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To cite this article: Olufunke Oladipupo, Ibukun Afolabi, Stephen Adubi & Olaperi Sowunmi (2020): Discovering the research focus of higher academic institutions, African Journal of Science, Technology, Innovation and Development, DOI: [10.1080/20421338.2020.1721635](https://doi.org/10.1080/20421338.2020.1721635)

To link to this article: <https://doi.org/10.1080/20421338.2020.1721635>



Published online: 28 Mar 2020.



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## Discovering the research focus of higher academic institutions

Olufunke Oladipupo, Ibukun Afolabi\*, Stephen Adubi and Olaperi Sowunmi

*Department of Computer and Information sciences, Covenant University, Nigeria*

*\*Corresponding author email: [ibukun.fatudimu@covenantuniversity.edu.ng](mailto:ibukun.fatudimu@covenantuniversity.edu.ng)*

The research focus of an institution indicates the academic strength of the institution. This academic strength goes a long way to determine the quality of academic product expected from such an institution. To this effect, this study aims at analyzing the research publication strength of 70 Nigerian universities that are visible in Scopus database for Computer Science from inception to 22 December 2017. They include 35 federal, 27 state and 8 private universities. This study is divided into two phases; the first phase consists of six major steps in a waterfall model and the second is carried out by adopting a knowledge discovery model using a clustering algorithm for pattern discovery in an unstructured data model. The data source for the analysis is the Scopus indexing database recommended by the Times Higher Education for international ranking of higher institutions. From the first phase, the predominant outlet for each institution was discovered alongside the percentage of publications in the dominant outlet and the number of publications by the institution within the database over the period of the analysis. In the second phase, the predominant areas of research of each institution within the field of Computer Science was determined. In particular, it was observed that such areas as deep learning and data science are under researched. The findings also revealed networking as the most published area in Nigerian universities, and a number of Nigerian computer science scholars engage in application research which link Computer Science with other disciplines with Nigeria and Africa as case studies. The findings from this research can support postgraduate students' decision in making the right choice of institution based on their research interest. It will also serve as an eye-opener for industries in promoting a result-oriented university-industry partnership.

**Keywords:** data mining, clustering, statistical analysis, publication, research focus, universities

### Introduction

Nigeria has an overwhelming number of universities. The advent of private universities in Nigeria has really influenced the increase in the number of universities. In October 2016, there were 40 federal, 42 state and 61 private universities (<http://nuc.edu.ng/>), making a total number of 143 universities in Nigeria. This has really improved the country in some ways. This high number of universities in Nigeria has provided job opportunities for university graduates as lecturers, researchers or administrators. It has also created more university admission opportunities for secondary school leavers. Moreover, as lecturers are being employed to take on responsibilities of teaching and research at the universities, their research output is also expected to increase, leading to greater global recognition. According to Wilbertz (2013), research helps to better understand the world around us, proving knowledge in a target subject matter which is then applied to solve, manage or avoid an existing or inherent looming problem.

The United States (USA) has the highest percentage of world class universities in the world (Times Higher Education 2016). A great number (65%) of the top 20 universities in the world ranked by the Times Higher Education (THES)<sup>1</sup> are American universities and this is largely due to the impact of their research and publications in the global community. Countries represented in the top 100 of the THES rank of 2015–2016 include the USA, the United Kingdom, the Netherlands, South Korea, Japan, Australia, Taiwan, France, Russia, Brazil, Switzerland, China, Canada, Singapore, Hong Kong, Sweden, Germany and Belgium (Times Higher Education 2016).

According to Chiemeké et al. (2009), it has been reported that the motivation of Nigerian researchers to

do research is non-existent primarily due to the lack of research funds and grants. Researchers have highlighted various factors affecting the 'dying' state of research in Nigeria (Chiemeké et al. 2009; Chikwe, Ogidi, and Nwachukwu 2015; Nwakpa 2015), such as difficulty in accessing research grants, brain drain of top academics creating a huge gap in the mentoring role, absence of research acumen by our researchers, very limited facilities available for quality research work and too much time devoted to teaching and administrative duties leaving little time for meaningful research work. However, the importance of research cannot be overlooked since research productivity is one of the main criteria for the promotion of academics in Nigerian universities (Adomi and Mordi 2003; Nwakpa 2015). Also, as the trend of research expectation is changing in universities, more emphasis is now being placed on publications in reputable journals (journals of international standard), predatory journals are prohibited and Scopus and ISI index journal articles are being rated higher. For example, University of Ibadan (UI) requires 40%, 60% and 70% of articles in internationally reputable (IR) journal outlets for promotion to the Lecturer I, Senior Lecturer and Professorial cadre, respectively (University of Ibadan 2015). Covenant University also gives more weight to publications in Scopus/ISI indexed journal articles when considering applicants for promotion from one cadre to a higher cadre (Covenant University 2015). Although every lecturer desires to publish in reputable, open access journals in order to promote the relevance and global visibility of their institution, there are constraints. The major constraint to publishing in such reputable journal is the cost of publishing; this could be in terms of time or cash that comes with most of the open access journals. It had been

observed that articles that are openly accessible to readers without subscription get cited more often than their counterparts that are not openly accessible (Gargouri et al. 2010).

