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Mapping the research productivity with its social impact of universities of west Bengal in the field of engineering and computer science

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Abstract
Research performance is one of the major concerns for all the higher education institutions. Research is one of the important among many factors for assessing the quality of an institute. Research reflects with the facilities provided by the institutes, such facilities like funding, journal and database accessibility, reward and recognition etc. The study aims to measure the research performance in the field of Engineering and Computer Sciences of six NAAC 'A' graded universities of West Bengal. The study also highlights the variance in terms of total research output of these universities. The study based on literature available in Scopus databases only. The study finds a huge variance among universities in terms of total publications in the subject fields taken for the study. Study also highlights the social impact of some top cited articles from these fields.

Keywords: Research performance, research difference, university research output, West Bengal, Scientometrics, dimensions, scopus, vosviewer

Introduction
Research has a long-term impact on society. Research of any field has a primary focus to develop or to sort out the issues related to the society. In this regard the research carried out from the higher education institutions has plenty of values. Research performance of any institutions largely depends on the infrastructure, facilities, funding for research provided or arranged by the institution. Infrastructure of the Universities in stream wise also varies, because some of the streams needed huge funding to build up the infrastructure. Considering these issues, the reflection on research performance also seen among the universities of West Bengal of higher graded. The research performance in the field of Engineering and Computer Science of the Universities of West Bengal has some variance in terms of total outputs based on the data retrieved from Scopus database.

As per the AISHE report 2019-2020 [1] there are 1043 universities in India, out of which 396 universities are managed privately. As per the report the total number of Universities from West Bengal is 47, out of which 1 Central university, 8 Institute of National Importance, 25 State Public University, 1 State Open University, 10 State Private University, 1 Deemed University Government and 1 Deemed University Private. Out of those 8 State Public Universities 6 are having NAAC 'A' grade as per the last visit in the respective universities. These are Jadavpur University, University of Calcutta, University of Burdwan, University of Kalyani, University of North Bengal and the Presidency University. All these universities cover almost all the streams, in some cases the variance of research output is huge. These due to many causes, such are some of the subjects are started late or lack of infrastructure due to funding, stream wise facilities of research, lack of growing interest among the researchers as well as faculties and so on.

Several past studies have been made to measure the research performance of higher education institutions. A study of Das and Bhattacharya, 2019 [11] listed 40 top institutions from India in terms of total documents published where top IITs, State Public Universities, Research Institutes and few State Private Higher institutions are present. Among the top ranked institutions two State Public University of West Bengal, *i.e.* Jadavpur University and University of Calcutta are well placed with their contribution during the study period. There are many studies has been completed to measure the performance of a particular institution,

such a study on University of Goa has revealed that the growth rate of publications was decreasing and to solve the decreasing rate the study suggests that they need more international funding for the increasing of growth rate of publications (Hugar, 2019) [17]. Another study has been done for measuring the research output of Six IITs of India where the data were screened from Scopus database during 2006-2015 and the study has based on the indicators like total publications, total citations, average citations, document types etc., and the study found that there was increasing trend of growth of literature among the IITs but the most of the scientific impact of these IITs associated with core subject areas of science (Pradhan & Ramesh 2018) [27].

Except these studies there are plenty of studies has been made nationally and internationally on Institutions Research Performance. Some of the studies has been done on national institutions like on Netaji Subhas Institute of Technology (Choudhary & Choudhary (2016) [10], Bid, S. (2016) [7] on of Indian Institute of Kharagpur, Pradhan, B. and Ramesh, D. B. (2017) [28] on Indian Institute of Technology Madras and Bombay, Nagarkar, S. and Kengar, M. (2017) [22] on Savitribai Phule Pune University etc. The literature base of most of these studies has been screened from Scopus database.

After screening the literature, we observed that no such studies are present there on universities of West Bengal to show the comparison of research contribution on any particular subject field. To bridge this gap this study has been made to show the comparison of research contribution during a study period among universities having same kind of gradation. This study uses some basic indicators of Scientometrics analysis which are basically measures the quantitative aspects of research performance to help the universities to identify how far they are situated compared to the high producing institutions from the same state. Thus, this research aims to achieve the following:

- To know the differences in number of published literatures in the subject fields taken for the study
- To know the trend of growth of published literature
- To know the best communication channels preferred by the universities in the field of engineering, chemical engineering and computer science
- To know the citation pattern and social impact of highly cited research
- To know the country wise co-authorship map of research
- To know the bibliographic coupling of sources of published literature

Methodology of the study

Data Collection: Among all the universities six NAAC 'A' graded universities of West Bengal were taken for the comparison of subject wise research output. Elsevier's largest abstract and citation database Scopus is considered for literature of the study. The time span of the study is from 2001 to 2021. The social impact data (i.e., Altmetrics Attention Score) of top cited documents in the field of engineering and computer science were collected from dimension.ai.

Indicators used: General indicators of Scientometrics analysis has been used as per the objectives of the study, such as, Year-wise publication distribution, Channels of Communication, Citations Pattern, Country wise co-authorship network, Bibliographic coupling of sources, social impact of highly cited articles etc.

Tools used: Microsoft Excel and VOS viewer visualizing tool has been used for data presentation and analysis and network visualization.

