

ROLE OF R&D - IN SHAPING FUTURE ENGINEERING PROFESSION



S. K. Mazumder
*Former AICTE Emeritus Fellow
and Professor*



Rakesh Mehrotra
Former Associate Professor

*Department of Civil Engineering,
Delhi College of Engineering (DCE/ DTU)*

INTRODUCTION

India made history on 24th September 2014, when it became the first country to place a space probe- Mars Orbiter Mission– fondly called Mangalyaan in India- in the first attempt. After Independence, India has made phenomenal progress in the engineering sector. As on 2012, India had 10,949 engineering colleges with about 15,76,500 of graduates and post graduates. Majority of the boys and girls in India opt for either engineering or medicine as their first choice. Unfortunately, most of the talented engineering students from India prefer to go abroad for higher engineering education in developed countries where they find a congenial environment to nurture their talent and flourish. Apart from higher remuneration, they get due recognition through research, publications, patenting, etc. This has resulted in a big vacuum in R&D activities in scientific and engineering sector in India (Rama Rao, 2013). Unless the trend is reversed, developed countries would monopolise and the existing gap in R&D between the developed countries and India would continue to remain the same and India would continue to purchase superior products from abroad at exorbitant cost. There is therefore a need to deeply introspect and take appropriate measures to bring future engineers in the R&D sector at par with those from the developed countries.

The country is undergoing industrialization and working towards self-reliance in almost every sphere. The Indian government rightly deserves full credit for advancing meaningful research in engineering and science in India. Modern initiatives like ‘Make in India’ and ‘Skills India’ are providing a great platform for developing the industrial base of the country by promoting indigenous technologies and research as well as advanced skills required by foreign companies and other organizations that are eyeing investments in this country.

India has already pioneered several technologies in agriculture, pharmaceutical, and chemical industries that are now being utilized by countries in South East Asia and Africa to attain self-sufficiency. Indian engineering colleges- students and faculties as well as researchers- are working arduously towards reducing the existing gap in R&D to make Indian products competitive and globalized.

In an earlier paper (Mazumder, 2017), the first author, discussed about the challenges facing engineering education in India. The purpose of this paper is to highlight the R&D activities with a view to shape future engineering profession in India.

TYPES OF R&D WORKS

Broadly, all R& D activities can be classified in to three broad groups, namely,

- Fundamental or Basic Research
- Applied Research
- Adaptive Research

Fundamental or basic research leads to invention/ discovery of new things hitherto unknown. It is very costly and time consuming and needs resourceful and most talented faculty. Usually, such research works can be carried out in educational and research institutions with the help of young, energetic and dedicated faculty members.

Applied research is carried out with the objective of developing new products using the new laws/inventions/ discoveries made through fundamental/ basic research. It can be carried out in academic and research institutions as well as in industries for developing new products.

Adaptive research is meant for further study based on fundamental and applied research outputs developed indigenously or abroad so as to make it possible to use the latest knowledge for solution of local problems being faced by the society under prevailing circumstances. It needs less money and time compared to basic and applied researches.

While most of the fundamental researches are carried out presently in USA, UK, France and, Germany, Japan makes use of them through applied and adaptive research.

R&D INSTITUTIONS IN INDIA

After Independence, the Government of India established a large number of R&D institutions/ agencies like CSIR, DRDO, DBT, DST, DAE, DOS, ICAR, ICMR, ISRO, NPL, etc. A national survey (FICCI, 2014) on the status of R&D in the country shows that India's Gross Expenditure on R&D (GERD) has increased more than fourfold from Rs 24,117 crore to about Rs 1,00,000 crore during the period 2004-2005 to 2016-2017. The survey, conducted by the National Science and Technology Management Information System (NSTMIS) under the Department of Science and Technology has also shown that the per capita R&D expenditure in India increased from Rs 300 in 2004-2005 to Rs 659 in 2014-2015 (DST, 2017). The GERD growth was driven mainly by the Government – refer table.

Agency	GERD %
Central Government	45.1%
State Governments	7.4%
Public Sector Industries	5.5%
Institutions of Higher Education	3.9%
Private industry	38.1%

Many of the public sector institutions in India e.g. BHEL, DRDO, EIL, NHPC, NTPC, NCDC, ONGC, SAIL, etc. have inbuilt R&D centers for carrying out regular research for improvement of the quality of their products. The Percentage of GDP spent on R&D in India vis-à-vis some of the countries in the world as in 2016-17 are given in the table alongside. According to the 2018 Global R&D forecast (Waldorf, 2018), India is now the sixth largest R&D spender in the world, and it is set to overtake Korea and Germany to reach the third spot by 2018. To put this in perspective, India is expected to invest \$71 billion this

Country	% GDP spent on R&D
USA	2.79%
China	2.05%
Brazil	1.24%
Russia	1.19%
South Africa	0.73%
India	0.69%
Pakistan	0.29%

year (2019) on R&D, including public and private investments. The US is expected to invest \$514 billion and China \$396 billion. Japan, Germany and South Korea expect to invest \$166 billion, \$109 and \$77 billion respectively.