According to Altbach (2015), publication in indexed journals is a booster of the image of institutions among the ranking bodies, which is determined by the publication citations. The ranking is motivated by the following:

- (1) Financial institutions who finance higher education want to know which universities are the ‘best’.
- (2) Universities try to boost their image for reasons such as prestige, and student and staff recruitment.
- (3) High competition among universities hoping to attract funds for research, especially in the form of grants.
- (4) Staff competition among students who wish to enrol at prestigious schools.
- (5) Academics compete to get employed by the ‘best’ universities.

On this note, it will not be out of place to conclude that a research-oriented institution with output evidence in indexed or high impact journals tends to be ranked higher. This is due to the emphasis placed on research output citation when rating the global relevance of academic institutions. To this effect, analyzing the Nigerian universities research publications in those indexed journals will reveal the prominent outlet from each institution, showcase the visibility of each institution in the global research community, divulge the publication spread of each institution and make known the predominant field of research in the universities investigated.

### Literature review

There are several research studies that have analyzed academic research productivity using different data sources and methodologies as discussed in this section. According to Khasseh, Soheili, and Mousavi Chelak (2017), research productivity is a measure of scholarly effort, which can be investigated using number of publications. In 2004, Guan and Ma analyzed research performance with respect to research publications in the computing domain in the period of 1993–2002 based on journals indexed in the INSPEC database from America, Europe and Germany. They discovered that the ratio of Citation Index (SCI) articles to total journal articles were 54.16%, 48.18% and 54.66% for the three counties, respectively. This indicates that reputable universities worldwide published in top journal outlets and the more articles a university had in reputable journals, the more globally relevant the university became. Davarpanah and Asleki (2008) analyzed 894 articles in 56 Library and Information Science (LIS) journals indexed in Social Sciences Citation Index (SSCI) between the years 2000–2004. They discovered that the majority of the articles surveyed (83.94%) were contributed by US and the UK universities. Serenko et al. (2010) did a scientometric analysis of peer-reviewed journals in the research area of Knowledge Management and Intellectual Capital (KM/IC) from 1994 to 2008. Javits et al. (2010) conducted a research study to find out if various resource inputs and institutional characteristics relate to article production.

Okafor (2011) carried out a research study to find out the research output, rate of postgraduate supervision and comparison of journal articles of academics in certain selected institutions. Goktas et al. (2012) used human experts to validate the content analysis of educational research papers from SSCI database and the ULAKBIM database. They were able to categorize papers by description, types, discipline, the research method data collection tools, data analysis and so on. Ezema and Eze (2012) used citation analysis to discover the publication outlet of Nigerian agricultural science research. Their data were obtained from two main journals in animal health and production. Zhuang et al. (2013) used the SCI and SSCI databases to evaluate the geographical influence of authors by the geographical impact factor index. Maharana (2013) used the Scopus bibliographic database to discover the average annual publication range and the degree of collaboration of Orissa University of Agricultural Technology using statistical and theoretical formulas. Their research identified most the prolific researchers, most the favoured research areas, authorship patterns in the papers published and so on. Using the Social Sciences Citation Index (SSCI), Maharana (2013) carried out a bibliometric analysis of the research output of Sambalpur University’s publications in ISI Web of Science. The methods used include Subramanyam’s formula to calculate degree of collaboration and Bradford’s law was used to determine scattering of literature.

Winkler et al. (2014) used descriptive and regression analysis to investigate academic knowledge in the domain of business and economics. Their data were obtained from Web of Science (Knowledge) for a broad set of institutions. Sheeja and Susan (2014) carried out research to identify the most prolific authors, the preferred source titles for communication of research publications and the citation status of the research community of Cochin University. The Web of Science (ISI) data over a period of five years were evaluated using scientometric techniques. Kasa, Ibrahim, and Momoh (2014) carried out research to analyze the publication research output patterns of agriculture and veterinary researchers at Ahmadu Bello University, Zaria. The analysis was able to ascertain the research output formats over a period of 10 years. The methods used include random sampling and bibliometric methods. The data consisted of the curriculum vitae and research publications of the senior academics at the institution. Khan, Jan, and Amin (2014) analyzed data gathered from SCOPUS between March and May, 2011 for various field of interest in the sciences in order to reveal the potential areas of research. Ruhanen et al. (2015) explored trends and patterns in sustainable tourism research over a period of 25 years. This was done using bibliometric analysis and discovered that sustainable tourism research remained constant while theoretical approaches continued to mature over time. In Al-Mutairi and Al-Shami (2015) research publications over a period of six years in 25 public universities in Saudi were analyzed. The report revealed the strong research areas in Saudi universities as engineering, medicine, physics and astronomy.