Inclusion/Exclusion factors

Inclusion factors-i: Only NAAC 'A' graded universities from West Bengal are considered for the study, ii. Scopus database considered for retrieving the published literature, iii. Research output in the field of Engineering, Computer Science and Chemical Engineering taken for the study. iv. Time span considered is between 2001 to 2021, v. Only Journal Articles have been Included

Exclusion factors-i: Except 'A' graded universities from West Bengal all other universities excluded in the study, ii. All other databases, iii. All other time periods, iv. All other document types

Data Analysis and Findings

Table 1: Descriptive overview of the dataset of research publications of Universities of West Bengal

Description	Criteria	Results
	Time Period	2001-2021
	Sources of Literature	Elsevier's Scopus
Documents		**No. of Total Documents**
	Jadavpur University	9307
	University of Calcutta	3813
	University of Burdwan	1239
	University of Kalyani	1142
	University of North Bengal	383
	Presidency University	256
Citations		**Average citations/documents**
	Jadavpur University	17.76
	University of Calcutta	13.61
	University of Burdwan	14.89
	University of Kalyani	15.13
	University of North Bengal	10.90
	Presidency University	16.70
Sources of Communication	Engineering	International Journal of Advanced Manufacturing Technology, IEEE Sensors Journal, Multimedia Tools and Applications
	Computer Science	Applied Soft Computing Journal, Microsystem Technologies, IETE Journal of Research

Collaboration	Most Collaboration with Countries (using VOS viewer Tool)	
	Engineering	United States, Germany, United Kingdom, Italy, Japan, Canada
	Computer Science	

Research Productivity

There are many reasons for the differences in terms of total research output from one university to another in a particular subject field. Some of these factors are, lack of arrangement of funding for research, research facilities, infrastructure, student's enrollment to the doctoral stages etc. Research in subject fields, like engineering, computer science largely depends on equipments and infrastructure of IT based communications, database accessibility for the literature of the field and many others things. The general public universities of West Bengal have lots of research contribution during the time of the study. But these institutions have a large variance in terms of research contribution in the field of Engineering, Chemical Engineering and Computer Science.

Table 1: University and Subject field wise Research Contribution

Subject Field		Engineering	Computer Science	Chemical Engineering	Total	%
Name of the Universities	Jadavpur University	5127	2167	2013	9307	57.664
	University of Calcutta	1954	720	1139	3813	23.625
	University of Burdwan	725	196	318	1239	7.677
	University of Kalyani	392	312	438	1142	7.075
	University of North Bengal	91	46	246	383	2.373
	Presidency University	134	31	91	256	1.586
	Total	8423	3891	3826	16140	100

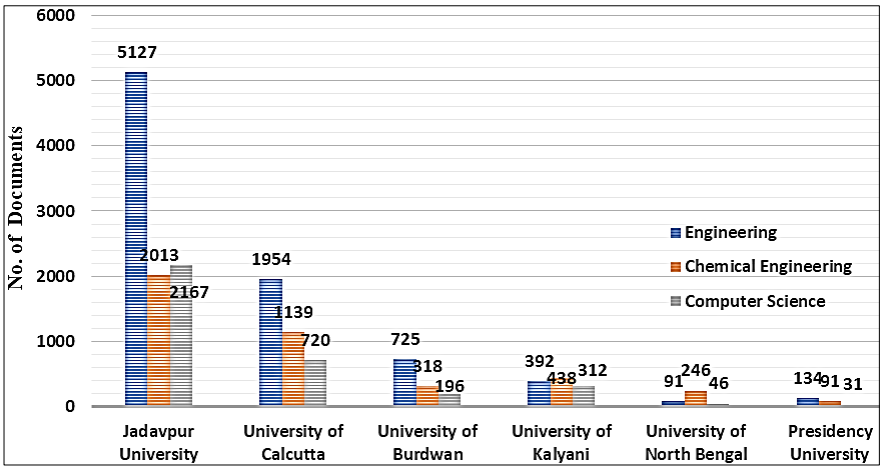

Fig 1: Research Performance: Stream-wise Document comparison

Growth of Literature

Jadavpur University is one of the leading universities in India producing best professionals in the field of Engineering and Computer Science, and this because of the facilities and teaching qualities they have. The research contribution of this institute is also the highest among all other Universities of West Bengal. Jadavpur University produced 5127 research papers in the field of Engineering during 2001 to 2021, and 2167 is from Computer Science and 2013 papers from Chemical Engineering. Followed by University of Calcutta with 1954 papers in Engineering, 720 papers in Computer Science and 1139 papers in Chemical Engineering. Other four universities produced less than 20% of the total shares, whereas Jadavpur University shares more than half, i. e. 57.66% in the fields taken for the study and University of Calcutta produced 23.63% of the total shares.

Table 2: Year-wise growth of literature in the field of Engineering, Computer Science and Chemical Engineering.

	JU			CU			BU		
Subject Field →	**Eng.**	**Chem. Eng.**	**Comp. Sc.**	**Eng.**	**Chem. Eng.**	**Comp. Sc.**	**Eng.**	**Chem. Eng.**	**Comp. Sc.**
2001-2003	166	82	51	74	31	13	20	6	4
2004-2006	309	151	114	102	67	23	39	7	13
2007-2009	558	171	244	175	96	48	68	14	19
2010-2012	760	239	294	267	134	71	112	49	13
2013-2015	983	415	402	349	278	114	149	87	24
2016-2018	1089	495	395	420	289	172	125	82	30
2019-2021	1262	460	667	567	244	279	212	73	93
Total	5127	2013	2167	1954	1139	720	725	318	196
Grand Total	9307			3813			1239		
	KU			NBU			PU		
Subject Field	Eng.	Chem. Eng.	Comp. Sc.	Eng.	Chem. Eng.	Comp. Sc.	Eng.	Chem. Eng.	Comp. Sc.
2001-2003	11	15	8	1	2	2	9	2	0

2004-2006	17	24	6	1	11	5	14	3	1
2007-2009	24	38	15	2	25	5	11	8	1
2010-2012	29	57	14	7	40	3	17	17	3
2013-2015	81	111	55	8	83	4	19	20	4
2016-2018	94	88	96	17	49	6	16	19	4
2019-2021	136	105	118	55	36	21	48	22	18
Total	392	438	312	91	246	46	134	91	31
Grand Total	1142			383			256		

Table 2 describes year-wise growth of literature in the field of Engineering, Chemical Engineering and Computer Science of six top public university from the state West Bengal. A total of 16,140 research publications were identified during 2001 to 2021. The total study period covers 21 years starting from 2001, and the it is divided into seven block of three years each. The above table shows the year-wise and subject wise counting of taken subject fields of each university separately. Highest number of contributions noted for Jadavpur University with 9307 publications, followed by University of Calcutta and University of Burdwan with 3813 and 1239 publications respectively.

