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Research Performance of Engineering Colleges in Karnataka as reflected in the Scopus Database

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Abstract

This paper intends to assess the growth of research publications and citations of engineering colleges affiliated to Visvesvaraya Technological University (VTU), Belagavi based on Scopus database. It is attempted to analyze parameters like the growth of research output among rural and city colleges i.e. geographical distribution of publications, pattern of research communication, share of national and international collaboration across Karnataka and high productivity institutions and top highly published journals and cited papers.

Key words: Research metrics, Citation analysis, Scopus database

1. Introduction

This study aims to provide a comprehensive picture of research activities carried out and published by engineering colleges of Karnataka. Systematic documentation and communication of scientific research results through publications is a complex task.

Analyzing research data helps to take strategic decisions regarding which areas of research need support. It helps the Head of the Institution/University to understand the institution's position relative to global or national standards of research production to measure how much research has been conducted? What is the impact? Numbers of articles published in journals having high impact factor by its faculty members; whether the number of research output production is increasing or decreasing; Citation value and h-index of an Author etc. Evaluation of research performance can be done by quantitative analysis using methods of counting, measuring, comparing quantities, analyzing measurements; While articles published by the journals with high impact journals based on citation, it refers to the quality of a particular Author and Calculation of H-index brings out qualitative analysis also.

Universities, government offices, experts must be acquainted with the knowledge regarding what type of research should be supported and which research project should receive more support than others.

1.1 History of Research Culture

In western countries, Government, Public and Private Universities will get research funding from the government agencies and foundations adhere to the condition that they should provide evidence of their accomplishments and capacities. As a part of national or professional accountability protocols, all types of institutions whether it may be Public/Private or Government must account for their performance in many countries. In addition, all the institutions should have an evidence-based understanding of the institution's performance reaching towards its goal and mission. This status can be achieved and maintained through continuous evaluation of the institution's functions. As research is a central function of any institution, it should evaluate its performance regularly.

1.2 Review of Literature

Measuring the growth level of research at individual level could not possible especially for the developing countries (Gupta et al., 2002). Gupta and Dhawan (2006) provided both quantitative and qualitative analysis of developments in Indian Science & Technology as seen in its research output in the form of national and international journal publications. The authors also mentions the status of Science & Technology in the country at that time. Sangam (2000) conducted a study on the nature and type of collaborative research in India that has been reflected in Psyclit CD-ROM database of 1974-1998.

Bibliometric analysis can be made to check the performance of the scientific production to know whether the articles published in peer-reviewed journals or not. Author opines that 'Though a Bibliometric study has been applied to explain general productivity in a given field, it can also be used to assess the productivity of individual researcher, journal, country, state or any other levels of performance' (Andres, 2009). The basic knowledge underlying such applications is the measures that can be considered by quality and impact of scientific paper. (Aksnes, 2006). Hence, Bibliometric indicators contribute a lot in the context of evaluation of research and formulation of science policy in a larger way. (Davarpanah and Amel, 2009).

Technical publications are the real embodiment of intellectual discoveries defined explicitly which aim to communicate new ideas or information for further advancement in knowledge (Sharma, 2009). Over the time, generally India and particularly Karnataka state have invested heavily in improving infrastructure for R & D activities in almost all the disciplines (Gupta and Dhawan, 2006). According to the international indexing databases like Web of Science, Scopus, overall publication growth rate of Karnataka seems relatively high in recent years.

A number of scientometric studies have been done in the area of Science & Technology in India. An article on activity and growth of Organic Chemistry research in India has been published by Karki et al. (2000) during 1971-1989; Kademani et al. (2006) conducted “a study on Scientometric dimensions of Nuclear Science and Technology research in India: A study based on INIS (1970-2002)”; Kademani et al. (2006) studied on “Scientometric dimensions of Thorium research in India”; Kademani (2008) wrote a paper on “Scientometric mapping of Vacuum research in Nuclear Science and Technology”; Mahbuba et al. (2010) published on “Scientometric analysis of Health and Population research in South Asia particularly of two research organizations”; Gupta (2010) conducted a comparative study of Science & Technology publication output of India, China and South Korea during 1998-2008; Sanni et al. (2013) published a paper on “evaluating the growth pattern and relative performance in Nipah virus research from 1999 to 2010”; Yang and Lee (2013) studied on “Bibliometric approach to research assessment: publication count, citation count & author rank”; Chuang et al. (2013) wrote high-impact paper published in the journal of chemical engineering.

