Essay No. 31. December 11, 2020

# EXCELLENCE IN RESEARCH AND INNOVATION IN INDIAN UNIVERSITIES
## RETROSPECT AND WAY FORWARD

**PK SUDHIR**
**Vice Chancellor**
**Vinayaka Mission's Research Foundation**
**(Deemed to be University) Salem, Tamilnadu**

**SAV SATYA MURTY**
**Director (Research)**
**Vinayaka Mission's Research Foundation**
**(Deemed to be University)**

**ASSOCIATION OF INDIAN UNIVERSITIES**
**NEW DELHI (INDIA)**

Scholarly Article from the book *REIMAGINING INDIAN UNIVERSITIES,*
**Editors: Pankaj Mittal and Sistla Rama Devi Pani,**
**Publisher: Association of Indian Universities, New Delhi (India), 2020.**

ISBN No. 81-7520-154-1

# EXCELLENCE IN RESEARCH AND INNOVATION IN INDIAN UNIVERSITIES

## RETROSPECT AND WAY FORWARD

**PK SUDHIR AND SAV SATYA MURTY**

*Research leads to innovation. Innovation is the process of creation, development or conceptualisation of a new product, process or service, or improving the efficiency, effectiveness of an existing system with the aim of improving wellbeing of people. There are many inventions made by inventors that has changed the life of mankind. It took centuries to establish organised research laboratories for research throughout the world. One of the public funded research universities of India, a jewel in the list of academic institutes in India contributing to research, remains Indian Institute of Science (IISc) established in 1909 in Bangalore with active financial support from Jamsetji Tata with the advise of Swami Vivekananda. Some of the parameters for measuring Research, Innovation & Excellence are the number of products developed, scientific ideas conceptualised, patents filed, scientific journal papers published, citations per paper published, h-index, i10 index etc. Though India is among the top 5 countries in terms of scientific publications, it does not match up in investments. As a fraction of GDP, public expenditure on R&D has been more or less stagnant between 0.6 per cent-0.7 per cent of GDP over the past two decades, which is well below that in developed and developing nations. Steps taken to improve the research ecosystem and to motivate the faculty and students in universities make a mark in the research.*

## PRELUDE

Research and innovation contribute significantly to the development of a country and for providing quality of life to its people. Centuries back, India had leading scientists and mathematicians who contributed to many innovations. Indian Institute of Science (IISc) and Tata Institute of Fundamental Research (TIFR) established before India's independence are still contributing in a good measure to research and innovation. Post-independence, many public funded research laboratories were established, but they are working in silos, though

contributing significantly to their mission programmes. During the same period, a good number of higher educational institutes like Indian Institutes of Technology (IITs), Central Universities, and National Institute of Technology (NITs) were established. In recent decades, many private universities were also established. They contribute to good number of journal publications, which is one of the measures of research carried out in their institutes. This paper covers the details of journal publications made by different top notch public funded higher educational institutes like IITs, Central Universities, NITs and leading private universities. It also talks about their citation count and measures the quality of these research papers published by these institutes. Based on datasets from the 2013 release of Scimago Rankings World Reports to evaluate the longitudinal performance of the quality and quantity of research output of select institutions were analysed. Though the numbers look attractive, they are not commensurate with the investments made. Also, the investments made are a small percentage of India's GDP and much smaller when compared to some of the developed and developing countries. The role of incubation centres is also mentioned; the paper also suggests various measures to be taken in the other institutes to improve the research and innovations and create an eco-system for significant research.

## RESEARCH AND INNOVATION

Research plays a significant role in the development of a country and its safety, security and wellbeing of the people of the country. This fact has been proved time and again. If the quality of life of the people in the developed countries like USA, UK, Japan etc. is good, it can be attributed to their higher per capita income due to the greater industrialisation resulted by the amount of quality research done over a period of time.

Research is defined as the creation of new knowledge or identification of new ways to use the existing knowledge in a new and creative way so as to generate new theories, concepts, methodologies. It is a methodical and detailed study of a specific problem, concern, or issue to find a solution. Research is being done by many individuals in different areas for centuries throughout the world and we are enjoying its benefits in our daily life (Dalal, 2018).