Cimenlera, Reevesa, and Skvoretz (2014) did a regression analysis of researchers' social network metrics on their citation performance in a college of engineering. Soheili, Khademi, and Mansouri (2015) and Khasseh, Soheili, and Chelak (2017) used regression analysis to compare the relationship between influencers in scientific publications and the number of publication. Ronda-Pupo (2017) explored, among others, the correlation between number of papers and PRI (Percentile Rank Index).

In the reviewed literature, it is obvious that researchers are focused more on Scopus/ISI indexed journal articles for their analysis and most of the analyses were limited to a specific department at a particular university. The entirety of universities in a country as a whole has not been given sufficient consideration to the best of our knowledge. According to Groß Ophoff et al. (2017) it is important for universities and other research institutions to have staff that produces high quality research, confers prestige on the university and attracts research funding. Also, according to Geuna and Martin (2003), evaluation of previous research output determines how research funds are allocated to universities. Hence, this research assesses the contents of research products in the Computer Science discipline which has not had much attention in previous research for all universities in Nigeria.

## Methodology

The methodology for this study is carried out in two phases in an attempt to address the following research questions:

RQ1: What is the dominant research outlet for each institution within the Computer Science field?

RQ2: How many publications are visible for each institution in the Scopus database within the Computer Science field?

RQ3: What is the publication trend for federal, state and private universities in Nigeria over the years within the Computer Science field?

RQ4: What is the research focus (area) of each university within the Computer Science field?

### **Phase one: Revealing prominent outlets and publication trends**

The first phase of the methodology is described with six processes which were carried out in a waterfall model as shown in Figure 1. This phase of the methodology addresses the research question (RQ) 1–3.

**Data Gathering:** The dataset used for this study was gathered from the Scopus indexing database between 18 and 22 December 2017. It comprises of all articles and conference papers in the 'Computer Science' subject area with at least one author affiliated with a Nigerian university as indexed by Scopus. In collecting the data, the list of all Nigerian universities was copied first from the National Universities Commission's (NUC) web site, the governing body that oversees all universities in Nigeria. At the time of the study, as previously noted, there were 143 universities in Nigeria. Using this list, an affiliation search was done for each university on the Scopus author search site. The returned list of documents was then refined by 'Subject Area' to 'Computer Science'