Scientometric and other quantitative metric studies assist the science policy makers to assess and measure the growth and impact of research in an area of study. These types of studies help us to know which Country, State, Institution or the individual scientist are active or forefront in a given field of research activity. These studies give insight into the dynamics of research activities that is the direction of research activity and to take necessary steps based on it (Kademani, 2011).

Based on the above literature survey, it is observed that most of the studies have been conducted on country wise output of a particular subject or comparative study of subjects, individual scientist or collaborative research, particular institution or comparative study of two or more institutions etc. But a few studies are related to research productivity of particular Universities/ States / Provinces. It is important to study the research productivity of

institutions in compare with the total output of that country. Such studies enable the policy makers or Decision makers of respective Universities or affiliating bodies to identify low productive institutions and less concerned disciplines to take appropriate measures, to develop a feasible plan of action to enhance productivity. Hence, present study has been chosen for the research.

Professional institutions are pioneer in producing scientific and technical knowledge, hence, research output produced by these institutions in the form of Articles, Theses, and Conference Proceedings gaining recognition at national or international level. India is one of the biggest higher education system in the world but unfortunately, it couldn't able to attract most of its bright young population to higher education stream. Indian government needs to address upon important impediments like lack of resources and infra-structure dense population, social and gender issues. In this article, an attempt has been made to know the trends of research in a technical university with respect to production of number of publications.

Development of a country is measured on its strength of engineering. In this regard, how better Government, Private or Autonomous Colleges are imparting knowledge in teaching as well as research area is also important in compare with the State Universities. Hence, an attempt of making sense of the research eco system in Karnataka has been undertaken.

The main objective of this study is to present the ranking of engineering colleges based on the growth of research and development (R&D) literature published by the scholars in any discipline and their citations since their inception. In particular, the study focuses on the following Objectives.

1. To identify the Research output of Engineering Colleges in terms of type of publication, Subject and chronology.
2. To know chronological distribution of Subject wise research output in various Engineering Colleges
3. To find out the top collaboration among the participating institutions.
4. To find the highly preferred journals during the period of study.
5. To seek the factors responsible for better research environment.

2. Methodology and Scope

This study emphasizes on the growth and contribution of publication and its impact on research conducted by the faculty members, research scholars of Engineering Colleges of

Karnataka. As explained earlier, this study consider research publications of the institutions as reflected in Scopus database. The study attempts to check the subject wise distribution of papers published; types of publication, annual average growth rate, degree of collaboration, top ranking institutions, top published journals, geographical distribution, and organizational affiliation of papers.

Present study is confined to the Engineering Colleges affiliated to Visveswaraya Technological University (VTU). There are a very few authentic, standard citation databases namely, Web of Science (WoS), Scopus, which are considered as bench mark by accreditation agencies like National Board of Accreditation (NBA), National Assessment and Accreditation Council (NAAC) and National Institutional Ranking Framework (NIRF). In this study, research publications indexed in Scopus database have been considered as it has wider coverage.

Scopus provide a quick and powerful access through source index and citation data to the scholarly content of world's leading publishers. By using suitable search syntax, records pertaining to the Engineering Colleges in the address field, records are downloaded.

Scopus is a comprehensive database covering all aspects of Science brought out by Elsevier Publishing group. It has been indexing articles reviews since 1996. Scopus indexes the titles of journals that are submitted as soon as they have been labeled by an institution.

2.1 Limitation

The study covers the research communications indexed in the Scopus. Research work published in regional languages and national level journals which are not indexed in Scopus are excluded from this study. As the present study is related to technical publications, almost all research paper publish in English. It can be suggested that further research can be extended by collecting data from the Indian Citation Index as majority of the Indian journals not covered by Scopus in order to get complete picture of the research output of the university.

3. Data analysis and Interpretation

The primary objective of this study is to present and analyse the college wise growth of research articles published by the scholars of Karnataka. Though VTU started in 1998 at Belagavi, there were already 16 premier institutions catering Engineering education. All of them come under VTU except University Visveswaraya College of Engineering, Bangalore. It

is interesting to note that 220 Engineering Colleges produced a total of 26,134 articles from their faculty members since 1960 till May, 2020.