Research leads to innovation. Innovation is the process of creation, development or conceptualisation of a new product, process or service,

or improving the efficiency, effectiveness of an existing system with the aim of improving wellbeing of people (Wiki pedia—Research). There are many inventions made by inventors that has changed the life of mankind, some of which are disruptive or incremental. Disruptive invention is something which makes a very big impact on the market and living of the people, like Thomas Edison's incandescent light bulb, Graham Bell's telephone, Marconi's radio, Alexander Fleming's penicillin—the first true antibiotic, Leo Hendrik Baekeland's plastic, Martin Cooper's cell phone etc. Incremental inventions are things like the development of 3G or 4G technology for cell phones when 2G technology is already in existence.

## RESEARCH AND INNOVATIONS WHICH MADE IMPACT

Some of the inventions are research findings which later made a big impact, such as identification of the Solar System by Nicolaus Copernicus, X-Rays by Wilhelm Conrad Roentgen, the Electromagnetic Theory by James Clerk Maxwell, Marie Curie's development of the theory of Radioactivity, and Albert Einstein's theory of Relativity. If we still go back some of the oldest medical systems invented are Dhanvatari's Ayurvedic system, Hippocrates's Unani system, and Samuel Christian Hahnemann's Homeopathy system, which are practiced even today.

Research and Development (R&D) plays a crucial role in any innovation process. It is an investment in technology and future capabilities that will be transformed into new products, processes or services. Sometimes, a research that was started for proving or understanding certain concepts, have stumbled upon new inventions. Galileo Galilei pioneered the experimental scientific method and was the first to use a refracting telescope to make important astronomical discoveries. He is often referred to as the "Father of Modern Astronomy" and the "Father of Modern Physics". Albert Einstein called Galileo the "Father of Modern Science"(Wikipedia-Galileo Galili). Greek mathematician Archimedes is widely considered by many to be the "Father of Mathematics (Wikipedia-Archimedes).

India also contributed significantly in those early years. Science and Mathematics were highly developed during the ancient period in India. Some famous ancient Indian mathematicians were Baudhayan, Aryabhatta, Brahmgupta, Bhaskaracharya, Mahaviracharya. Some famous scientists were Kanad, Varahamihira, Nagarjuna Kanada, also

known as Kashyapa, was an ancient Indian natural scientist and philosopher who founded the Vaisheshika school of Indian philosophy that also represents the earliest Indian physics. Aryabhatta was the first well known mathematician cum astronomer from the classical age of Indian mathematics and astronomy. He invented *Zero,* which changed the understanding of Mathematics (Wiki pedia—Aryabhatta). Varahamihira's mathematical work included the discovery of the trigonometric formulas. He improved the accuracy of the sine tables of Aryabhatta and defined the algebraic properties of zero as well as of negative numbers (Wiki pedia—Varahamihira). Nagarjuna was considered as the wizard of chemical sciences. In the area where medieval alchemists of England failed, Nagarjuna had discovered the alchemy of transmuting base metals into gold (Wiki pedia—Hindu Jagruti). However, India could not sustain the leadership because of lack of support and ecosystem.

## THE JOURNEY SO FAR

It took centuries to establish organised research laboratories for research throughout the world. AT&T Bell Laboratories is one of the earliest research laboratories established in 1925 by Alexander Graham Bell. These labs have over 33,000 patents and 13 Nobel Prize winners. It has many inventions to its credit that are game changers for the world such as the transistor, cellular technology, data networking, laser, solar cells, communication satellites, etc.

Simultaneously, one major change that took place in the 20th century was the commercialisation of inventions. Earlier, scientists felt that their inventions shall be freely available for the benefit of people at large. However, there was a debatable change in perception among the scientists and their employers and concept of IPRs have come.

Public funded academic institutes were established in India and they started contributing to research and innovation. Indian Institute of Technology Roorkee (IITR), formerly University of Roorkee and Thomason College of Civil Engineering, was established in 1847 in British India by the then Lieutenant Governor, Sir James Thomason. It is the second oldest technical institution in Asia, known for its mastery in Civil Engineering. The Electrical Engineering Department of the Thomason College was established in the year 1897 and was one of the earliest such specialisations in the world. IITR has produced about 25 Shanti Swarup Bhatnagar Prize for Science and Technology winners (Wiki pedia—IIT-Roorkee).