R&D IN ACADEMIC INSTITUTIONS IN INDIA

In a world increasingly propelled by technology, R&D is the foundation of any nation’s economic growth. Topmost engineering institutes and universities in India e.g. IITs, IISc, IIITs, IEST, NITs, BITS, JU, JNU, BHU, AMU, are focusing more on research and development rather than mere studies. Consequently, engineering students and faculty now conduct more research in various technologies than any time earlier in the history of this country. The Elsevier report to DST (2017) states-

‘Improving India’s international and cross-sector collaborations could be key to further growing the impact and visibility of India’s research. The trend is continuing as more and more scientific research papers from India are being published worldwide. A large number of these research papers speak of ground breaking work in new fields of engineering and technology’.

Many of the higher educational institutions in India posses Centers of Excellence for carrying out sophisticated high level research in diverse disciplines in engineering, science and technology e.g. Aeronautics and Aerospace, Applied Electronics, Architecture & Planning, Automotive, Bio-genetics, Bio-informatics & Bio-system, Biomedical, Chemical, Civil, Computer science & Technology, Electrical, Electronic and Instrumentation engineering, Electro-mechanical System, Applied Mathematics, physics and Chemistry, Environment, Industrial, Instrumentation and Control, Integrated Manufacturing, Materials, Mechanical, Metallurgical, Mining, Nano science & Nano Technology, Production, Software, Structural System, Telecommunication, VLSI Design, etc.

Some of the IITs/ Institutes carrying out specialized research study in core engineering disciplines are given below:

	Aerospace Engineering	Chemical Engineering	Civil Engineering	Computer Science & Technology	Electrical and Telecommunication Engineering	Mechanical Engineering
IEST (Kolkata)			✓			✓
IISc	✓		✓	✓	✓	✓
IIT (Bombay)	✓		✓		✓	
IIT (Delhi)		✓		✓	✓	✓
IIT (Kanpur)	✓			✓		✓
IIT (Kharagpur)	✓	✓	✓	✓	✓	✓
IIT (Madras)			✓		✓	✓
IIT (Roorkee)			✓			
Institute of Chemical Technology		✓				
ISI (Kolkata)				✓		
NCL		✓				
Vikram Sarabhai Space Centre	✓					

R&D IN INDIAN INDUSTRIES

A country of India's size should invest at least 2% of GDP on R&D; but this cannot be achieved without the private sector enhancing its investments in technology development (FICCI). Furthermore, despite global economic turmoil, India remains one of the fastest growing economies. Thus, a huge opportunity lies for the businesses in India to enhance their R&D and commercial efforts. Incentivizing R&D would also lead to employment generation and creation of knowledge economy. Therefore, development of technology parks, knowledge incubators and patent-management corporations, smart cities, etc. should be encouraged.

India represents a very diverse market, even amongst Asian countries and there are numerous pull factors that make India a lucrative destination for R&D. Access to technical competencies, young talent pool, cost savings, proactive government support and presence of an indigenous market are some of the significant factors attracting multinational companies to expand their R&D base and production operations in India. One of the major problems facing the private sector in India vis-à-vis R&D is the fact that most of Indian private business lies with small and medium enterprises and those sectors which have very limited capital to invest in R&D.

The Indian private sector has done creditable work in technology services, but it is now up to them to boost the country's R&D capability. By sheer luck, the large number of R&D centers of multinationals in the country has created an excellent talent pool for them to draw from. These centers can attract the best of scientists and technologists from India and abroad, facilitating greater interaction between industry, educational Institutions and national R&D centers. It can help the flow of funds from industry to R&D activity in these centers which might lead to better and newer products and services. India is proud of private research institutes like TIFR, IBM, Texas Instruments, GE, Motorola, etc. Private R&D has shown signs of improving but the growth has either come from public sector companies or from MNCs. In fact, it is the MNCs that accounted for 90% of the patents filed in India today. Indian's consider that the innovation or development done by them in the course of their day to day work is routine and thus forgo opportunities for filing copyrights, patents, etc. They need to be educated on this count.

Overall India-based R&D services market reached US\$ 20 billion in 2015, up by 9.9 per cent over 2014. R&D services market stood at US\$ 7.76 billion and R&D globalisation market (Captives) stood at US\$ 12.25 billion. India's R&D globalisation and services market is set to almost double by 2020 to US\$ 38 billion. The encouragement for research in India gave a significant opportunity for multinational corporations across the world as it is having the availability of intellectual capital. Legions of Indian engineers working across the globe highlight the highly trained manpower available at competitive costs.