3.1 Types of documents in Scopus

Table 1: Types of documents of engineering colleges in Scopus

Document Type	No.
Article	9217
Book	9
Book Chapter	725
Conference Papers	12062
Data Paper	30
Editorial	98
Erratum	37
Letter	46
Note	36
Retracted	2
Review	301
Short Survey	9
	26134

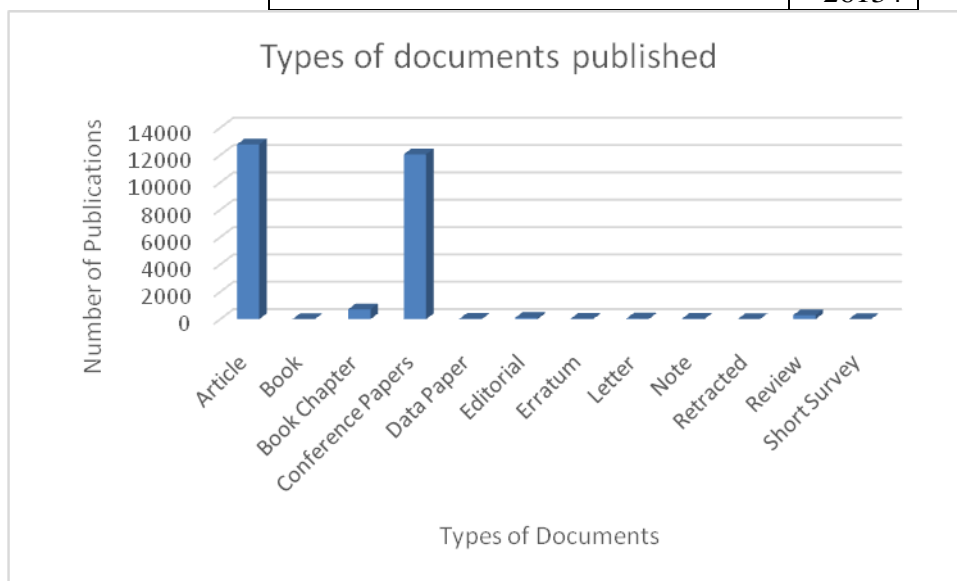


Figure 1: Types of Documents published

Though the publications include all types of documents including articles, Books, Book chapters, Conference papers, Data papers, Editorials, Erratum, Letter, Notes, Retracted articles, Reviews, short surveys and articles; Conference papers alone make a lion share by contributing 12,062 out of total 26,134 publications. (Table 1).

3.2 Growth of publications

Table2: Year wise growth of publications

Duration	Number of Colleges	No. of Publications	Cumulative No. of Publications	Annual Growth Rate (AGR)%
1961-1970	16	1	1	0
1971-1980	39	10	11	90
1981-1990	50	52	63	42
1991-2000	80	268	331	41.53
2001-2010	175	4610	4941	162.01
2011-2020	194	21193	26134	35.97

