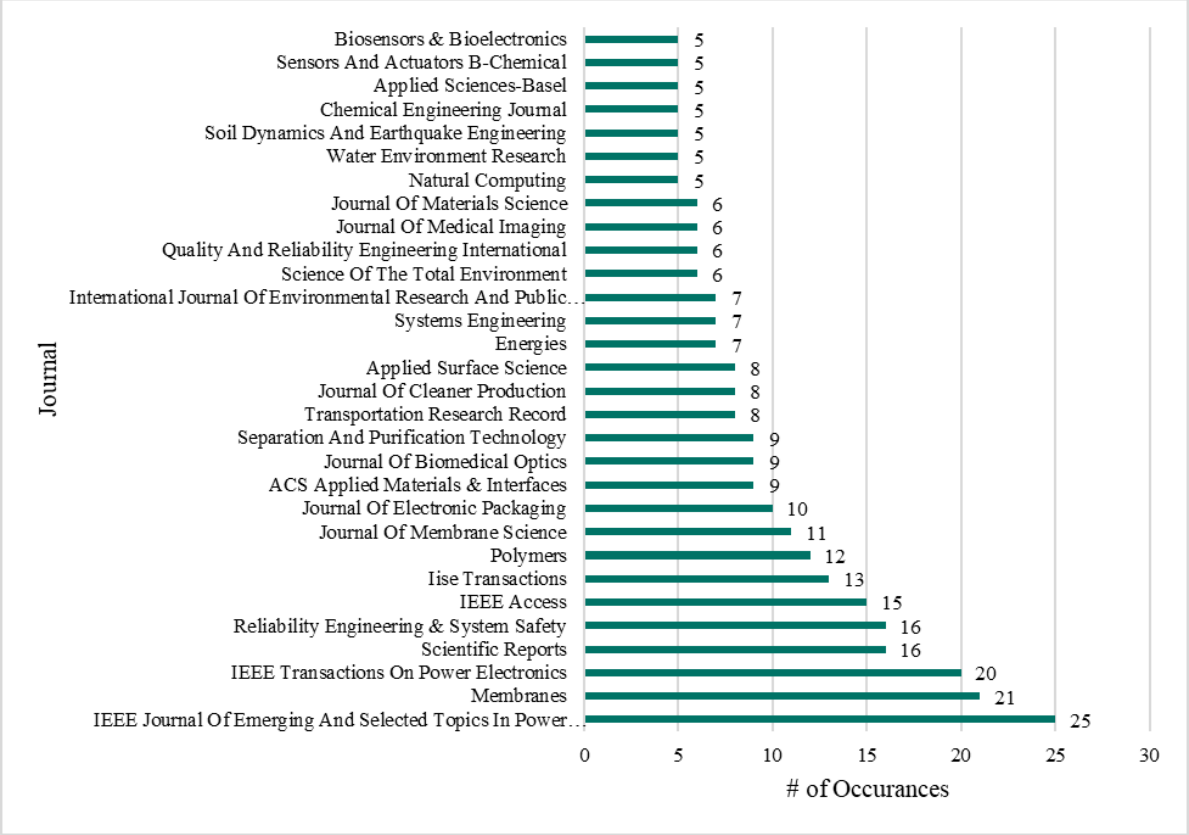


Fig. 9. 30 most frequently published-in journals by the College of Engineering from 2018-2022

3.4. Department Impact and Productivity

The overall productivity and impact of each department can be inferred by looking at the number of articles published, total citations for those articles, number of faculty members, and the ratio of those statistics (see Table 2). Based solely on WoS, the department which has the highest number of articles published in 2018-2022 by active faculty is the Electrical Engineering department. This department published 174 articles; this contrasts with the department with the fewest articles published (65), Computer Engineering.

Table 2. Faculty members, articles, and citations from each department

Department (Engineering)	Chemical	Mechanical	Electrical	Biological	Biomedical	Civil	Industrial	Computer	All Departments
# of Faculty Members	14	16	17	14	15	17	23	22	138
Articles Published	105	97	174	151	121	75	111	65	815
Citations	1128	832	1584	1865	1113	703	928	252	7444

Interestingly, while one would expect the number of articles and citations to increase proportionately with the number of faculty members in a department, this was not the case. The productivity of a department can be best seen when considering the ratio of articles published per number of faculty members (see Fig. 10). When considering all departments, the average number of articles per faculty member is 5.9. Despite tying with Chemical Engineering for the fewest faculty members, the Biological Engineering department had the highest number of articles per faculty member with 10.8. These statistics show that the Biological Engineering department is a particularly productive department in the engineering college.