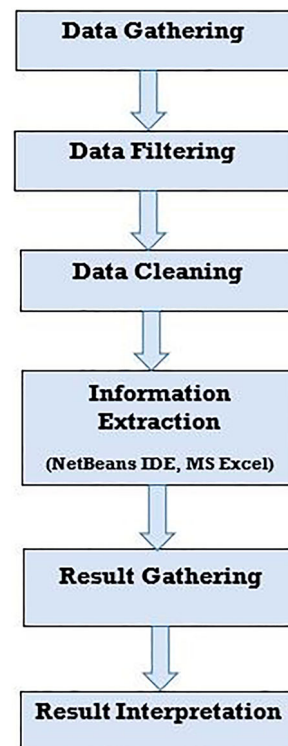
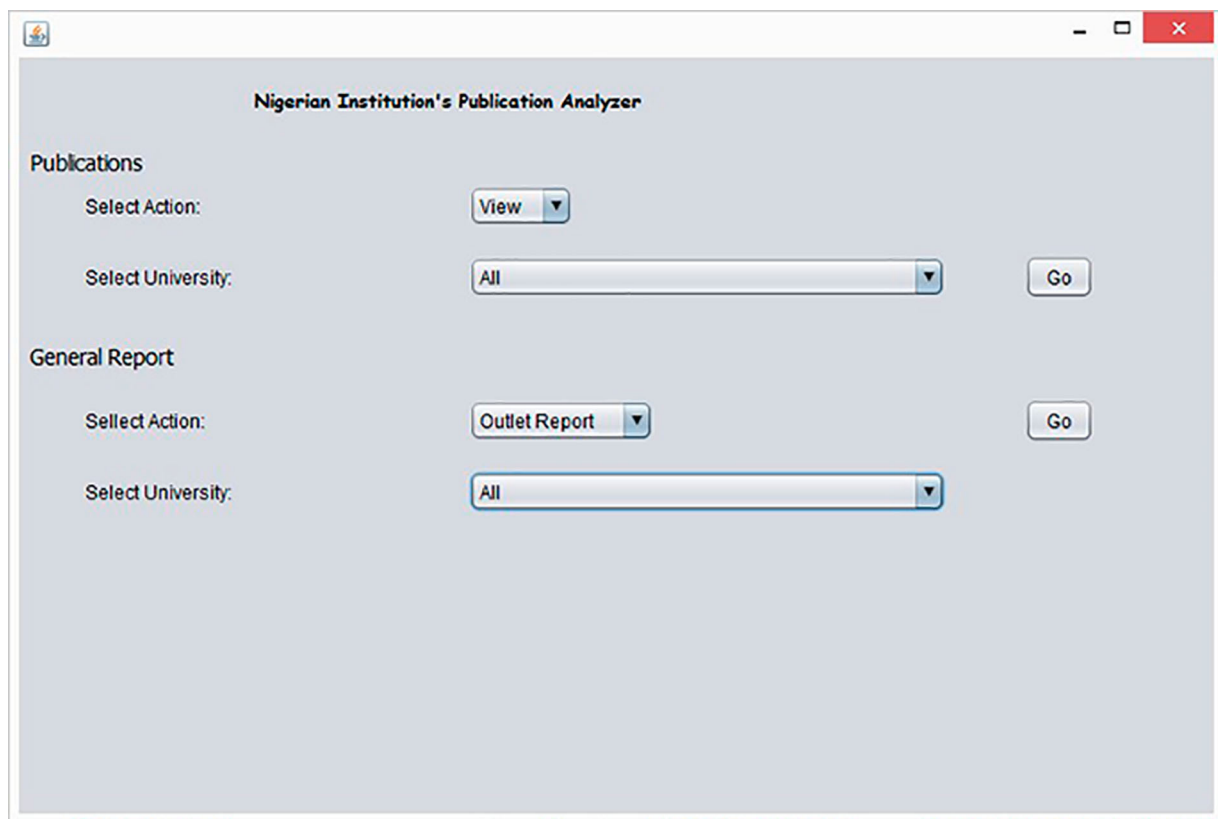


Figure 1: Part one method description.

and by 'Document Type' to 'Article' and 'Conference Paper'. This process generated refined results which met our criteria. The results were then exported using the 'CSV export' tool into .csv files. It is important to state here that not all the universities appeared in the search results because they did not have publications in the Scopus database as of the date of data collection. A total of 70 out of the 143 Nigerian universities had at least one publication in the database which gives a total of 3805 exported records. The statistics shows the distribution as 66% from 35 federal universities, 18% from 27 State universities and 16% from 8 private universities.

**Data Filtering and Cleaning:** For each university, the csv reports were opened with a spreadsheet (Microsoft Excel) and all columns that were not needed for the analysis were removed. This included columns such as the DOI, page numbers, article numbers, conference dates and conference locations, amongst others. The prepared documents were then exported to a Relational Database Management System (RDBMS), MySQL to be structurally suitable for Java programming language connection. Also, an individual list of authors had to be filtered from each record because all authors for a publication were saved as a single string, which would not make analysis of individual author's publications possible. A module was written using the Java programming language to perform this process. The relevant attributes for the purpose of this study include 'Authors', 'Title', 'Year', 'Source title', 'Affiliation', 'Abstract', and 'Document Type'.

**Information Extraction:** A program in Java using the NetBeans IDE was developed to extract relevant target information from the data gathered. This information was used in the reporting and presentation of the study



**Figure 2:** Java application interface for information extraction.

findings from the research trend analysis of this research. The Java Programming language was used together with Structured Query Language (SQL) to carry out the analysis. First, a module was written in Java to extract the list of unique authors from each record of the dataset. SQL queries were written for each of the analysis; they were then integrated with the Java programming language to communicate with the RDBMS table where the dataset was stored. A friendly interface was also developed using Java. A user can interact with the interface to get different reports, as seen from the screenshots in Figure 2. The results are displayed on the application user interface and also write to a file. The NetBeans IDE and the SQL Yog were used to facilitate and integrate the entire process.

*Result Gathering:* Relevant information extracted from the data was stored in MySQL database which can also be used as a reference point for future research work.

*Interpretation:* For phase one of this study, the result and relevant facts from the research are presented using graphical tools in a clear and concise manner. Details of this can be seen in the result section of this paper.