One of the public funded research universities of India, a jewel in the list of academic institutes in India contributing to research, remains Indian Institute of Science (IISc), which was established in 1909 in Bangalore with active financial support from Jamsetji Tata (Wiki pedia—IISc). It has a origin of great interest. During a chance meeting between Jamsetji Tata and Swami Vivekananda, on a ship in 1893 incidentally, they discussed Tata's plan of bringing to India the steel industry. Such was the passion of Jamsetji Tata that he wrote five years later to Vivekananda: "I hope and trust, you remember me as a fellow-traveller on your voyage from Japan to Chicago. I very much recall even at this moment your views on the growth of the spirit characterized by severe self-discipline and abstention from all forms of indulgence in India. Tata was impressed by Vivekananda's views on science and leadership abilities. Hence he wanted him to guide in his campaign to start a Research Institute of Science for India. Vivekananda supported the project with enthusiasm. Jamsetji Tata constituted a Provisional Committee to prepare a plan for setting up of an Institute of research and higher education, with the aim of advancing the scientific capabilities of the country. The committee presented the draft proposal to Lord Curzon on 31 December 1898. IISc was established in 1909 and Morris Travers, the co-worker of Sir William Ramsay in the discovery of the noble gases, became its first Director. The first Indian Director of IISc was the Nobel Laureate Sir C.V. Raman. IISc has been a doing great job in Research since then. Bharat Ratna Dr. C.N.R. Rao who has an h-index of 155 currently, was with IISc for long and also had been its director. Research, innovation and excellence in India has taken another quantum jump with the establishment of Tata Institute of Fundamental Research (TIFR) in 1945, currently a deemed to be university and an outstanding research institute. TIFR was founded through the initiative of the great scientist and visionary Homi J. Bhabha and it is currently an aided Institute of Department of Atomic Energy. Its contribution has been recognised in the form of 32 Padma awards over the years, more than 25 Shanti Swarup Bhatnagar awards, seven Infosys awards and 15 Swarnajayanti Fellowships, in addition to international awards like the ICTP Prize, TWAS Prize and the New Horizons Physics (Milner) Prize etc. The rate of publications from TIFR has been consistently high over the years, with more than 1000 publications (including Conference Proceedings) during 2014-15(TIFR, 2016).

Public funded research laboratories and academic institutes were established in the post-independent India, thanks to the foresight of the then governments, such as Atomic Energy Establishment,

Defence Research and Development Organisation, Indian Space Research Organisation, Council of Scientific and Industrial Research Laboratories, Indian Council for Medical Research Laboratories etc. Though these departments made extraordinary contributions to research and innovation, they work mostly in silos and collaborations with academic institutes is limited considering their size and investment made by the government. During the same period, the government established higher educational institutes like the Indian Institutes of Technology in different parts of the country, central universities and regional engineering colleges, which were later known as National Institutes of Technology that are significantly contributing to research and innovation.

## PARAMETERS FOR MEASURING THE RESEARCH AND INNOVATION

Some of the parameters for measuring research, innovation and excellence are number of products developed, scientific ideas conceptualised, patents filed, scientific journal papers published, citations per paper published, h-index, i10 index etc. For obvious reasons, these parameters vary drastically between the institutions doing Basic Research and Applied Research. As per the study conducted by Department of Science and Technology (DST), Government of India in 2016, IISc tops in the research output in India with 22,056 scientific journal publications between 2002-2014. During the same period, Indian Institue of Technology (IIT) Kharagpur had published 15,797 and Indian Institue of Technology (IIT), Delhi had published 14,956 journal papers. According to data available with the Human Resource Development (HRD) Ministry, Indian Institue of Technology (IIT)-Madras has filed 132 patents by its students and faculty in 2018. Indian Institue of Technology (IIT), Mumbai is second with 104 patents, IISc Bangalore is close behind with 101 patents and IIT Delhi has registered 96 patents (Hindustan Times, 2018). As per the data uploaded on 19th November, 2019, the number of patents filed by Indian Institue of Technology and Management (IITM) in 2018-19 was 195 while the number of patents granted were 45 (iitsystem.ac.in). The number of patents filed by IIT Delhi in 2019 is 150 (Business Today, 2019). As per data, Elsevier, a top publisher of scientific articles and journals, places India in the fifth position for scientific research (The Print, 2018).

The number of Web of Science (WoS) Total Publications (TPs) between 2010-16 for the four sets of most productive higher

educational institutes, namely 19 IITs, 25 institutes each of Central Universities(CU), National Institutes of Technology (NITs), and private universities is 51159, 41470, 16604, and 28466 respectively (Bansal, 2019). The data is given in Table 1.