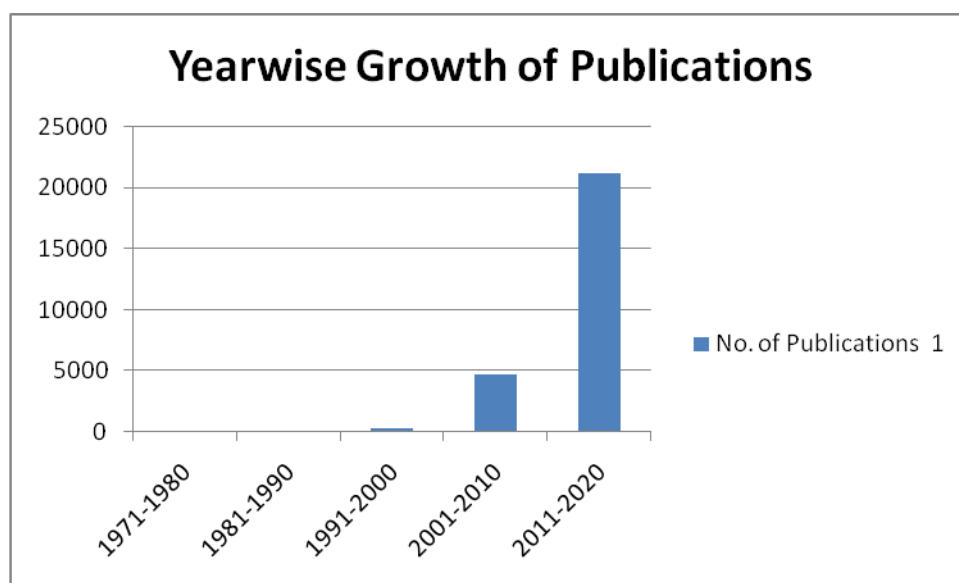


Figure 2: Year wise growth of publications

The above figure shows that 331 articles published up to 2000, 4610 publications happen just in the first decade of 21st century as number of colleges increased rampantly and publications reached highest than ever, almost five-fold more than the last decade during 2010-2019 as NBA, NAAC accreditation agencies and NIRF like bodies prioritize publications as a criterion for accreditation and ranking. (Table 2).

Table 2 depicts the Annual Growth Rate (AGR) of publication during the period (1951-2020). There was a maximum annual growth rate 162.01 during 2001-2010 followed by 90 AGR in the period 1971-1980. The minimum AGR 35.97 was reported during period 2011-2020 though the research production is highest among all the decades. Whole AGR data as shown in Table 3. The annual growth rate (AGR) are calculated by using the formula stated by (Kumar and Kaliyaperumal, 2015).

$$\text{AGR} = \frac{\text{Current Decade Total} - \text{Previous Decade Total}}{\text{Previous Decade Total}} * 100 / \text{Number of Years}$$

There are three categories of engineering colleges namely-Colleges affiliated to VTU, Colleges affiliated to VTU but got Autonomous status and Govt. Engineering Colleges. As administration, status and financial condition of these colleges are different from each other, it is not fair to compare all together. Hence, publication details of those Colleges have been listed and ranked separately.

3.3 Ranking of colleges based on publications

Table 3: Top Ranking Autonomous Engineering Colleges

Sl.No.	Autonomous colleges	Year of Establishment	Publications	Citations
1	R.V. College of Engineering, Bangalore	1963	1506	5201
2	B.M.S. College of Engineering, Bangalore	1946	1425	6432
3	M.S. Ramaiah Institute of Technology, Bangalore	1962	1349	10221
4	PES College of Engineering	1962	1198	5571
5	Siddaganga Institute of Technology, Tumkur	1963	1109	5538
6	DayanandaSagar College of Engineering, Bangalore	1979	1050	5572
7	N.M.A.M. Institute of Technology, Nitte	1986	830	1918
8	Nitte Meenakshi Institute of Technology, Bangalore	2001	587	1315
9	National Institute of Engineering, Mysore	1946	505	3228
10	K.L.S. Gogte Institute of Technology, Belgaum	1979	496	2402

From the above data, we can arrive at the conclusion that generally, older institutions have good infrastructure and can be able to publish more articles. As they exist since long time, they have more disciplines, more faculty resulting in a greater number of papers which naturally yield high citations. Majority of the top ranked autonomous Colleges are started in the year 1964, 1970s, 1986 and are well established. Exception to this observation, NMIT which is ranked 8th place was started latest in 2001. Though it is youngest among other autonomous colleges, its achievement is remarkable. Regard to citation, the third highest in publication MSRIT has got 1st place, and all other five Colleges ranked 1st, 2nd, 4th, 5th and 6th publication wise (Table 3).

Table 4: Top Ranking Private Engineering Colleges

Sl.No.	College Name	Year of Establishment	Publications	Citations
1	J.S.S. Academy of Technical Education, Bangalore	1997	510	1412
2	B.M.S. Institute of Technology, Bangalore	2002	477	4205
3	Bangalore Institute of Technology, Bangalore	1979	435	2739
4	C.M.R. Institute of Technology, Bangalore	2000	414	1050
5	P A College of Engineering, Mangalore	1999	377	2950
6	Acharya Institute of Technology, Bangalore	2000	319	1896
7	R.N.S. Institute of Technology, Bangalore	2001	317	834
8	New Horizon College of Engineering, Bangalore	2001	298	1432
9	B.L.D.E.A's V.P. Dr. P.G. Halakatti College of Engineering and Technology, Bijapur	1980	289	2089
10	Sri Venkateshwara College of Engineering, Bangalore	2001	252	544

In case of Private-unaided Colleges, (Table 4) it shows that infra-structure and priorities of the new Colleges shifted from mere teaching to research. May be the Colleges situating in the capital city is also a reason as they are more exposed to research activities, consultancies and industry collaboration.