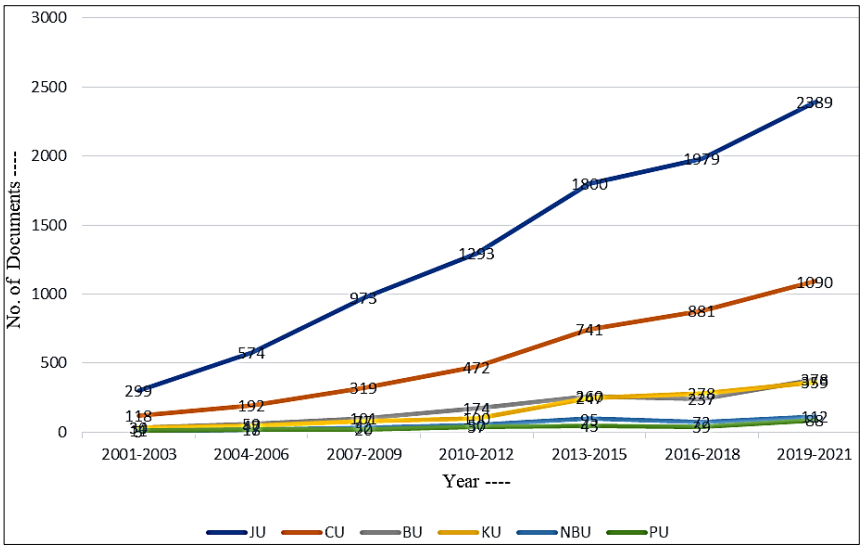

Fig 2: Year-wise trend of growth of literature

A huge variance among the universities has been noted of the trend of literature growth (figure 2) in the subject fields taken for the study. In the starting period, i.e., during the year 2001-2003 all the universities started below 300 research paper in the three years, but all the universities have not produced similar kind of numbers with the times goes on. All the universities have a positive trend but for Presidency University and University of North Bengal the trend line is quite even with due respect to other four universities. University of Burdwan and University of Kalyani performed little better but still they have not crossed 400 publications in any of the blocks of a three years. University of Calcutta performed well than the mentioned four universities and this university produced more than 1000 paper in the last block, i.e., during the 2019-2021. In the field of Engineering, Computer Science and Chemical Engineering among the six state universities of West Bengal Jadavpur University produced more than half of the research papers and the have maintained a very positive trend comparing to other universities. Jadavpur University started with 299 papers in the year 2001-2003 and ended with 2389 papers in 2019 to 2021. The trend of the literature growth suggests that Jadavpur University and University of Calcutta has the main producing universities of research papers in the field of Engineering and Computer Science. It also proves, though all the six universities have the NAAC 'A' gradation, but these two universities have the best facilities for the research in the respective fields.

Citation Analysis with Social Impact

Table 3: Citation Counts

Jadavpur University			**University of Calcutta**			**University of Burdwan**		
Total publications	**Total Citations Received**	**Average Citations/ Paper**	**Total publications**	**Total Citations Received**	**Average Citations/ Paper**	**Total publications**	**Total Citations Received**	**Average Citations/ Paper**
9307	165327	17.76	3813	51902	13.61	1239	18450	14.89
University of Kalyani			**University of North Bengal**			**Presidency University**		
Total publications	**Total Citations Received**	**Average Citations/ Paper**	**Total publications**	**Total Citations Received**	**Average Citations/ Paper**	**Total publications**	**Total Citations Received**	**Average Citations/ Paper**
1142	17275	15.13	383	4176	10.90	256	4274	16.70

Citation count is one of the main aspects of measuring the research performance of an institution. Among the six universities of West Bengal, the papers published from Jadavpur University has received the greatest number of citations (165327), at an average of 17.76 citations per paper for 9307 papers, followed by University of Calcutta with a total of 51902 citations at an average of 13.61 per paper. In terms of average citations Presidency University performed well with an average citation of 16.70 per paper after the Jadavpur University, though they only mange to publish 256 papers during the study period. The lowest average citations per paper noted for University of North Bengal, i.e., 10.90 per paper for the total of 383 papers published during 2001 to 2021.