TABLE 1: NO. OF PUBLICATIONS BY TOP 5 INSTITUTES OF IIT, CUS, NIT AND PRIVATE UNIVERSITIES (2010-16)

| **IITs** | **TP** | **Central Universties** | **TP** | **NITs** | **TP** | **Private Institutions** | **TP** |
|---|---|---|---|---|---|---|---|
| IIT, Kharagpur | 9208 | University of Delhi | 8327 | NIT, Rourkela | 2185 | Manipal University | 4018 |
| IIT, Bombay | 7485 | BHU, Varanasi | 8054 | NIT, Trichy | 2072 | Vellore Institute of Technology, Vellore | 3570 |
| IIT, Delhi | 7172 | Aligarh Muslim University | 4307 | Sardar Vallabhbhai NIT, Surat | 1178 | Thapar University, Patiala | 2270 |
| IIT, Madras | 7122 | University of Hyderabad | 3795 | NIT, Durgapur | 1146 | BITS, Pilani | 2254 |
| IIT, Kanpur | 5957 | Jawaharlal Nehru University, New Delhi | 3012 | NIT, Karnataka, Suratkal | 1106 | Jamia Hamdard, New Delhi | 1950 |

As could be seen from Table 1, institutes that are long standing, well equipped, have quality faculty and well managed universities are faring better whether they are public funded or private funded. However, considering that there are almost 1000 universities in the country and the higher education system in India being the third largest in the world, next only to the United States and China, the research and innovation from academic institutes have to be significantly improved.

Though India is among the top five countries in terms of scientific publications, it does not match up in investments. The total Research and Development (R&D) expenditure tripled in the last one decade from Rs. 24,117 crores in 2004-05 to an estimated Rs. 1,04,864 crores in 2016-17. However, as a fraction of Gross Domestic Product(GDP), public expenditure on R&D has been more or less stagnant between 0.6 per cent-0.7 per cent of GDP over the past

two decades, which is well below that in developed and developing nations such as USA (2.8 per cent), China (2.1 per cent), Israel (4.3 per cent), and Korea (4.2 per cent) according to a report by the Economic Advisory Council in 2019 (The Hindu, 2020).

## QUALITY OF RESEARCH OUTPUT

Quantity of research output is important. At the same time, quality of the publications is equally significant. Citations and average citations per journal paper are the most widely used indicators for deciding the quality. The Total Citations (TC) count is directly available from the data. For measuring the Quality of Publications, TC data, Average Citations Per Paper (ACPP) calculated and h-index for all the four sets of institutions i.e., IITs, Central Universities, NITs and Private Universities, for each year are used. Tables 2A to 2D present these indicators for each of the four institution-sets (Bansal, 2019).

TABLE 2A: QUALITY OF RESEARCH (IITS)

| Year | Total Publications (TP) | Total Citations (TC) | ACPP | h-index |
|---|---|---|---|---|
| 2010 | 5247 | 84356 | 16.07 | 93 |
| 2011 | 5473 | 81295 | 14.85 | 88 |
| 2012 | 5913 | 74110 | 12.53 | 76 |
| 2013 | 6678 | 74986 | 11.22 | 77 |
| 2014 | 7740 | 57708 | 7.45 | 57 |
| 2015 | 8906 | 38823 | 4.35 | 41 |
| 2016 | 11202 | 17379 | 1.55 | 25 |

TABLE 2B: QUALITY OF RESEARCH (CUS)

| Year | Total Publications (TP) | Total Citations (TC) | ACPP | h-index |
|---|---|---|---|---|
| 2010 | 4416 | 67857 | 15.366 | 83 |
| 2011 | 5076 | 68000 | 13.396 | 80 |
| 2012 | 5490 | 71619 | 13.045 | 81 |
| 2013 | 5925 | 55574 | 9.38 | 65 |
| 2014 | 6271 | 41484 | 6.615 | 49 |
| 2015 | 6803 | 26665 | 3.92 | 40 |
| 2016 | 7489 | 10415 | 1.391 | 22 |