#### **Phase two: Discovering the research focus**

The second phase of this study methodology addresses the research question (RQ) 4, by uncovering the research focus of Nigeria universities in the field of Computer Science. This phase is referred to as the Text Mining stage or Text Analysis. To carry out the text analysis, the K-means clustering algorithm – one of the most widely used hard clustering techniques in text analysis as reported by Garla et al. (2011) and Afolabi, Ezenwoke, and Ayo

(2017) – was used because of its suitability for the study dataset.

The algorithm works as follows:

- (1) Identify the cluster size ( $k = 3$  in  $k$ -means).
- (2) Select at random, the  $k$  cluster centres that exist in the data space.
- (3) Allocate data points for different clusters with respect to shortest distance (Euclidean) to the centre of the cluster.
- (4) Re-calculate new cluster centres, this is done by getting the average observations assigned to a cluster.
- (5) Steps 3–4 are then repeated until the convergence criterion is satisfied.

The k-means clustering was used to discover the research focus of each university that appeared in the search result. The K-means algorithm was implemented with Rapid Miner Studio (<https://rapidminer.com/>) as a tool to cluster the data record for each university.

#### **Results of the study**

The result of the analysis in phase one of the methodology is displayed in Table 1. Table 1 reveals the outlet that is dominant for each institution, the number of publications in the dominant outlet, the percentage of the dominant outlet publications and also the total publications in the Scopus database for that institution. For the purpose of reporting, the institutions with 27 or more in their predominant outlet were selected for display to represent universities that have a high frequency of publication in their predominant outlet.

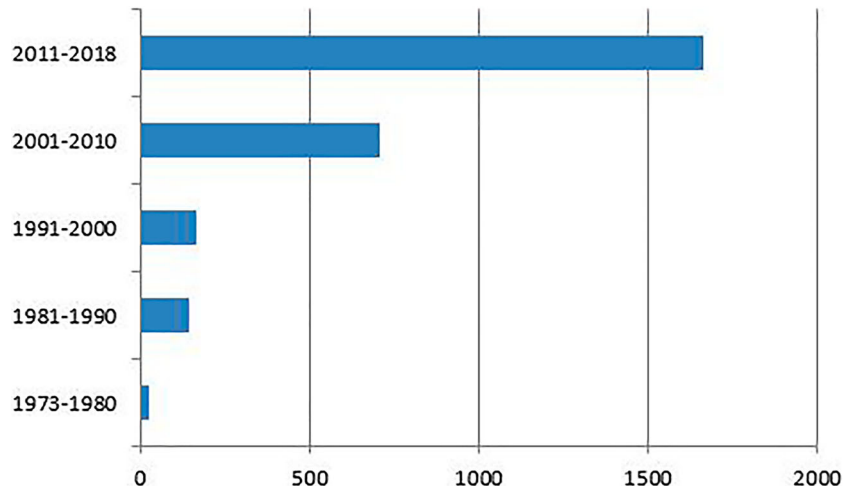
**Table 1:** Dominant publication against number of publications.

Affiliation	Dominant outlet	# publications in dominant outlet	% of publications in dominant outlet	Total number of publications in Scopus
Covenant University	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	57	14%	399
University of Ibadan	European Journal of Scientific Research	72	22%	333
Federal University of Technology, Minna	CEUR Workshop Proceedings	40	19%	210
University of Lagos	European Journal of Scientific Research	29	14%	209
Ahmadu Bello University	Research Journal of Applied Sciences\, Engineering and Technology	31	19%	164
Delta State University	European Journal of Scientific Research	27	13%	135
Rivers State University of Science and Tech	European Journal of Scientific Research	29	25%	114

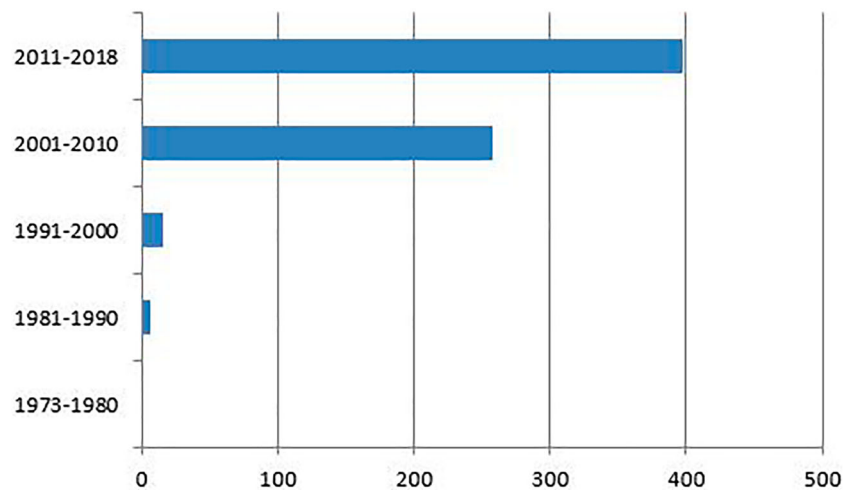
The publication trend for federal, state and private universities over the years are revealed in Figures 3–5, respectively. The text analysis result using the k-means clustering algorithm is presented in Table 2.