Table 4: Top cited articles with its Alt metrics Attention Score

Sl. No.	Author	DOI	Affiliated University	Citations	AAS*
Engineering					
1	Perkins *et al*. (2001) [26]	10.1109/98.904895	Jadavpur University	710	3
2	Das, Abraham and Konar (2008) [13]	10.1109/TSMCA.2007.909595	Jadavpur University	582	-
3	Bhattacharya (2008) [5]	10.1016/j.cej.2007.05.021	University of Calcutta	546	-
4	Islam *et al*. (2012) [18]	10.1109/TSMCB.2011.2167966	Jadavpur University	482	1
5	Bhattacharya and Chattopadhyay (2010) [11]	10.1109/TPWRS.2009.2034525	Jadavpur University	382	-
6	Bhattacharya, Mandal and Das (2006) [4]	10.1016/j.cej.2006.06.012	University of Calcutta	369	-
7	Patra *et al*. (2007) [25]	10.1016/j.nano.2007.03.005	University of Calcutta	351	3
8	Chatterjee, Chakraborty and Basu (2014) [8]	10.1088/0957-4484/25/13/135101	University of Kalyani	346	3
9	Banerjee *et al*. (2014) [6]	10.1186/s40643-014-0003-y	University of Calcutta	330	9
10	Shanmugasundaram *et al*. (2001) [32]	10.1016/S0142-9612(00)00220-9	Jadavpur University	321	6
Total Score				4419	25
Chemical Engineering					
1	Malik (2003) [21]	10.1016/S0143-7208(02)00159-6	Jadavpur University	803	1
2	Bhattacharya *et al*. (2008)	10.1016/j.cej.2007.05.021	University of Calcutta	546	-
3	Malik and Saha (2003) [21]	10.1016/S1383-5866(02)00200-9	Jadavpur University	457	-
4	Ojha *et al*. (2011) [24]	10.1016/j.chemolab.2011.03.011	Jadavpur University	425	6
5	Roy *et al*. (2016) [29]	10.1016/j.chemolab.2016.01.008	Jadavpur University	385	6
6	Naiya, Bhattacharya and Das (2009) [23]	10.1016/j.jcis.2009.01.003	University of Calcutta	376	-
7	Bhattacharya, Mandal and Das (2006) [4]	10.1016/j.cej.2006.06.012	University of Calcutta	369	-
8	Patra *et al*. (2007) [25]	10.1016/j.nano.2007.03.005	University of Calcutta	351	3
9	Roy and Kar (2015) [31]	10.1016/j.chemolab.2015.04.013	Jadavpur University	347	6
10	Chatterjee, Chakraborty and Basu (2014) [8]	10.1088/0957-4484/25/13/135101	University of Kalyani	346	3
Total Score				4405	25
Computer Science					
1	Das and Suganthan (2011) [12]	10.1109/TEVC.2010.2059031	Jadavpur University	3388	9
2	Sinha, Chakrabarti and Chattopadhyay (2003) [33]	10.1109/TEVC.2002.806788	Jadavpur University	992	-
3	Das *et al*. (2009) [23]	10.1109/TEVC.2008.2009457	Jadavpur University	968	3
4	Roy and Roy (2008) [30]	10.1002/qsar.200710043	Jadavpur University	620	4
5	Bandyopadhyay *et al*. (2008) [2]	10.1109/TEVC.2007.900837	Jadavpur University	589	3
6	Das, Abraham and Konar (2008) [13]	10.1109/TSMCA.2007.909595	Jadavpur University	582	3
7	Chatterjee and Siarry (2006)	10.1016/j.cor.2004.08.012	Jadavpur University	554	-
8	Islam, S. M. *et al*. (2012) [18]	10.1109/TSMCB.2011.2167966	Jadavpur University	482	1
9	Ojha *et al*. (2011) [24]	10.1016/j.chemolab.2011.03.011	Jadavpur University	425	6
10	Roy *et al*. (2016) [29]	10.1016/j.chemolab.2016.01.008	Jadavpur University	385	6
Total Score				8985	35

*AAS – Altmetrics Attention Score from dimension.ai

Table 4 describes the most cited papers with their social impact from the three subject fields taken for the study. From each of the subject field 10 most cited papers has been identified with their Author and DOI and respective university name. In Engineering out of ten most cited papers 5 from Jadavpur University, 4 from University of Calcutta and 1 from University of Kalyani. Chemical Engineering also comes under the Engineering so the distribution is almost same with the Engineering. In case of Computer Science all ten top cited papers comes from Jadavpur University. Top ten papers from Engineering got 4419 citations together whereas top ten of Computer Science got 8985 citations which is double in case of engineering.

Social impact of these top cited papers also measured by the Altmetrics Attention Score from dimension.ai. The result shows for top ten papers of engineering have received 25 Altmetrics Attention Score at an average of 2.5, it means that a paper has been shared on social media 2.5 times averagely, whereas Computer Science papers have received 35 Altmetrics Attention Score, that means a paper has shared 3.5 times averagely in Twitter, Facebook etc.

Channels of Communication

Table 5: Most preferred channels of communication

Journal Title & No. of Papers Published	
Jadavpur University	
Engineering	1. International Journal of Advanced Manufacturing Technology – 96 2. IEEE Sensors Journal - 72 3. Multimedia Tools and Applications - 66
Chemical Engineering	1. Rsc Advances - 219 2. New Journal of Chemistry - 155 3. Colloids and Surfaces a Physicochemical and Engineering Aspects - 60
Computer Science	1. International Journal of Advanced Manufacturing Technology - 96 2. Multimedia Tools and Applications - 66 3. Applied Soft Computing Journal - 61
University of Calcutta	
Engineering	1. Optik - 72 2. Optical Engineering - 48 3. Superlattices and Microstructures – 38
Chemical Engineering	1. Rsc Advances - 190 2. New Journal of Chemistry – 77 3. Journal of Photochemistry and Photobiology A Chemistry - 38
Computer Science	1. Microsystem Technologies - 29 2. IETE Journal of Research - 22 3. Quantum Information Processing - 19
University of Burdwan	
Engineering	1. Optik - 42 2. Journal of Alloys and Compounds - 41 3. Materials Research Bulletin - 22
Chemical Engineering	1. Rsc Advances - 49 2. New Journal of Chemistry - 26 3. Tenside Surfactants Detergents - 25
Computer Science	1. RAIRO Operations Research - 12 2. Soft Computing - 10 3. Computers and Industrial Engineering - 08
University of Kalyani	
Engineering	1. Microwave and Optical Technology Letters - 34 2. Physica B Condensed Matter -14 3. Journal of Electromagnetic Waves and Applications - 11
Chemical Engineering	1. Rsc Advances - 62 2. Synthesis - 52 3. New Journal of Chemistry - 50
Computer Science	1. International Journal of Grid and Distributed Computing - 20 2. Wireless Personal Communications - 9 3. Advances in Modelling and Analysis - 8
University of North Bengal	
Engineering	1. European Physical Journal - 12 2. Waves in Random and Complex Media - 9 3. Mechanics Based Design of Structures and Machines 5
Chemical Engineering	1. Rsc Advances - 39 2. Journal of Chemical and Engineering Data - 36 3. Petroleum Science and Technology - 21
Computer Science	1. Advances in Modelling and Analysis - 6 2. Modelling Measurement and Control - 5 3. Spatial Information Research - 4
Presidency University	
Engineering	1. European Physical Journal - 13 2. Chemical Engineering Journal - 9 3. Journal of Nanoscience and Nanotechnology - 6
Chemical Engineering	1. Rsc Advances - 11 2. Chemical Engineering Journal - 9 3. Journal of Chemical and Engineering Data - 7
Computer Science	1. Games and Culture - 3 2. International Journal of Modern Physics - 2 3. Symmetry - 2