Table 5: Top Ranking Govt. Engineering Colleges

Sl.No.	College Name	Year of Establishment	Publications	Citations
1	University B.D.T College of Engineering, Davangere	1951	166	1293
2	Government Engineering College, Haveri	2007	58	96
3	Government Engineering College, Hassan	2007	45	60
4	Government Engineering College, Ramanagaram	2007	32	31
5	Government Engineering College, Chamarajnar	2007	29	81
6	Government Engineering College, Raichur	2007	26	77
7	Government Engineering College, Mandya	2007	21	61
8	Government Engineering College, Huvinahadagali	2007	16	84
9	Government Engineering College, Kushalnagar	2007	2	-
10	Government Engineering College, Krishnarajpet	2007	1	-

Among Govt. Engineering Colleges, BDT College of Engineering is the oldest one which has become constituent College of VTU and leading in publication production. Remaining Colleges started after 2007 in district and remote centers. Many Colleges except Hassan,

Ramanagara, Chamarajanagar, Raichur, Mandya are situated in rural places deprived from the basic amenities and have limited infra-structure, (Table 5) Attracting expert faculty at these places is also difficult which counts for better contribution of publications.

Analyzing table 3- Top Ranking Autonomous Engineering Colleges, table 4- Top Ranking Private Engineering Colleges and table 5- Top Ranking Govt. Engineering Colleges altogether, we can assume that research productivity of the institutions depends on age and type of institutions. The other factors which contribute for more publication include may be number of faculty members, research infrastructure, their accreditation that helps to get financial support for research from different funding agencies etc.

- i. Though University B.D.T the Govt. College of Engineering, Davangere is the older one which was established in 1951, it has just 341 publications as such of a private engineering college started 2010 onwards. No other Govt. engineering colleges crossed even one hundred publications.
- ii. It shows that private institutions balance both teaching and research components to increase their ranking.
- iii. Autonomous institutions stood first in publication ranking, the reasons may be-
 - a. Majority of them are older
 - b. As they are older, they have improved infra structure, more disciplines of engineering leading to more strength of post graduate students and faculty members.
 - c. Freedom to update their syllabi according to the technological advancement and industry requirement.
 - d. NBA, NAAC and NIRF agencies led to competition in ranking and thus private and autonomous engineering colleges prioritize publication.
- iv. The Colleges situated in and around Bangalore have research publications to their credit as they have more exposed to industry interactions, research activities and hence preferred by meritorious students and faculty.

3.4 Journals preferred by engineering college authors

Table 6: Top Ranked journals chosen for publication opted by engineering faculty

Sl.No.	Name of the Journal		Impact Factor	Year of first publication	No. of Publications	Type Commercial(C)/Open access (OA)
1	Materials Today: Proceedings	Elsevier	0.97	2014	774	C
2	Advances in Intelligent Systems and Computing	Springer	0.57	2014	643	C
3	AIP Conference Proceedings	AIP	0.4	1970	480	Society Pub. Paid with embargo of 1 year

4	Lecture Notes in Electrical Engineering	Springer	1.476	2006	386	Commercial E Conf Proceed
5	International Journal of Recent Technology and Engineering	Elsevier	0.107	2012	342	OA
6	International Journal of Innovative Technology and Exploring Engineering	Elsevier	0.102	2012	258	OA
7	Communications in Computer and Information Science	Springer	0.49	2007	251	C
8	Materials Research Express	IOP	1.929	2014	185	OA
9	International Journal of Applied Engineering Research	IJSR	0.51	2009	181	C
10	Journal of Advanced Research in Dynamical and Control Systems	Institute of Advanced Scientific Research	0.27	2008	172	C

Top research publications include both journals and conference proceedings. Among the top 10 journals, 4 from Applied Engineering, 2 each from Computer Science Engineering and Mechanical Engineering, 1 each from Physics and Electrical Engineering (Table 6).

