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Paradoxes and Contradictions in the Growth of Engineering Education in India

Challenges and Prospects

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Council for Social Development

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Engineering Education in India: Challenges and Prospects
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Abstract

Higher education in India has expanded remarkably during the post-independence period, and more impressively during the last three to four decades, emerging as the second largest system in the world after China. However, the growth has not been even and, being unplanned, unregulated and market driven, shows distinct anomalies: some branches of higher education like engineering & technology and management have expanded rapidly and some like sciences, social sciences and humanities have remained stagnant, if not shrunk; some regions in the country have witnessed a highly impressive growth, while some regions are bereft of quality institutions in good number; the private sector has grown much faster than the public sector in higher education, visibly widening inequalities in access to education between socioeconomic groups and posing problems for effective regulation and governance; quality being traded off in favour of expansion; and so on.

Using the most up-to-date secondary data available in multiple authentic sources, policy documents and media reports, the paper analyses the rapid growth of engineering education in India, in its several dimensions. It analyses (a) patterns of growth in engineering education, (b) inequalities in the growth, (c) concerns relating to declining quality, (d) bizarre trends and patterns in the funding of engineering education by the government and households, and (e) the dynamic labour market conditions that the engineering graduates face. Finally, a critical comment is offered on the recent reforms being attempted in engineering/technical education, besides discussing some of the essential changes and improvements needed towards restructuring and rejuvenating the engineering education system in India. The critical descriptive account on the status and prospects of engineering education in India presented here, will be of immense interest to academia as well as administrators and policy makers.

Paradoxes and Contradictions in the Growth of Engineering Education in India: *Challenges and Prospects*

Jandhyala B.G. Tilak
Pradeep Kumar Choudhury

1. Engineering Education: Achievements, Aspirations and Concerns

It is widely recognised that higher education plays a critical role in the development of nations by impacting a variety of dimensions of the society -- social, cultural, economic, technological, political and human development (Tilak, 2003). Higher education which includes technological and professional education, apart from general education, contributes to the dynamic economic growth with the production of 'specialised human capital' (Schultz, 1988), yielding direct economic benefits, and playing an equally important role in producing a large multitude of externalities (McMahon, 2018). The valuable human capital, and the socially conscious, civilised and enlightened citizens with critical thinking and noble values it produces, contribute to the improvement in human well-being in its various facets. Further, in a competitive global knowledge economy that is experiencing rapid changes that are taking place in the global knowledge production in the twenty-first century there is an increasing demand on higher education to produce ever-increasing quality and skilled human resources with creative minds and the higher education system contributes significantly in fulfilling these demands (Tilak and Choudhury, 2019). Also, the human capital produced by the higher education system, by engaging itself in nation-building activities can fuel social, economic, technological, political and cultural transformation of the societies. For the same reason, individuals and nations invest in education, some very passionately. As a result, we find, rapid growth of education, higher education in particular in almost all countries of the world. World enrollments in higher education have increased two hundred-fold from roughly half a million in 1900 to about 100 million by 2000 (Schofer and Meyer, 2005, p. 898).

Demand for higher education has grown very rapidly in the world during the last two decades of the present century – the number of students has more than doubled -- going up from 100 million in 2000 to 224 million in 2018, and as it continues to grow. By

2040, student enrollment in higher education is predicted to surpass 590 million (Martin and Godonoga, 2020). With the massive expansion of higher education across the globe, it has evolved over the years from providing education for a few elites to providing to the common masses. By widening access and producing more educated and skilled human capital, including specialised human capital, higher education promises a more prosperous planet.

In India too higher education has experienced remarkable growth during the post-Independence period, and more impressively during the last three-four decades, in such a way that it became the second largest system in the world after China, pushing USA to the third place. The growing aspirations of young Indians, particularly in the critical phase of 'demographic dividend' that the country is passing through on the one hand, and India's resolve to create a knowledge society on the other has contributed to tendencies towards the massification of higher education. There were only 0.26 million students in higher education, enrolled in 750 colleges and 30 universities in India in 1950-51; the numbers increased to about 37.4 million students in 993 universities, 39,931 colleges and 10,725 'stand-alone institutions' in 2018-19 (MHRD, 2019). The gross enrollment ratio as estimated by the Ministry of Human Resource Development (MHRD), based on data collected from institutions of higher education through the *All-India Survey of Higher Education*, has gone up by nearly seventy times – from 0.4 per cent in 1950-51 to 26.3 per cent in 2018-19 (UGC, 2015; MHRD, 2019), though the current ratio is still far below the ratio in countries like China, many advanced countries, and the world average (UIS, 2020). The National Education Policy 2020 (MHRD, 2020) aims at reaching a gross enrollment ratio of at least 50 per cent by 2035.