RESEARCH PUBLICATIONS

Indian research publications increased from 16,000 papers to 40,000 papers a year increasing world share from 2.2% to 3.4% during the period 2004-05 to 2016-17. Citation impact of papers has increased during the decade from 40% of the world average to 60%. In several critical fields, India maintained a higher share than its average of the world's most cited papers. China's research output grew 22.3% compared to India's 14.3%, but Indian researchers have higher citations per paper-2.7 compared to China's 2.2. (DST, 2017)

Unfortunately, most of the research works carried out in educational and research institutions in India end in publishing of thesis and research papers. One of the major shortcomings of the Indian university system has been the focus on basic research (rather than applied research) that has limited value to industry and hence industrial support is lacking. The industry needs to realise that unless the basic research advances, the applied would stagnate after sometime.

However, there is a visible change now and many of the industries are coming closer to the educational institutions of higher learning through creation of chairs, centers of excellence, development of laboratories, sponsoring industrial research and consultancy, etc.

ROLE OF PROFESSIONAL SOCIETIES TO IMPROVE R&D

There are a numbers of Professional societies like the, Consulting Engineers Association of India, Aeronautical Society of India, Computer Society of India, Institution of Electronics and Telecommunication Engineers, Indian Institute of Chemical Engineers, Indian Institution of Industrial Engineering, Society of EMC Engineers (India), Indian Society for Technical Education, Indian Science Congress Association, Indian Society of Hydraulics and numerous other societies in every discipline of engineering. These societies publish journals and newsletters periodically and organize conferences to disseminate knowledge. They also encourage scholars by giving several awards for best papers, best thesis, best projects, etc. They organize short time courses and seminars on advanced topics, key note talks/ memorial lectures from experts from India and abroad with a view to expose/ inspire attendees in advanced R&D works being carried out in India and abroad Some of these societies arrange regular training program for young engineers from industry and institutions for updating of latest knowledge in different specialised subjects/ disciplines with the help of faculties drawn from educational, research, consultancy and industrial institutions. Inter-institutional collaboration is a key to success in R&D activities (Mazumder, 2008, 2014).

THE FUTURE SCENARIO

After independence, India has made significant progress in R&D in almost all disciplines in engineering. The quality of our engineers, however, needs further improvement. One of the biggest problems in this respect is that most of the talented engineers are going abroad for higher study and research resulting in a big vacuum in engineering and research institutions in India. India has made substantial progress in R&D however, to take it world class level, it has to be further strengthened through collaboration between educational/ research institutions and industries at all levels - departmental, institutional, industrial, and international. The existing gap in R&D between India and other developed countries needs to be bridged so that India becomes independent and not have to source foreign know how and be compelled to purchase superior products from abroad at high costs. The Government is seized of this and hence the emphasis on “Make in India”, which in the future will change the tide and make India an exporting nation not just of talent but highly sophisticated products, all developed indigenously in all spheres.

REFERENCES

1. DST (2017) “Research and Development Statistics at a Glance”, A report prepared by Elsevier and submitted to Deptt. of Science and Technology (DST), Ministry of Science & Technology, Government of India, New Delhi-16, Dec.2017
2. (FICCI) “Harnessing Private Sector Investment in R&D”, Federation of Indian Chambers of Commerce & Industry, Federation House, Tansen Marg New Delhi-110001 (www.ficci.in/spdocument/20884/R&D-Industry-Report.pdf)
3. (FICCI, 2014) “Next-Gen Innovation through Interdisciplinary Research” Proc. Global R&D Summit -2014 Organised by FICCI, November 12-13, The Lalit, New Delhi
4. Mazumder, S. K. (2017) “Challenges Facing Engineering Education in India”, pub. in ‘View Point’, by CEAI, Sept.2017
5. Mazumder S. K. (2014) “Industry –Academia Collaborations for Engineering Excellence” org. by Bengal Engineering College (now IEST, Shibpur) Alumni Association, Delhi (BECAAD) at India International Center, New Delhi
6. Mazumder, S.K. (2008),” Quality Improvement Through Collaboration Between Educational, Research a Consultancy Institutions in India” pub in the Journal ‘Consulting Ahead’ by Consultancy Development Center, Vol.2 Issue-1 January
7. Rama Rao, P. (2013), “Higher technical education in India: Prospects, challenges and the way forward”, INSA Public Lecture, New Delhi
8. Waldorf Astoria Orlando (2018) “Global R&D Funding Forecast”, “R&D 100 Conference Magazine, Winter, 2018. 14200 Bonnet Creek Resort Lane, Orlando, Florida, United States (407) 597-5500