**Discussion**

Researchers have shown interest in studying the research output of higher academic institutions using various approaches (Guan and Ma 2004; Okafor 2011; Goktas



**Figure 3:** Publication trend for federal universities.



**Figure 4:** Publication trend for state universities.

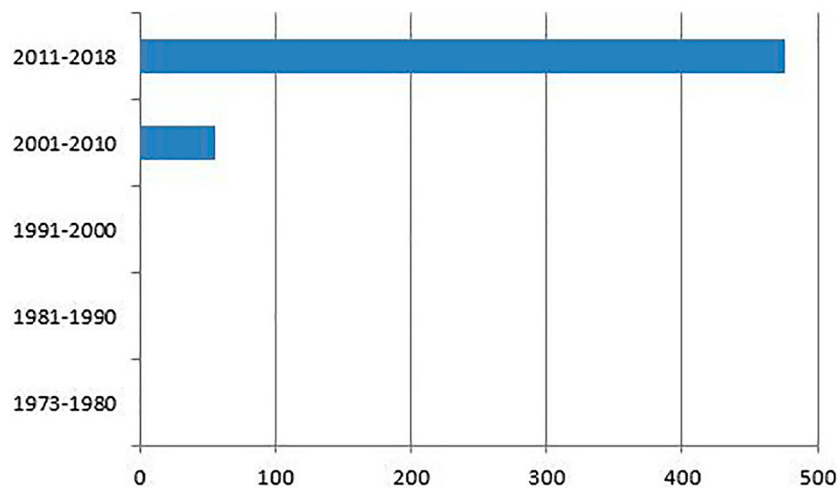


Figure 5: Publication trend for private universities.

Table 2: Text analysis result using clustering algorithm.

S/No	University	Research focus discovered
1	ABU	Algorithm, applications, grid, performance, electrical, theoretical, corrosion, water
2	BAYERO	Fuzzy, nonlinear, algorithm, heuristic, cloud, simulation, Nigerian, information, knowledge, economy, model, neural network, classifier, social, global, development
3	FED UNI DUTSE	Neural network, forecasting, optimization, discovery, performance, algorithm, regression, assemble, model, framework, classification, security
4	Fed Uni Lafia	Corruption, insecurity, Africa, penetration, security, neural network, expert, economic, algorithm, grid, efficient, genetic algorithm, cluster, agent
5	Fed Uni Otuoke	Journal, academic, publish, digital, Implementation, game, gender, association, software, Africa, Nigeria, mobile phone, culture, enterprise
6	Fed Uni Oye Ekiti	Commerce, radio, signal, inhibitor, magnetic, medical, recognition, sensor, remote
7	Fed Uni Pet Res	Bandwidth, server, disease, web, satisfaction, information, protocol, develop, robot, web
8	Fed Uni Akure	Model, network, recognition, congestion, learn, design, technology, process, education, algorithm, image, speech, fingerprint
9	Fed Uni Tech Minna	Model, equation, image, algorithm, optimal, network, mobile, service, sensor, reliability, attack, detection, software, engineering, security, development, health
10	Fed Uni Tech Owerri	Network, internet, scanty, information, cloud, service, reliability, model, rule, medical
11	Fed Uni Wukari	Algorithm, class, problem, adaptation, image, digital, protection, learn, software, Nigeria
12	FUNAAB	Mine, agent, database, business, gene, requirement, model, internet, equation, biography, ontology, security, image, mobile
13	NDA	Mobile, recognition, speech, technique, accuracy, algorithm, adoption, dynamic
14	NNAMDI AZI	Sensor, positive, portal, network, agglomer, diagnosis, image, sequence, radiographer, health, HIV, Nigeria
15	NOUN	Fraud, bank, finger print, recognition. pattern, classifier, detection, authentic, protocol, Investment
16	OAU	Model, film, image, algorithm, electrode, technique, software, technology, internet, innovation, health, bandwidth, network, probability, agent, buffer, model congestion, information
17	UI	information, system, document, automate, search, speech, text, image, retrieval, cloud, protocol, model, performance, internet, algorithm, software
18	UNIVERSITY_M Aiduguri	Model, flow, refugee, reliability, correlation, internet, information, technology, resource, optimal, image, extract, model
19	UNI OF AGRIC_MAKURDI	Fuzzy logic, statistical technique, model, development, voting, protocol, fingerprint, water, storage, pressure, moisture, technology
20	UNI_UYO	Business cluster, technology, internet model, governance, ontology, information, research, development, fuzzy logic, malaria, medical, diagnostic, hepatitis, rule, grid, religion, intention, infiltration, model, network, speech
21	UNI_ABUJA	Web, development, adoption, model, forecast, mine, Nigeria, matter, content, moisture, acid, cook, learn, information
22	UNIBEN	Formulation, extrapolation, problem, aviation, adoption, software, model, network, develop, information, computer
23	UNICAL	Information, development, internet, technology, gender, computer, knowledge, mobile, religion, efficiency, business, computer, river, software, internet
24	UNIJOS	Diagnosis, correlate, image, noise, equation, healthcare, extract, technology, communication, learn, engineering, function, scientific, tree