In table 5 most preferred communication sources producing the greatest number of papers from each of the subject fields of a particular University has been identified. In Engineering and Chemical Engineering, the significant journals are International Journal of Advanced Manufacturing Technology, Rsc Advances, Optik, Multimedia Tools and Applications, Optical Engineering, Microwave and Optical Technology Letters, European

Physical Journal are the most preferred journals for communication. In computer Science the preferred communication channels are International Journal of Advanced Manufacturing Technology, Multimedia Tools and Applications, Applied Soft Computing Journal, Microsystem Technologies, IETE Journal of Research etc.

Co-authorship Network: Country-Wise

In order to discover new knowledge and specialization, researchers are determined to collaborate with other experts, co-authorship network analysis represents the authors willing to co-operate with other members in the network" (Khandelwal, 2021) [19]. According to E Fonseca *et al*., 2016, collaboration increases the scope of research and encourages the innovation. Here in figure 3 and figure 4 the co-authorship network of subject field Engineering and Computer Science has been drawn by the analysis of VOS viewer visualization tool.

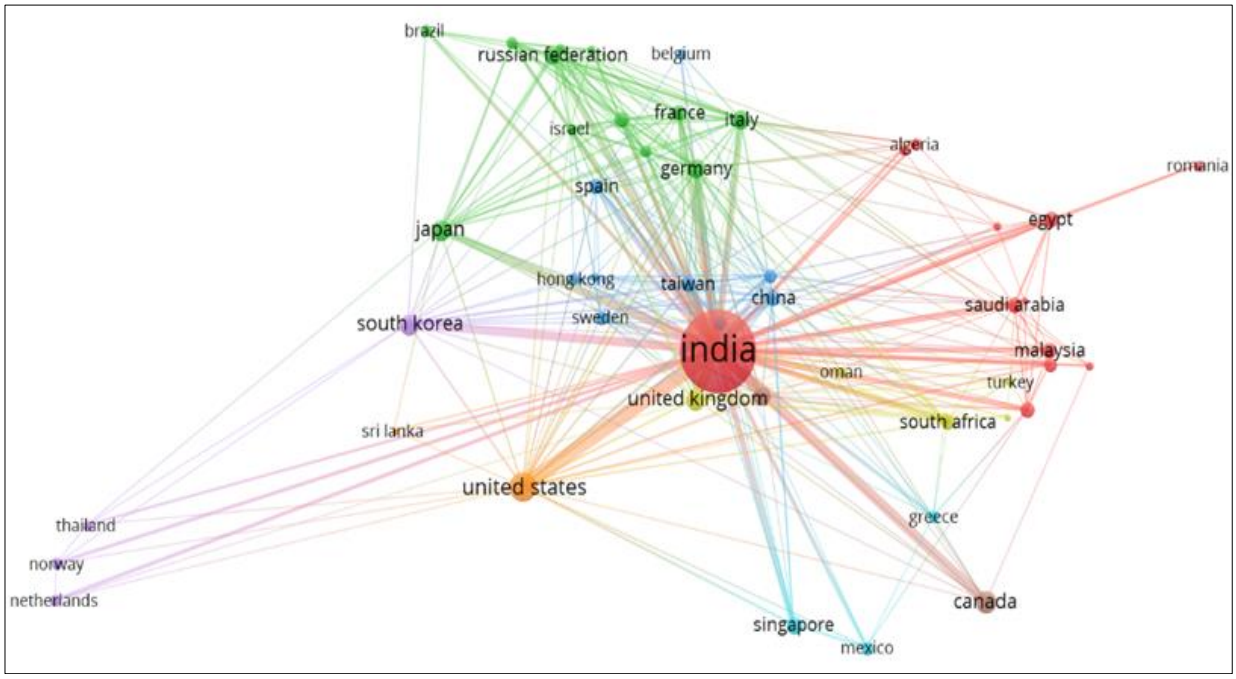

Fig 3: Co-authorship based on Country-wise link strength, engineering field

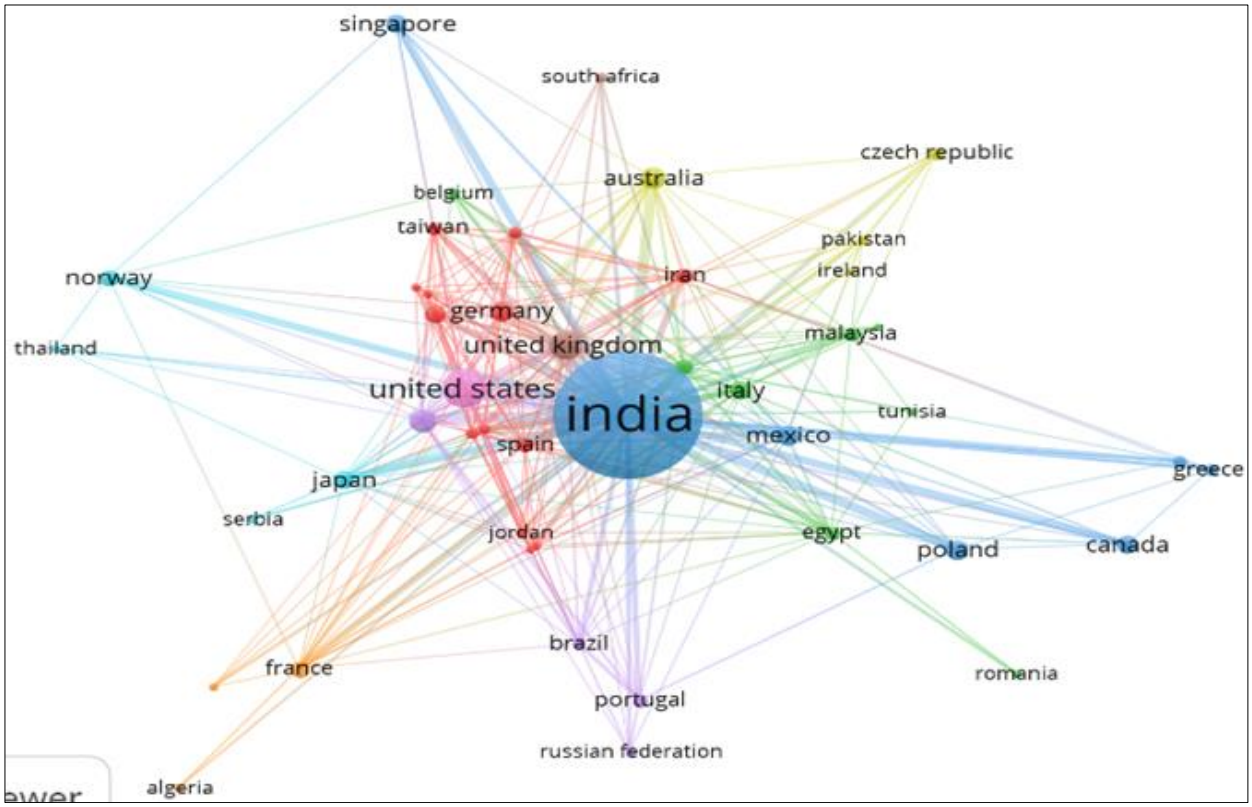

Fig 4: Co-authorship based on Country-wise link strength, Computer Science field