TABLE 2C: QUALITY OF RESEARCH (NITS)

| Year | Total Publications (TP) | Total Citations (TC) | ACPP | h-index |
|---|---|---|---|---|
| 2010 | 1277 | 18955 | 14.843 | 54 |
| 2011 | 1461 | 16179 | 11.074 | 46 |
| 2012 | 1645 | 17273 | 10.5 | 42 |
| 2013 | 2100 | 17923 | 8.535 | 43 |
| 2014 | 2544 | 14936 | 5.871 | 32 |
| 2015 | 3233 | 9333 | 2.887 | 24 |
| 2016 | 4344 | 5050 | 1.163 | 15 |

TABLE 2D: QUALITY OF RESEARCH (PVT. UNIV.)

| Year | Total Publications (TP) | Total Citations (TC) | ACPP | h-index |
|---|---|---|---|---|
| 2010 | 1957 | 27849 | 14.23 | 68 |
| 2011 | 2432 | 26226 | 10.784 | 59 |
| 2012 | 3060 | 30291 | 9.899 | 52 |
| 2013 | 3853 | 27775 | 7.209 | 48 |
| 2014 | 4303 | 24369 | 5.663 | 42 |
| 2015 | 5527 | 16909 | 3.059 | 31 |
| 2016 | 7334 | 7149 | 0.975 | 19 |

It can be seen from the tables that IITs lead with the highest number of citations as well as the highest average h-index. This is somewhat closely followed by Central Universities and then the NITs and Private Universities. Considering the fact that private universities have a good number of papers in the recent years and are growing fast, it can be easily assumed that private universities will get higher number of citations in the years to come, as the citation window size gets bigger. The top one per cent most cited papers of India during the years 2010-16 (total Papers: 4588) are referred to as highly cited papers (HiCP)(Bansal, 2015).

Table 3 gives a total number of papers published, number of faculty, research expenditure for three years, and per faculty expenditure/year for IISc and other established private universities, which indicates the quality of research and resources spent for achieving the quality.

TABLE 3: QUALITY OF RESEARCH VS RESEARCH EXPENDITURE

| Institute | Total Papers | No. of Faculty | Expenditure for 3 years in Rs. Crores | Expenditure/ faculty/year in Rs. Crores |
|---|---|---|---|---|
| IISc, Bengaluru | 7237 | 430 | 1603.67 | 1.24 |
| Manipal University | 3240 | 2586 | 3759.88 | 0.49 |
| VIT, Vellore | 4289 | 1720 | 1539.84 | 0.30 |
| Thapar Institute of Engineering and Technology | 1802 | 482 | 417.79 | 0.29 |
| BITS, Pilani | 2183 | 694 | 1126.61 | 0.54 |

The O (or Output) indicator is an exact measure of the quantity or size of the publications made by an institution and is the total number of publications made in scholarly journals that are indexed in Scopus. The three proxies that signify in various ways the quality of academic research output are given below(Parthap, 2014).

1. The NI (or Normalised Impact) compares the average scientific impact of the institution with that of the world average taken as 1. Thus, a score of 0.8 means that it is a 20 per cent below average citation performance, while a score of 1.3 implies that the institution is cited 30 per cent above average citation performance.
2. The Q1 (or high quality publications) is the ratio of publications that the institution published in what the Scimago team takes as the most influential scholarly journals of the world; those that are ranked in the first quartile (25 percent) in their categories as ordered by Scimago Journal Rank (SIR). Since this is indicated as a percentage, the ratio (Q1/25) is yet another normalised proxy for the quality of publication, with a value of one taken as the world average.
3. The ER (or Excellence Rate) signifies the percentage of an institution's scientific output that is included into the set formed by the top 10 per cent of the most cited papers in the relevant and respective scientific fields. It serves as an important measure of the high quality output of the research institution. Again, the ratio ER/10, permits one to normalise this proxy so that the world average becomes 1.