(Continued)

Table 2: Continued.

S/ No	University	Research focus discovered
25	UNILAG	Algorithm, learn, rot, virtual environment, information, computer, model, web, technology, method, detection, equation, depth, development, management, processor, memory, performance, heterogeneous
26	UNILORIN	Model, algorithm, problem, technique, prediction, optimal, learn, information, internet, system, web, technology, mobile, aviation
27	UNIPORT	Software, test, framework, program, information, cluster, technology, learn, brain, speed, computer, learn, technology, information, performance, adoption
28	UNN	Model, computer, parallel, processor, heterogeneous, program, learn, information, knowledge, network, technology, algorithm, model, image, fingerprint
29	ABIA STATE UNI	Investigate, drug, network, woman, hypothesis, pattern, information, association
30	ADEKUNLE AJASIN UNI	Model, management, water, temperature, law, property, magnetic
31	AKWA IBOM STATE UNI	Machine, efficiency, roughness, pattern, information, learn, recognition, network, security, cloud, multimedia, web, decision, optimize, probability, performance
32	AMBROSE ALLI UNI	Model, solar, radiation, programme, information, business, technology, insulation, electric
33	ANAMBRA STATE UNI	Performance, intervention, linguistic, optimal, technology, extract, correlation, predict, test
34	BAUCHI STATE UNI	Pseudo, algebraic, web based, model, cluster, network, information, government, awareness, security, resources, revenue
35	CRUTECH_CALABAR	Model, detection, intrusion, attack, algorithm, pattern, performance, analysis, mortality, pollution, noise, efficiency
36	DELSU	Specie, porosity, digital, information, web, training, internet, crime, medical, software, virus, government
37	EBONYI STATE UNI	Broadcast, packet, cluster, sensing, reliability, coding, performance, communication, transmission, risk, diagnosis, signal, information
38	EKITI STATE UNI	Model, network, voice, economic, growth, community, information, learn, problem, internet
39	ENUGU STATE UNI	Model, medical, expert, diagnostic, rule, voltage, controller
40	IBB UNI	social, technology, service, laser, colony, algorithm, resource, future, node
41	IMO STATE UNI	Analysis, learn, innovation, speed, technology, crude, oil, information, corrosion, performance, weather, model
42	KANO STATE UNI	Software, design, knowledge, language, sequence, algorithm, accuracy, classification, test, tank sensor, protocol, network
43	KEBBI STATE UNI	Semantic, web, retrieval, search, language, google, limitation, algorithm, optimization, swarm, velocity, temperature, equation
44	KOGI STATE UNI	Risk, sesame, bank, analysis, internet, genetic, weather, water, development, culture, global
45	KWARA STATE UNI	Joke, construct, contextual, winter, internet, network, performance, information, education, teacher, learn, satisfaction, computer
46	USMAN	Simulator, algorithm, network, broadcast, information, adopt, method
47	LASU	Knowledge, monetary, prediction, water, signal, model, algorithm, accurate, rainfall, design
48	LAUTECH	Network, security, bank, mobile, wireless, atm, packet, image, algorithm, antenna, signal, prediction, prototype, internet, learn, service, software, medical, technology, information, emotion
49	NASARAWA STATE UNI	Method, social, internet, network, education, science, culture, language, animation, electronic, security, information, design
50	OOU AGO IWOYE	Computer, security, network, accuracy, model, neural, sampling, learn, information, internet, genotype, model, cowpea
51	OSUN STATE UNI	Satisfaction, mine, electricity, attenuation, prediction, rainfall, accuracy, satellite, knowledge, coding, network, service, magnetic
52	RIVER STATE UNI	Model, reactor, corrosion, predict, control, business, bank, magnetic, velocity, component, performance, bank, technology
53	TASUED	Internet, devices, handheld, mathematics, image, size, detection, simulation, voting, workload, application, web, process
54	UMARU MUSA	Machine, route, learn, network, model, redundancy, intelligent, service, algorithm, Bayesian, decision
55	AFE BABALOLA	Machine, process, development, stochastic, mobile, devices, Nigeria, social, internet, science
56	AMERICAN_UN	Network, algorithm, energy, power, wireless, efficiency, mobile, cable, antenna, transmission, satellite, traffic, capacity, noisy, medical, trend, software, learn
57	BELLS	Security, intension, mobile, satisfaction, model, software, performance, gone, program, cluster, learn
58	BENSON IDAHOSA	Fuzzy, virus, Ebola, mortality, digitally, design, multiplex, loop
59	COVENANT UNIVERSITY	Network, problem, model, energy, algorithm, optimization, signal, software, requirement, learn, cloud, government, service, bank, web, quality, mobile, development, technology, service
60	IGBINEDION UNIVERSITY	Phone, mobile, deployment, service, Nigeria, statistical, analysis, fraudulent
61	LANDMARK UNIVERSITY	Signal model, bank, analyze, internet, phone, mobile, Nigeria, governance