Co-authorship network based on countries identifies those countries which are with high link strength in terms of association or in collaboration with the documents also affiliated by an author from the institutions of the study. To identify the countries with the high rate of collaboration with the Universities of West Bengal, the basic criterion set in tool is minimum number of documents of a country selected as 2 and minimum citation received by a country is also chosen as 2. Based on this basic criterion total number of countries identified by the tool is 111 and out that 58 meet the threshold in the field of Engineering and out of 123 country 55 meet the threshold in Computer Science field. In Figure 3 and 4 the country wise co-authorship network analysis has been shown in which association of authors from other countries and authors from India in engineering and computer science field is presented. In these two subject fields the countries produced more authors in collaboration to India are of United States, United Kingdom, South Korea, Italy, Japan, Canada Australia, Germany etc.

Top 5 clusters from both the subject areas are identified and these clusters are based on the highest link strength among the collaborative countries. Cluster 1 in both the field consists of 13 countries and cluster 2 is of 12 countries and 8 countries respectively in engineering and computer science (Table 6 and 7).

Bibliographic Coupling of Sources

Bibliographic coupling occurs when two papers cited by a common third paper in their bibliographies. It means those two papers are of from the same subject field and it also denotes that those two papers are bibliographically coupled if they both cite one or more documents in common. This widely used method performs automatic clustering for big data sets and identifies cases in which two documents cite the same third work in their bibliographies (Hassan, M. K. *et al*., 2021) [16].