Proceedings of Materials Today (Elsevier publisher) is the one where highest number of articles-774 published by the faculty of VTU in the last two decades. Advances in Intelligent Systems and Computing (Springer publisher) occupied 2nd place with publishing 643 articles and American Institute of Physics-AIP Conference Proceedings has got 3rd place with 480 publications. This will help the authors to find out a journal with good impact factor, minimum period for publishing, with or without article processing charges etc.

Among the top ten journals, seven are commercial and three are Open Access. There is no doubt internet contributed a lot for information explosion. Internet reduced the time of searching and retrieving the information required for article writing or research work. At present, information is available free of cost through open access channels like OA journals, social media sites. Everyone advocates open access when it comes to publishing of their own articles, they choose commercial journals that are peer reviewed and indexed in Scopus. Irony is researchers want information free but while publishing, majority authors opt commercial and don't mind to pay hefty processing fee which is burden for themselves as well as not helping fellow researchers. Conte, Sarah opines the same that although the idea of freely available journals to the public is nice when it comes time to publish, many researchers opt commercial or print, perhaps it is because of more well-established journal and the four main factors are visibility, cost, prestige, and speed (<https://www.aje.com/arc/making-the-choice-open-access-vs-traditional-journals/>). The same has been reflected in the table 7

where 22562 articles are published in commercial journals and only 3572 articles are published in Open Access journals.

Table 7: Type of journals accessed

Access Type	Publications
Open Access	3572
Commercial	22562
Total	26134

Though publishing in open access journals was familiar since 1984, only 17 articles published until 2003 and it gear up only after 2004 (Table 7). But comparatively, awareness of open access journals is not high or preferably researchers are selecting commercial journals which is self-evident from the table 6.

3.5 Research distribution among subjects

Subjects of research conducted in VTU affiliated Colleges has been scattered over 28 areas starting from General Engineering, Computer Science, Basic Sciences to Bio related areas and multidisciplinary subjects.

Table 8: Subject wise Distribution of Publications

Sl No.	Subject	Number of Papers
1	Engineering	12775
2	Computer Science	11490
3	Materials Science	5411
4	Physics and Astronomy	4730
5	Mathematics	2832
6	Chemistry	2435
7	Energy	1768
8	Chemical Engineering	1551
9	Environmental Science	1196
10	Medicine	1064