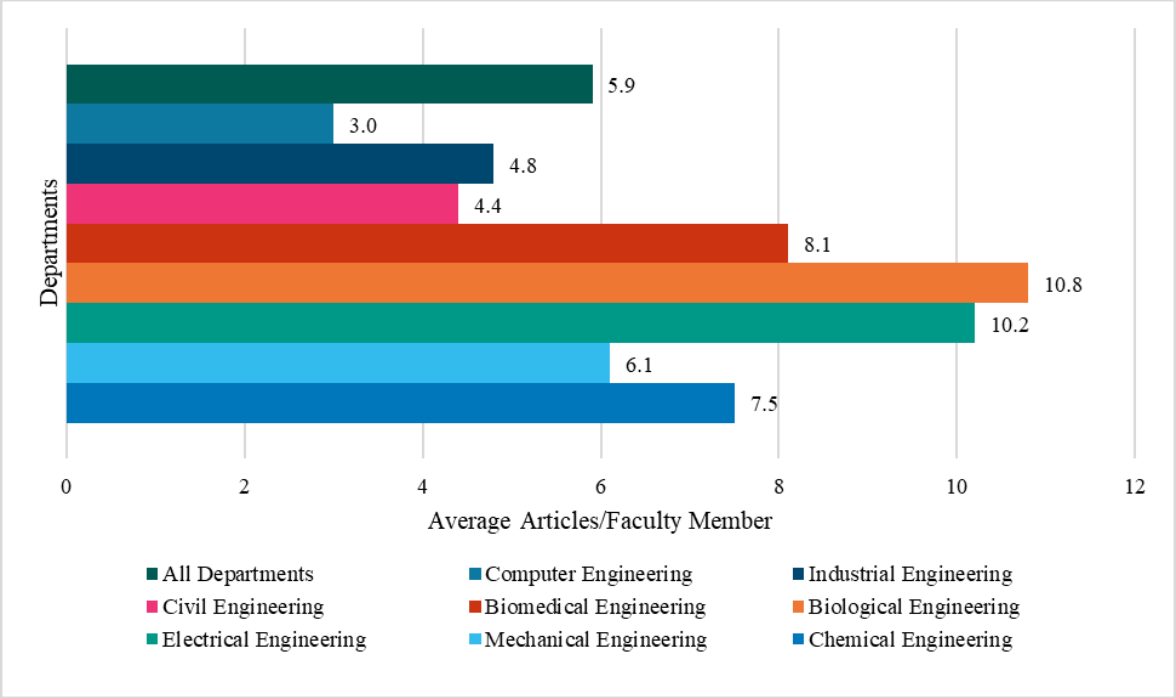


Fig. 10. The average number of articles published per number of faculty members in a department.

While a department may be sufficiently productive regarding the sheer number of published articles, there is no guarantee that those articles will impact the scientific community. To assess this, the average number of citations/articles is a more meaningful metric (see Fig. 11). The overall average citations/article is 9.1. Once again, the Biological Engineering department has the highest number in this dataset; the average citations/article is 12.4. This indicates that the

Biological Engineering department is both highly productive and impactful compared to the other engineering departments at the University of Arkansas College of engineering.