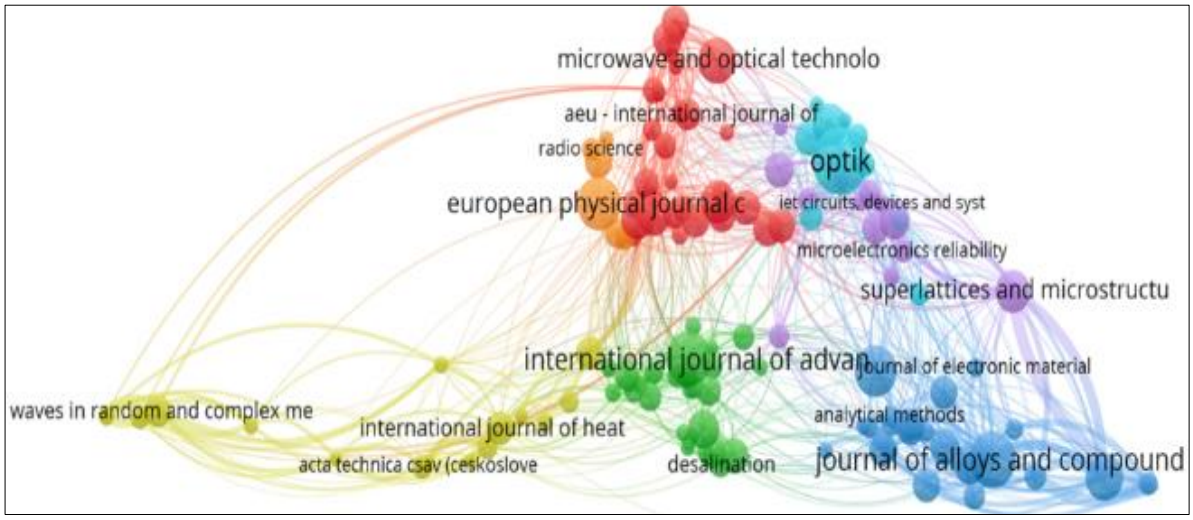

Fig 5: Bibliographic Coupling of Sources, Engineering

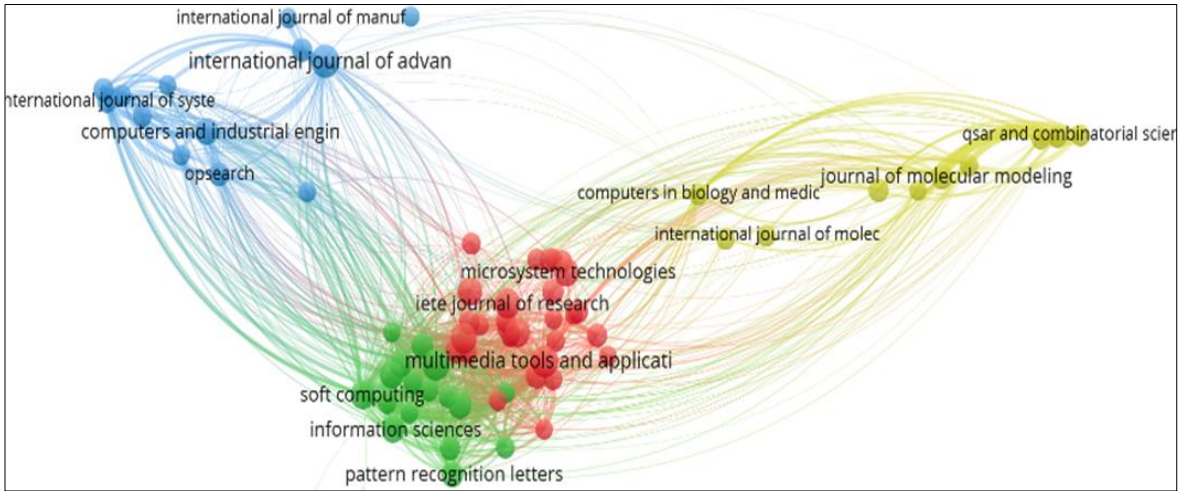

Fig 6: Bibliographic Coupling of Sources, Computer Science

VOS viewer analyzing tool has been considered to identify the sources which has the most link strength regarding bibliographical coupling. To do the bibliographic coupling analysis of sources criteria's set in VOS viewer tool as minimum documents of a source is 10 and minimum citation received by a source is 10, with this basic configuration in Engineering, out of total 854 sources, 129 meet the threshold and in Computer Science out of 625 sources 72 meet the threshold. Table 8 and Table 9 shows the clusters of most linked journals in engineering and in computer science field. Top three clusters from both the field have been identified, in Engineering cluster-1 has 30 sources, cluster-2 has 29 and cluster-3 has 23 sources and in Computer Science cluster-1 consists 30 sources, cluster-2

consists 18 sources and cluster-3 consist by 13 sources. Some of the important sources with high link strength as bibliographically coupled in the articles in Engineering field (Figure 5) are Advances in Intelligent Systems and Computing, AEU - International Journal of Electronics and Communications, and Electric Power Components and Systems etc. On the other hand, in Computer Science field (Figure 6) - Advanced Science Letters, Biomedical Signal Processing and Control, BMC Bioinformatics, Computer Methods and Programs in Biomedicine, Computers and Electrical Engineering are the most linked sources in terms of bibliographic coupling fetched by the network analysis tool VOS viewer.

Findings

A) Finding 1: The variance of producing research papers among the six universities in the field of engineering, computer science and chemical engineering is noticed (table 1), where over 80% of research papers contributed by two University, i. e. Jadavpur University (57.66%) and University of Calcutta (23.63%). The rest of the four universities produced only 20% research papers of the total shares.

B) Finding 2: A high positive trend throughout the study year has been noticed for Jadavpur University and University of Calcutta and during the period from 2010 to 2015 the growth of trend was on the peak. Other four universities have also grown with a positive trend, but for Presidency University and University of North Bengal the trend line is quite even with due respect to other universities (figure 2)

C) Finding 3: Highest number of citations received by Jadavpur University at an average of 17.76 citations per paper and the lowest average noticed for University of North Bengal, i.e., only 10.90 citations per paper (table 3). In respect to average citations Presidency University and University of North Bengal performed well.

D) Finding 4: Social impact of highly cited papers has been measured with the Altmetrics Score measured by dimension.ai. In the field of engineering or in chemical engineering the total attention score counted for top ten cited paper is 25, that means a single paper received 2.5 Altmetrics Attention Score averagely, whereas top ten cited papers of computer science received 35 Attention Score at an average of 3.5 for each paper (table 4).

E) Finding 5: International Journal of Advanced Manufacturing Technology, Rsc Advances, Optik, Multimedia Tools and Applications are the preferred communication channels in engineering and in the field of computer science, the preferred channels are same in some cases as of engineering fields, such are International Journal of Advanced Manufacturing Technology, Multimedia Tools and Applications, Applied Soft Computing Journal, Microsystem Technologies, IETE Journal of Research.

F) Finding 6: United States, United Kingdom, South Korea, Italy, Japan, Canada Australia, Germany are the most collaborative countries in respect to co-authorship in the field of Engineering and Computer Science research of universities of West Bengal (Figure 3 & 4).

G) Finding 7: Advances in Intelligent Systems and Computing, AEU - International Journal of Electronics and Communications, Electric Power Components and Systems in Engineering (Figure 5), Advanced Science Letters, Biomedical Signal Processing and Control, BMC Bioinformatics Computer Science (Figure 6) are the most linked sources in terms of bibliographic coupling in the concerned field respectively.

Conclusion

Research performance is the outcome of overall performance of an institution academically as well as administratively. Research is associated with all the facilities, all the infrastructures provided to the researchers of an institution. In the field of engineering and computer science, the performance of Jadavpur University and University of Calcutta in terms of total publication and received citation is better compared to other four universities. With the analysis and findings of the study it could be concluded that Jadavpur University and University of Calcutta are far better performer than the other universities of West Bengal, though all are of same kind of gradation by the NAAC.

Future research direction

With the objectives of this study and by adding few more indicators with it, this research could be stepped ahead to measure the research performance of all the universities in respect to all other subject fields together to highlight the overall scenario of research performance of Universities of West Bengal.