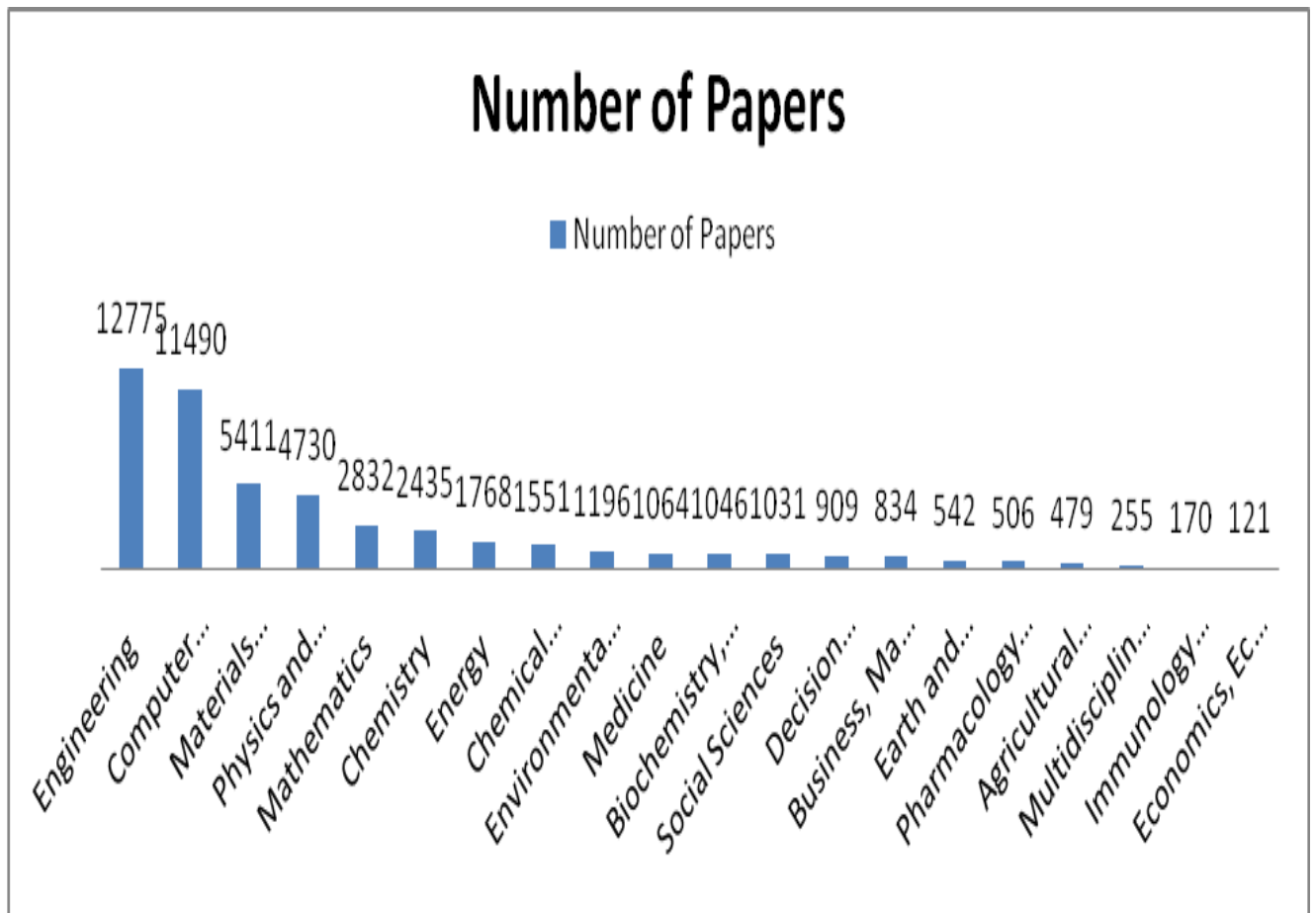


Figure 3: Subject wise distribution of publications

Though the top one Allied engineering viz Electrical, Electronics, Mechanical, Aeronautical, Biotechnology, Civil engineering altogether produced 12775 while Computer Science which is in second place alone has produced 11490 articles. It denotes that Computer Science has occupied all the spaces of human life and it continues in future also.

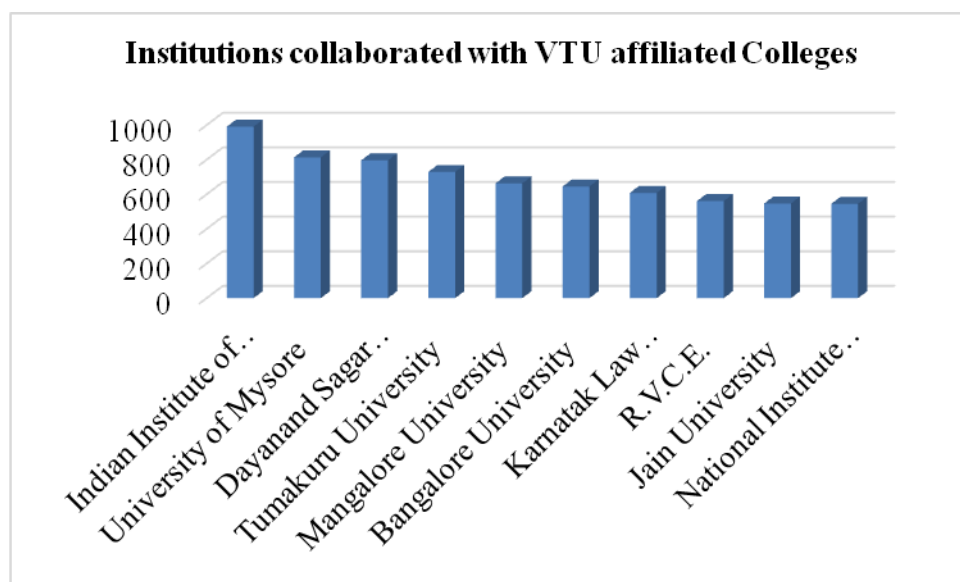
Though articles published by the faculty of engineering colleges, the subject area of articles is vast spread including Basic Sciences, Applied Sciences i.e. Engineering, Social Sciences & Management, Biosciences including Medical Sciences and Neurosciences. Hence, it is clear that application of engineering methodology is necessary in all the disciplines (Table 8)

Generally, an effective research cannot be conducted by a single person and the scholar will be affiliated to one or the other institutions. Research quality is also measured by the type of the collaboration means reputation of the institutions collaborated. VTU affiliated Colleges have conducted research in collaboration with many institutions of national importance, Central institutes and international institutions.