TABLE 4: RANKINGS OF HEIS APPEARING IN SIR 2013 ACCORDING TO VARIOUS INDICATORS

| Values | | | | Rankings | | |
|---|---|---|---|---|---|---|
| **HEI** | **No. of Publications** | **$Q^2$** | **X** | **Output** | **$Q^2$** | **X** |
| IISc | 9111 | 2.44 | 22221.51 | 1 | 4 | 1 |
| IITKGP | 7665 | 1.93 | 14816.90 | 2 | 9 | 2 |
| IITB | 5822 | 2.12 | 12369.41 | 7 | 7 | 3 |
| IITD | 6629 | 1.78 | 11799.68 | 3 | 14 | 4 |
| IITM | 6252 | 1.85 | 11573.71 | 5 | 11 | 5 |
| IITK | 5075 | 2.10 | 10658.27 | 10 | 8 | 6 |
| TIFR | 3490 | 3.01 | 10515.64 | 14 | 2 | 7 |
| Univ. of Delhi | 6488 | 1.32 | 8534.83 | 4 | 30 | 8 |
| BHU | 5336 | 1.38 | 7374.12 | 8 | 26 | 9 |
| IITR | 4277 | 1.64 | 7031.46 | 12 | 17 | 10 |

An important point to be mentioned here is that these three indicators intrinsically encompass what is called the field normalisation aspect, i.e. they account for the fact that different publications and citation practices across varied disciplines will lead to significantly different citation rates and that this can be normalised by adopting NI, Q1 and ER as bibliometric indicators, which are defined below. Default ranking using output as the only criterion is easy as it is a unidimensional indicator. However, as there are three different quality indicators, ranking by quality needs that these three different indicators are combined into a single composite quality indicator. It is possible to use a Euclidean measure to combine these three quality proxies into a single one. For this purpose, it is proposed that the $q^2$ proxy, where $q^2$ is defined as $((NI)^2 + (Q1/25)^2 + (ER/10)^2)/3$. This is a simple measure and it is a composite quality indicator with a value of 1 describing the world norm constituted from the three indicators, namely NI, Q1/25 and ER/10, each of which defines a world norm with a value of 1. Thus in this analysis, the simplified the Scimago Institutions Rankings (SIR) reports data to one quantity term (Q = O) and quality term ($q^2$). The single composite term, $X = q^2 Q$ is that term that serves as the best proxy for total performance in the current research context(Parthap, 2014). Table 4 Data is based on SIR 2013 rankings World Reports to evaluate the quality and

quantity of research output based on longitudinal performance of select institutions belonging to this sector for the period 2003-2011.

The count of scientific documents takes into account articles, conference papers, short reviews etc. collected by Scopus.

## INCUBATION CENTRES

Incubation centres are an essential component in any institute especially in engineering and technological institutes for the faculty and students to try out their research and engineering ideas to make prototypes and test them. Once they are successfully tested, they can be commercialised through proper commercial models.

It can be seen from the data furnished in various tables above that the quantum and quality of research output which decides the research, innovation and excellence in Indian universities depends on: the infrastructure in the university, research inclination by the faculty, research funding, facilitation, research ecosystem built, etc.

If the research output is good in IISc, to a large extent it is because of the research investment made by each faculty member, state of the art infrastructure available, vibrant research ecosystem, quality and qualified faculty, and the academic freedom they enjoy. It is true to a large extent in other IITs too.

It should always be borne in mind that universities must not restrict themselves to just awarding degrees but pursue research with all earnestness which will improve their academic quality as well as research output. For a university having constituent/affiliated colleges making a beginning in research, the following measures will yield positive results over a period of time:

- Frame a Research Promotion Policy for the university and revise whenever policy changes are required to improve the system.
- Motivate all faculty to spend more time on research for improved quality research output and facilitate their research by providing sufficient time for the same by adjusting their workload.
- Interested work groups may be formed for working on different research problems, in the form of task forces by identifying suitable faculty across the departments based on the research topic.

- Improved research infrastructure.
- Capacity building of the faculty and students through exposure to the state- of-the-art-technologies. This can be achieved through their active participation in quality international/national conferences, symposiums, workshops etc. They shall have good network linkages to the scientific faculty around the world.
- International collaborations through faculty exchange programmes, sharing of research infrastructure.
- Full- time research associates either in the form of PhD scholars or Post- doctoral fellows. They shall be supported with good fellowship amounts. This is in addition to the research contributions made by the faculty.
- Seed money for the faculty/students in the form of internal funding to test or try out their research ideas or hypothesis.
- Financial support for the UG/PG students to carry out their research projects and dissertations.
- Though a research scientist derives the satisfaction from his research results and recognition by peers, institutes and recognition through awards, he has to feel it to get motivated. Till then, the university has to incentivise the efforts put by the faculty in the form incentives for publishing in high quality journals, patents filed, products incubated etc.
- Proper facilitation is essential for the faculty to carryout research without any bureaucratic hindrances.
- A research ecosystem has to be built for the faculty/students through proper systems, structures and review & follow up mechanism.