Within higher education, technical education, and more specifically engineering education has registered an extra-ordinary high rate of growth. Engineering, science and technology have transformed the world we live in, contributing to significantly longer life expectancy and an enhanced quality of life for large numbers of the world's population (UNESCO, 2010). Given the increasing use of technology in human life, the critical role of engineering education in addressing the pressing challenges of our societies is well recognised worldwide, and accordingly many countries of the world place engineering education and career engineering at a high pedestal as vital for economic growth (QEPEF, 2016). The importance of technical education, engineering education in particular, has been well acknowledged for a long period of time all over the world, including in India.

The contributions of engineering education in India that started largely with building roads and bridges is currently addressing several new and emerging challenges such as providing more equitable access to information for our populations, environmental protection and natural resource management, artificial intelligence, natural and man-made disaster mitigation and so on. Even today, a large number of engineering graduates from India have made an impact in the corporate world internationally. For instance, several Indian engineering graduates are working in the Silicon Valley of the USA and the survival and growth of IT sector in this region is said to be largely dependent on them. In the expanding global knowledge economy, the impact of specialised human capital for rapid economic growth is being realised and therefore, the demand for engineering education has gone up rapidly across the globe (Dubey et al., 2019).

There were only a handful of engineering institutions in India in the nineteenth century; but noticeable growth has taken place only after independence with the establishment of Indian Institutes of Technology (IIT), Regional Colleges of Engineering (known presently as National Institutes of Technology [NIT]) and other institutions. Slow and steady growth took place during the first three decades after the launching of development planning in India in 1950. Growth has picked up since the beginning of the 1990s and a phenomenal expansion has taken place during the last three decades.

Among the various disciplines of study in higher technical education, the growth of engineering education during the last 50 years has been most impressive. In 2018-19, around 13 per cent of all students enrolled in higher education are in engineering education (it was about 16 per cent in 2015-16, according to UGC [2018]), while this share was less than 5 per cent in 1990 and 7.2 per cent in 2005. Engineering & technology is the fourth major discipline (after arts, science and commerce) with an enrollment of 3.8 million students. In the 2018-19 academic year, close to one million students have graduated in engineering & technology.

However, during the last three decades, engineering education in India has gone through, like the rest of higher education, several pertinent transitions. The profession has also experienced several internal and external shocks, the major ones being declining public investment, rapid privatisation, shortage of faculty, and deteriorating quality. While the expansion of the higher education sector in India has helped the country to rapidly march fast towards a stage of massification, it is equally important to examine the trends and patterns of growth, as it is associated with several maladies. As a result today, engineering education faces umpteen challenges, including critical shortage of teaching faculty, poor quality of education, extremely limited research output, rising student fees, and overall costs of education, raising questions of affordability and inequalities in access, growing unemployment, low wages of engineering graduates, and son. Some of these problems are attributable to the unplanned and unbridled growth of the engineering education, a very rapid growth of the private sector, and weak and ineffective governance mechanisms. A careful look at the expansion of the higher education system in India reveals that the expansion has been uneven on several fronts. Besides high levels of spatial/regional (inter-regional, inter-state and intra-state) inequalities, with some regions/states growing fast and some lagging far behind others, high degree of inequalities exist in access to higher education between several groups of population – social (caste and religion), economic, and gender. These aspects have been highlighted by some scholars in the recent past (for example, Tilak, 2015; Tilak and Choudhury, 2019). In addition, an important dimension that has not attracted much attention of many scholars refers to disciplinary imbalances in the growth of higher education. Higher technical education has experienced fast growth particularly after the introduction of economic reforms in the early 1990s, which are widely felt to be irreversible. The high rate of expansion experienced especially during the last three decades has been propelled by the private sector. A high growth is clearly visible in cases of disciplines like engineering & technology, business management, financial management, hotel management, catering technology, architecture, town planning, pharmacy etc., which are revenue-rewarding streams for private investors in education (Anandkrishnan, 2014), as well as to the students in terms of dividends in the labour market as compared to other disciplines like the humanities and social sciences, natural and physical sciences, apart from the arts and fine arts which are almost extinguished. It may not be wrong to perceive that the growth in technical education has taken place at the cost of these disciplines, creating enormous disciplinary imbalances in higher education.