Appendix

Table 6: Co-authorship network of Countries in Engineering

Cluster 1: (13 Countries)	Cluster 2: (12 Countries)	Cluster 3: (9 Countries)	Cluster 4: (6 Countries)	Cluster 4: (4 Countries)
• Algeria	• Brazil	• Austria	• Chili	• Netherlands
• Bangladesh	• Czech Republic	• Belgium	• North Macedonia	• Norway
• Egypt	• Finland	• China	• Oman	• South Korea
• India	• France	• Hong Kong	• South Africa	• Thailand
• Iraq	• Germany	• Iran	• Turkey	
• Malaysia	• Israel	• Spain	• United Kingdom	
• Morocco	• Italy	• Sweden		
• Nepal	• Japan	• Taiwan		
• Pakistan	• Poland	• Vietnam		
• Romania	• Portugal			
• Saudi Arabia	• Russian Federation			
• United Arab	• Switzerland			
• Emirates				

Table 7: Co-authorship network of Countries in Computer Science

Cluster 1: (13 Countries)	Cluster 2: (8 Countries)	Cluster 3: (7 Countries)	Cluster 4: (4 Countries)	Cluster 5: (4 Countries)
• Austria • China • Denmark • Germany • Hong Kong • Iran • Israel • Jordan • New Zealand • Spain • Sweden • Taiwan • Vietnam	• Belgium • Cyprus • Egypt • Italy • Malaysia • Romania • Saudi Arabia • Tunisia	• Bangladesh • Canada • Greece • India • Mexico • Poland • Singapore	• Australia • Czech Republic • Ireland • Pakistan	• Brazil • Portugal • Russian Federation • South Korea

Table 8: Bibliographic Coupling of Sources in Engineering

Cluster 1: (30 Sources)	Cluster 2: (29 Sources)	Cluster 3: (23 Sources)
• Advances in intelligent systems and computing • Aeu - international journal of electronics and communications • Electric power components and systems • Electric power systems research • Electronics letters • Engineering applications of artificial intelligence • Expert systems with applications • Ieee access • Ieee antennas and propagation magazine • Ieee sensors journal • Ieee transactions on antennas and propagation • Ieee antennas and wireless propagation letters • Ieee transactions on dielectrics and electrical insulation • Ieee transactions on instrumentation and measurement • Iet microwaves, antennas and propagation • Iet science, measurement and technology • Information sciences • International journal of electrical power and energy systems • International journal of rf and microwave computer aided engineering • Isa transactions • Journal of electromagnetic waves and applications • Measurement: journal of the international measurement confederation • Medical and biological engineering and computing • Microsystem technologies • Microwave and optical technology letters • Multimedia tools and applications • National academy science letters • Progress in electromagnetics research • Progress in electromagnetics research b • Wireless personal communications	• Allied energy • Biochemical engineering journal • Chemical engineering and processing: process intensification • Chemical engineering journal • Chemical engineering science • Computers and industrial engineering • Desalination • Desalination and water treatment • Indian journal of engineering and materials sciences • Industrial and engineering chemistry research • International journal of advanced manufacturing technology • International journal of applied engineering research • International journal of industrial engineering computations • International journal of management science and engineering management • International journal of production economics • International journal of production research • International journal of systems science • Journal of cleaner production • Journal of manufacturing systems • Journal of materials processing technology • Journal of reinforced plastics and composites • Journal of the institution of engineers (india): series e • Journal of the textile institute • Materials and design • Materials and manufacturing processes • Proceedings of the institution of mechanical engineers • Process safety and environmental protection • Applied sciences • Transactions of the institute of indian geographers	• Acs applied bio materials • Advanced science letters • Analytical methods • Bulletin of materials science • Digest journal of nanomaterials and biostructures • Ionics • Journal of alloys and compounds • Journal of computational and theoretical nanoscience • Journal of electronic materials • Journal of materials science • Journal of materials science: materials in electronics • Journal of nanoscience and nanotechnology • Materials letters • Materials research bulletin • Materials science and engineering a • Materials science and engineering b: solid-state materials for advanced technology • Materials science and engineering c • Nano energy • Nanomedicine: nanotechnology, biology and medicine • Nanotechnology • Physical B: condensed matter • Sensors and actuators, b: chemical • Synthetic metals

Table 9: Bibliographic Coupling of Sources in Computer Science

Cluster 1: (30 Sources)	Cluster 2: (18 Sources)	Cluster 3: (13 Sources)
• Advanced science letters	• Advances in modelling and	• Computers and industrial engineering

• Advances in intelligent systems and computing • Biomedical signal processing and control • Bmc bioinformatics • Computer methods and programs in biomedicine • Computers and electrical engineering • Engineering science and technology, an international journal • Expert systems • Expert systems with applications • Ieee access • Ieee systems journal • Iete journal of research • Innovations in systems and software engineering • International journal of communication systems • International journal of grid and distributed computing • International journal of modern physics c • International journal of pattern recognition and artificial intelligence • International journal of rf and microwave computer-aided engineering • Journal of ambient intelligence and humanized computing • Journal of information security and applications • Journal of supercomputing • Journal of the institution of engineers (india): series b • Lecture notes in computer science • Medical and biological engineering and computing • Microsystem technologies • Multimedia tools and applications • Nonlinear optics quantum optics • Optical materials • Quantum information processing • Wireless personal communications	analysis b • Applied soft computing journal • Engineering applications and artificial intelligence • Fundamenta informeticae • Fuzzy sets and systems • Information sciences • Isa transactions • Journal of intelligent and fuzzy systems • Journal of intelligent systems • Knowledge-based systems • Neural computing and applications • Pattern recognition • Pattern recognition letters • Signal, image and video processing • Soft computing • Spatial information research • Studies in computational intelligence • Swarm and evolutionary computation	• Computers and mathematics with applications • European journal of operational research • International journal of advanced manufacturing technology • International journal of manufacturing technology and management • International journal of numerical methods for heat and fluid flow • International journal of systems science • International journal of systems science: operations and logistics • Journal of manufacturing systems • Journal of materials processing • Operational research • Opsearch

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