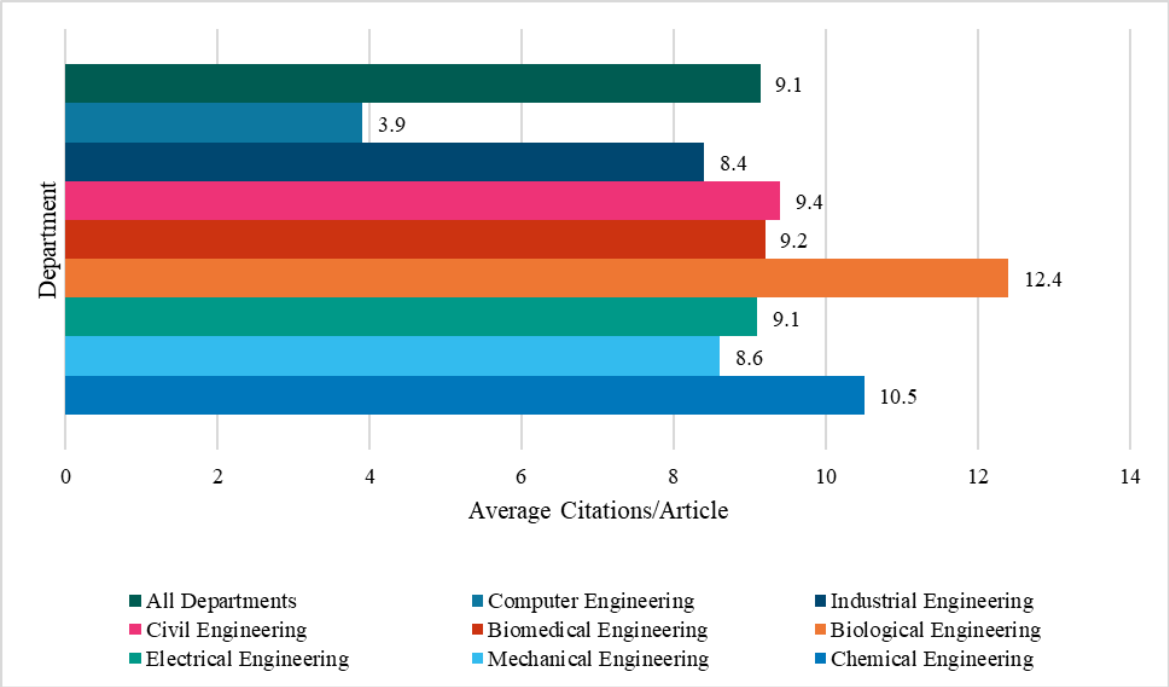


Fig. 11. The average number of citations per article published in a department

3.5. Collaborations

Of the 815 articles published, 164 (~20%) were collaborative efforts between two or more faculty members. The breakdown of which departments were involved in collaborations can be seen in Table 2. The most collaborative departments were Chemical Engineering and Biomedical Engineering, which were involved in 41% and 40% of all collaborations. These departments being the two most collaborative is unsurprising given the fact that they also were the two departments that *shared* the most collaborations; the Chemical and Biomedical Engineering departments collaborated 35 times (21% of all collaborations). Biomedical Engineering also collaborated with most other departments. Industrial Engineering was the only department that the Biomedical Engineering department did not collaborate with. Interestingly, Industrial Engineering was the department with the greatest number of *internal* collaborations (i.e., collaborations between faculty members of the same department). Internal Industrial Engineering collaborations accounted for 13% of all collaborations.

Table 3. Collaborative efforts between departments in the College of Engineering. Each interception between colored rows and columns represents the number of collaborations shared between faculty members within the relevant departments

	Chemical	Mechanical	Electrical	Biological	Biomedical	Civil	Industrial	Computer	Sum Total
Chemical	13	2	0	14	35	3	0	0	67
Mechanical	2	9	1	0	5	2	1	0	20
Electrical	0	1	19	0	7	3	3	5	38
Biological	14	0	0	0	1	0	2	0	17
Biomedical	35	5	7	1	13	2	0	1	64
Civil	3	2	3	0	2	8	0	0	18
Industrial	0	1	3	2	0	0	22	0	28
Computer	0	0	5	0	1	0	0	5	11

4. Conclusions

WoS is a powerful tool for researchers in more ways than one. The search capabilities make articles easy to find, and the export features make it easy to gather metadata quickly. Using MS Excel and VBA programming, data analysis can be done flexibly and easily. This kind of analysis can uncover trends in research between groups that are generally not considered together. Several such trends are apparent by analyzing the departments in the University of Arkansas College of Engineering. Firstly, the greatest share of the literature coming from the College of Engineering is from the Electrical Engineering department. However, the Biological Engineering department has the highest impact per article. Modeling and optimization are the overall trends suggested by the keywords. Still, more specific niches such as membranes and polymers, life cycle assessment and environment sciences, nanoparticles, and biomaterials also are apparent. Many departments are collaborative within themselves, but the Chemical and Biomedical Engineering departments had far more multidisciplinary collaborations than internal ones. Overall, a short but effective study could be conducted with relative ease using WoS and VBA programming.

References

[1] S. A. S. AlRyalat, L. W. Malkawi, and S. M. Momani, "Comparing Bibliometric Analysis Using PubMed, Scopus, and Web of Science Databases," *JoVE (Journal of Visualized Experiments)*, no. 152, p. e58494, Oct. 2019, doi: 10.3791/58494.

[2] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *Journal of Business Research*, vol. 133, pp. 285–296, Sep. 2021, doi: 10.1016/j.jbusres.2021.04.070.