## CONCLUSION

Research and innovation play an important role for the development of any country. Exclusive research institutes established post-independence are working well in their silos meeting their mission programmes without many collaborations, considering their size and quantum of public money spent on them. The IISc, IITs, Central Universities, NITs and some of the private universities established in pre and post independence era are contributing fairly well to the research and innovation. As per AISHE 2018-19, report there are more than 50,000 higher educational institutes (HEI) in India (GoI, 2019). The number of students pursuing higher education in India is about 3.8 crores (Livemint, 2019).

Though these number looks big, the quantum and quality of research in the country is far from satisfactory. The quantitative measures of the research and innovation are number of innovations made, journal articles published, patents filed/granted, the citation count of the journal publications made, h-index etc. When we correlate the number of HEIs with the number of innovations made, number of papers published, their citation count, patents filed/granted, the picture looks unsatisfactory. Through a close look at the numbers presented in higher educational institutes, both public and privately funded, the following can be observed if the rest of the institutes (95 percent) also contribute to research and innovation in some measure, then India can claim to be a research hub. All efforts shall be to make it happen as soon as possible. It is possible only by increasing the investments made in research and developing a proper research ecosystem. The government shall play a major role in both these enablers. The paper summarises with the steps to be taken to improve the research ecosystem and to motivate the faculty and students in universities making a beginning to make a mark in the research.

## References

Bansal, Sumit Kumar (2019). Comparing research performance of private universities in India with IITs, central universities and NITs, *Current Science*, Vol. 116, No. 8, 25 April

Business Today (2019) 27th Dec

Dalal, Bhavna (2018). The Significance of Research in Innovation, *Forbes India*, Dec. 4,

GoI (2019) AISHE Report 2018-19, MHRD, Government of India

Hindu (2020), Government Eyes Public-Private Fund to Give R&D a Shot in the Arm, *The Hindu*, 22 Feb.

Hindujagruti. https://www.hindujagruti.org/hinduism-for-kids/82.html

Hindustan Times (2018), Dec 01.

iitsystem.ac.in. https://www.iitsystem.ac.in/?q=patents/publicview

Livemint (2019), 21st September, 2019.

Prathap, Gangan. (2014). The Performance of Research-Intensive Higher Educational Institutions in India, *Current Science*, Vol. 107, No. 3, 10 August 1.

TIFR (2016). NAAC Self-Study Report–2016, Tata Institute of Fundamental Research, Mumbai.

The Print (2018) 4 Dec.

Wiki Pedia– Research. https://en.wikipedia.org/wiki/Research

Wiki Pedia– Galileo Galilei. https://en.wikipedia.org/wiki/Galileo_Galilei

Wiki Pedia– Archimedes. https://en.wikipedia.org/wiki/Archimedes

Wiki Pedia– Aryabhata. https://en.wikipedia.org/wiki/Aryabhata

Wiki Pedia– Varahmihira. https://en.wikipedia.org/wiki/Varahmihira

Wiki Pedia– IIT Roorkee. https://en.wikipedia.org/wiki/Indian_Institute_of_Technology_Roorkee

Wiki Pedia–IIS. https://en.wikipedia.org/wiki/Indian_Institute_of_Science

# PK Sudhir

PK Sudhir is Vice Chancellor of Vinayaka Mission´s Research Foundation (Deemed to be University) Salem, Tamilnadu. Earlier, he was the Controller of Examinations for two terms in Kerala University of Health Sciences, Thrissur. He conceptualised a fully automated and robust examination system the report of which was published in the National Medical Journal, All India Institute of Medical Sciences. He conducted an interdisciplinary research studies in Adenoids and Cataract. He has many scientific papers on health science education to his credit.

# SAV Satya Murty

SAV Satya Murty is Director (Research) at Vinayaka Mission´s Research Foundation (deemed to be university). Prior to joining VMRF, he worked as distinguished Scientist and Director of Indira Gandhi Centre of Atomic Research, Kalpakkam. He pursued his PhD from Homi Bhabha National Institute. In his distinguished academic career, he contributed immensely towards research. He has four book chapters and more than 200 research papers to his credit in peer reviewed international and national Journals. He is the editor of international journals and national journal. He is also a recipient of Homi Bhabha Award.