et al. 2012; Ruhanen et al. 2015). Some of these researchers believe that rather than citation analysis, publication count is more sustainable for bibliometric analysis in

developing countries (Okafor 2011), and the more articles a university has in reputable journals, the more relevant the university will be globally. In addition, some research



(e.g. Goktas et al. 2012; Song and Suh 2018) also analyzed the content of research publications. In this study, we combined publication count for bibliometric and text mining techniques using the k-means clustering algorithm for publication content analysis. We investigated the publication trend in federal, state and private universities in Nigeria and also discovered their research foci in the field of Computer Science.

The publication count in Table 1 shows that the institution with the highest publication count in the Scopus database within the coverage period is Covenant University with a publication count of 399, of which 57 (14%) appear in *Lecture Notes in Computer Science* (including the subseries *Lecture Notes in Artificial Intelligence* and *Lecture Notes in Bioinformatics*) which is the institution's dominant outlet. This is followed by the University of Ibadan with 333, of which 72 (22%) appear in the *European Journal of Scientific Research* being its dominant publication outlet. Table 1 therefore answers the first (RQ1) and second (RQ2) research questions investigated.

The publication trend of federal, state and private universities over the coverage period, as revealed in Figures 3–5, shows a gradient increase as the years rolled by. It is also important to note that state and private universities did not have publications at all between 1973 and 1980. It is also of note that even though the establishment of private universities is more recent (year 2000 onwards), the quantity of their publication output in the Scopus database almost matches that of the state universities which were established nearly a decade before them. This implies that if the quality of tertiary education is determined by quality of academic research output, as observed by Guan and Ma (2004) and Okafor (2011), then the quality of tertiary education in Computer Science in Nigeria started to increase from the year 2000 with the establishment of private universities.

Table 2 answers the fourth research question (RQ4). From the output of the clustering algorithm presented in Table 2, the recurring words in most Nigerian universities unveiled the direction of the common interest of these universities in the Computer Science research field. The finding revealed that there are some areas of Computer Science that have been under-researched or not researched at all, such as deep learning, data science and so on. Table 2 also shows that networking is the most published area in Nigerian universities (work published by 22 universities). This suggests that there are authorities in this area in the identified universities. In the same vein, the recurrence of words such as *finance*, *medical*, *business*, *Nigeria* and *Africa* implies that a number of Nigerian computer scholars engage in application research which links Computer Science with other disciplines with Nigeria and Africa as case studies. This observation supports the current assertion by Azondekon et al. (2018) that there is a move towards interdisciplinary research.

### Conclusions and further study

This research was able to discover the research focus of institutions. This result will help to understand the academic strength of the institutions in question. It will also provide a guide to selecting relevant institutions to study

in Nigeria based on research interests which will consequently improve on the quality of academic products expected from such institutions. The report from this research will also help to promote a result-oriented industry and university partnership. Finally, the study provides a holistic view of the focus of Nigerian universities currently, thereby providing insight as to which area of research has been focused on or is under-researched. This will awaken new research interest applicable to the Nigerian or external context. In future work, we intend to introduce semantic analysis to the procedure of discovering research focus, so as to be able to discover more semantically relevant keywords. Also, we plan to explore other approaches to analyzing the research publications such as using social network analysis to discover collaboration patterns of the researchers.

### Note

1. <https://www.timeshighereducation.com/world-university-rankings>.

### Disclosure statement

No potential conflict of interest was reported by the author(s).

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