[3] J. T. McAllister, L. Lennertz, and Z. Atencio Mojica, "Mapping A Discipline: A Guide to Using VOSviewer for Bibliometric and Visual Analysis," *Science & Technology Libraries*, vol. 0, no. 0, pp. 1–30, Dec. 2021, doi: 10.1080/0194262X.2021.1991547.

[4] W. Liu, "A matter of time: publication dates in Web of Science Core Collection," *Scientometrics*, vol. 126, no. 1, pp. 849–857, Jan. 2021, doi: 10.1007/s11192-020-03697-x.

[5] R. Pranckutė, "Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World," *Publications*, vol. 9, no. 1, Art. no. 1, Mar. 2021, doi: 10.3390/publications9010012.

[6] "Web of Science Core Collection Help." https://images.webofknowledge.com/images/help/WOS/hp_subject_category_terms_tasca.html (accessed Aug. 07, 2022).

[7] L. Leydesdorff, S. Carley, and I. Rafols, "Global maps of science based on the new Web-of-Science categories," *Scientometrics*, vol. 94, no. 2, pp. 589–593, Feb. 2013, doi: 10.1007/s11192-012-0784-8.

[8] T. L. Chambers, "Teaching Engineering Analysis using VBA for Excel," vol. 18, pp. 71–81, Apr. 2008.

[9] S. J. Rubin and B. Abrams, "Teaching Fundamental Skills in Microsoft Excel to First-Year Students in Quantitative Analysis," *J. Chem. Educ.*, vol. 92, no. 11, pp. 1840–1845, Nov. 2015, doi: 10.1021/acs.jchemed.5b00122.

[10] S. Hrehova, "Description of using different software tools to analyze the selected process," in *2019 20th International Carpathian Control Conference (ICCC)*, May 2019, pp. 1–5. doi: 10.1109/CarpathianCC.2019.8765948.

[11] "Faculty Directory | Chemical Engineering | University of Arkansas." https://chemical-engineering.uark.edu/directory/index.php (accessed Aug. 07, 2022).

[12] "Directory | Mechanical Engineering | University of Arkansas." https://mechanical-engineering.uark.edu/Directory/index.php (accessed Aug. 07, 2022).

[13] "Faculty Directory | Electrical Engineering | University of Arkansas." https://electrical-engineering.uark.edu/directory/index.php (accessed Aug. 07, 2022).

[14] "Faculty and Staff | Biomedical Engineering | University of Arkansas." https://biomedical-engineering.uark.edu/directory/ (accessed Aug. 07, 2022).

[15] "Faculty Directory | Industrial Engineering | University of Arkansas." https://industrial-engineering.uark.edu/directory/index.php (accessed Aug. 07, 2022).

[16] "Faculty Directory | Biological Engineering | University of Arkansas." https://bio-ag-engineering.uark.edu/directory/index.php (accessed Aug. 07, 2022).

[17] "Faculty Directory | Civil Engineering | University of Arkansas." https://civil-engineering.uark.edu/directory/index.php (accessed Aug. 07, 2022).

[18] "Directory | Computer Science and Computer Engineering | University of Arkansas." https://computer-science-and-computer-engineering.uark.edu/directory/index.php (accessed Aug. 07, 2022).

Aubrey Lynn Schultz

Aubrey Lynn Schultz is a Ph.D. student in Chemical Engineering in the Ralph E. Martin Department of Chemical Engineering at the University of Arkansas (UofA). Aubrey got her MS from the UofA under Dr. Shannon Servoss, and her BS in Chemical Engineering from Oklahoma State University. Aubrey now works under Dr. Bob Beitle Jr., doing research on Point-of-Care diagnostics in resource-limited areas. Aubrey is also a graduate research assistant in the UofA David W. Mullins Library under the Engineering and Honors College librarian, Jay McAllister. Aubrey leads the Chemical Engineering Writing Club at the UofA and serves as the 2021-2022 Vice President for the Arkansas Chemical Engineering Graduate Student Organization (AChEGS).

Jay McCallister

Jay McAllister has been the engineering and honors college librarian at the University of Arkansas Fayetteville since 2018. Jay earned his Bachelor of Arts in History from the University of Oklahoma in 2008 and his Master of Science in Library Science from the University of North Texas in 2014. Jay enjoys teaching students, faculty, and the local community about library skills and how it contributes to lifelong learning. Jay's previous research has focused on data visualization, open access, and database collection comparisons. His current research interests focus on 21st-century libraries, engineering librarianship, and immersive technologies for academic libraries. Jay currently holds professional memberships in the American Society for Engineering Education and the American Library Association.