3.6 Collaborated Institutions

Table 9: Top 10 collaborated institutions with engineering colleges of VTU

Sl.No.	Institutions collaborated	Year of Establishment	Number of publications
1	Indian Institute of Science, Bengaluru	1909	991
2	University of Mysore	1916	813
3	Dayanand Sagar Academy of Technology and Management	1963	796
4	Tumakuru University	2004	729
5	Mangalore University	1980	663
6	Bangalore University	1964	645
7	Karnatak Law Society's Gogte Institute of Technology	1979	608
8	R.V.C.E.	1963	561
9	Jain University	2009	547
10	National Institute of Technology Karnataka	1960	545

**Figure 4: Top collaborated institutions with engineering colleges**

The above figure shows that Indian Institute of Science is in the first place having maximum collaboration with the VTU affiliated Colleges. IISc a premier institution which has got place in the world's pioneer ranking agency like THE World University Rankings is situated in Bangalore, Karnataka where VTU affiliated Colleges exist. Hence, it is a matter of pride that VTU affiliated Colleges having the highest collaboration with IISc. (Table 9)

Second place goes to University of Mysore, the first university of the Karnataka state. Next places are followed by Dayanand Sagar Academy of Technology and Management. Fourth, fifth and sixth places occupied by Universities namely-Tumkur University, Mangalore University, Bangalore University. Seventh and eighth rank goes to Karnatak Law Society's Gogte Institute of Technology, R.V.C.E., ninth by Jain University and tenth place to the

famous technical institute, National Institute of Technology, Karnataka (NITK). It is noteworthy that Tumakuru University which started in 2004 has got fourth place and Jain University is in the ninth place and proved that they prioritize research and publication work.

Table 9: Top 10 collaborated foreign countries with engineering colleges of VTU

Sl.No.	Countries	Papers produced
1	United States	951
2	United Kingdom	514
3	Germany	379
4	Saudi Arabia	343
5	South Korea	325
6	Australia	324
7	China	307
8	France	254
9	Netherlands	244
10	Spain	233

It is great to note that among 26,134 articles published by engineering colleges, 12,513 articles are collaborated with foreign countries. United States is in the first place with 951 articles, followed by United Kingdom, Germany with 514 and 379 articles respectively.

4. Conclusion

The study has identified the prolific and lagging areas of research. Publication of Computer Science has major share compared to other core engineering areas like Electrical Engineering; but another core Mechanical Engineering is also high. To balance the lagging areas of research like Electrical, Electronics, Civil engineering, Basic Sciences namely- Physics, Mathematics and Chemistry areas, encouragement can be given in the form of Scholarships, Stipend and Grants by the regulatory bodies like All India Council for Technical Education (AICTE), University Grants Commission (UGC) and State Governments.

It is found that Engineering Colleges situated in other than corporate cities like Mysore, Bangalore, Mangalore, Dharwad, Gulbarga, Davangere regions need to improve their research output in terms of quantity as well as quality. It is possible with increased investment in R&D, deployment of more quality manpower as research guides, selecting competent research scholars, providing top class infrastructure, extending industry collaboration and thus create conducive environment for research like laboratories, learning resources, etc.

This study serves as ready reckoner for the policy makers and administrators of State & Central Govt., Visvesvaraya Technological University (VTU), UGC and AICTE to take necessary steps for the overall development of the activity in terms of publications in particular. As funding is a real testimonial which promotes research activities, Department of Science and Technology (DST) can also play a vital role. In the same way, the Karnataka State Council for Science and Technology (KSCST) situated in IISc campus is already assisting budding students who have interest in research can extend its help to rural areas. The analysis also helps to know trends, characteristics as well as the grey areas of research that concerned authorities and government can focus to streamline the mechanism.

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