Some of these problems are common to the entire field of higher education, but they have assumed more acute proportions in the case of engineering education. In addition, there are specific problems associated with engineering education, such as imbalanced development of engineering education -– some sub-streams of engineering flourishing at the cost of other sub-streams, mismatches in the labour market reflected in gluts and shortages, rising fees and individual costs, predominant role of student loans, and so on. However, except for several committee reports, very few studies have been devoted to systematically analysing the major challenges and issues that engineering education is facing. Particularly, the absence of studies examining socioeconomic effects of the growth, including the nature of growth is striking, which help to understand how the new demand is created by the 'New Middle Class' (Fernandes, 2006). An important issue for examination is the inequality in the expansion of engineering education in India and the role of the private sector in this. It is worthwhile examining the changing trends and patterns in the growth of engineering education in the country, especially since the 1980s, and seeing whether the growth path was affected by economic slowdowns which brought a recession in the global economy, and what have been the changing policy responses to these issues. The complexities found in the global engineering labour market have changed the discourse on engineering education. Understanding the engineering education market nowadays is becoming quite complex in India, particularly with the emergence of different kinds of players with different interests, and a very large number of private-unaided institutions.

Among the very few studies on engineering education in India, Banerjee and Muley (2009) and Biswas et al., (2010) are important recent ones that provide a profile of the growth of engineering education in India. Banerjee and Muley (2009) document the trends in student intake, number of engineering graduates, post-graduates and PhDs. It also includes a comparison of a few select Indian institutions –- an IIT, a NIT and a private engineering college. Biswas et al. (2010) go a little further and attempt to make a good assessment of the status of engineering education in the country in the light of national and global changes. These two studies serve as a precursor for our present study. Choudhury (2016) in a short paper briefly examined the growth of engineering education in India in the post economic reform period with a specific focus on expansion, enrollment pattern and public financing. During the last decade, that is after those major studies were conducted, there have been several changes in engineering education in India, and global conditions. In fact, as Madheswari and Mageswari (2020, p. 215) observed, today "VUCA (Volatile, uncertain, complex and ambiguous) characterise the engineering education scenario." All this necessitates a fresh study, which is attempted here. How volatile, uncertain, complex and ambiguous the system has become? We discuss the changing landscape of engineering education in India using the data from several secondary sources and reports published by the Government of India with the hope of inspiring new studies and informed discussions. The paper is an attempt to provide a comprehensive and up-to-date assessment of engineering education in India. It aims to identify and explore the major issues and new challenges faced by this sector in the contemporary times. We approach to examine the issues in engineering education in a different way from the few earlier research studies as we integrate major issues in this filed to get a comprehensive picture that would undoubtedly contribute to on-going policy discourses and debates considerably and to further research. It must, however, be stated at the very outset that the analysis is limited with the availability of secondary data to several specific indicators on engineering education in India.

This paper presents a critical, descriptive and analytical account of some of these challenges that engineering education in India faces, and its prospects, using available data on engineering education and on conditions in the labour market for engineers, and on the basis of a variety of alternative indicators. The analysis covers five major dimensions: First, the trends and patterns in the growth of engineering education in India and the major changes it has experienced over the years are discussed, particularly considering the expansion in terms of number of institutions and enrollments. Second, it also describes the emerging strong role of the private sector vis-à-vis the public sector in engineering education. In fact, since almost all the dimensions of growth in engineering education have an interface with the growing role of the private sector, we are not discussing the role of the private sector in a separate section. In fact, if one is speaking about engineering education in India, one would only be speaking about private education, as the public sector hardly accounts for 10-15 per cent of the total engineering education sector in the country. Third, concentrating on regional imbalances in the growth of engineering education, the study examines the region and state specific growth of engineering education and inequalities in growth in engineering education both at the regional and the state level. We also cover inequalities in access to engineering education by caste and gender. At the same time, we also recognise the caste, gender and region interacting with each other exacerbating inequalities. Fourthly, we discuss quality concerns of engineering education in India, Fifth, using the data on public expenditure from *Analysis of Budget Expenditure on Education* (MHRD) and on household spending (collected from the National Sample Survey Office [NSSO]) some of the emerging concerns in financing of engineering education in the country are discussed. Sixth, changing labour market conditions that influence the demand for engineering education in India are analysed. The labour market conditions include employability, unemployment and wages associated with engineering graduate manpower. We also look at policy reforms that have been introduced at various points and the policy reforms that are being presently discussed. In a sense, the paper is narrowly concerned with engineering education, though some aspects of technical education as a whole are also briefly examined, but on engineering education, the attempt has been to be comprehensive in coverage of analysis of issues.

An important contribution of the study is an analysis of the most recent data available in multiple sources of secondary data, policy documents and media reports on many aspects relating to engineering education. As the study is empirical in nature, the analysis mainly focuses on examining the issues using the latest data on standard indicators such as the number of engineering institutions, enrollments, sanctioned intake,[1] attendance, faculty size, public (union and state governments) expenditure, household expenditure, employment and wages/salaries for engineering graduates. Reliable quantitative information is not adequately available to analyse aspects such as the labour market conditions and quality issues in engineering education, and therefore, some proxy variables are used. For example, information on the qualifications of the faculty appointed in engineering institutions, and on their contributions to research, teaching and the third function –- engagement with the society and community service would have been better indicators of quality of teachers. We do not have information on these aspects.

At the outset, an important limitation of the study may be briefly noted. First, engineering education is offered in India in polytechnic institutes and colleges/universities and both are recognised by the All-India Council for Technical Education (AICTE), the apex body meant to regulate technical education in the country. Diploma level programmes of 3-4 year duration are offered in polytechnics and degree (the first degree of four year duration, second/post graduate/master's level degree generally of two years duration or integrated degree programmes of five years, and research -– PhD studies of about four- year duration) programmes are offered in colleges and mostly in universities and university-level institutions only. As per the latest statistics (2019-20), there are 3706 polytechnics with an enrollment of 6.1 lakhs, and 3168 degree (and post graduate degree) level institutions with an enrollment of 8 lakhs. Thus, in all, there are 1.4 million students in engineering education in the country in 6163 institutions.[2] Students who complete secondary education (grade 10) are eligible for admission in polytechnics, while students have to complete senior secondary level (grade 12) for admission in degree programmes. Diploma programmes are less expensive with lower levels of fees than degree programmes, and hence they are also accessible relatively more easily to the middle and lower socio-economic strata of the society. While both diploma and degree programme are high in demand and are also valued in the labour market, a good number of secondary school graduates who complete diploma programmes also join degree programmes in the second year or third semester, given the social status accorded to degree programmes and additional advantages in wages associated with degree programmes. Though thus polytechnics form a sizeable part of engineering education, we focus here essentially on degree level engineering studies which form a part of higher education, except for occasional reference to the pre-degree diploma studies.

The rest of the paper is organised as follows: the next section gives a brief account of the major data sources used in the study. Section 3 examines the changing trends and patterns of the growth of engineering education in terms of institutions and enrollment,

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1 Figures on 'in-take' refer to number of admissions sanctioned/approved by the government or the AICTE in a given institution, while enrollment or admissions refer to the number of students actually admitted. Rarely one can admit more students than the sanctioned intake. If the intake is higher than admissions, it refers to unused/excess capacity of the institution.

2 https://facilities.aicte-india.org/dashboard/pages/dashboardaicte.php (accessed on 15 November 2020).

particularly highlighting the changing growth pattern of this sector observed during the 1990s and later. Specifically, it discusses changes in the demand for engineering education in India during the last three decades as this period has experienced dramatic global and national events -– globalisation, emergence of global markets, and global economic slowdown -- which have had an enormous impact on the engineering education sector. In fact, along with economic reforms, the 1990s has also been associated with a social upsurge over the rights and privileges, including reservations in higher education and employment, of weaker sections in India. Inequalities in the growth in engineering education are discussed in Section 4, by examining variations in access of weaker sections of society identified by region, gender, social (caste) and economic groups to engineering education. Also, an attempt is made to compare and contrast the expansion of engineering education with the growth of other branches of technical education, and other branches of higher education including social sciences in this section. Section 5 looks at the quality concerns of engineering education in India. It starts with discussing the recruitment of teachers, and their qualifications, as these are significantly related to the quality of faculty which will have an impact on their teaching and research. We also refer in this context to issues on regulation and accountability using National Board of Accreditation (NBA) reports and other policy documents of the AICTE and MHRD with an expectation that they may reveal relatively unknown factors if any, behind the expansion of the private sector in engineering education and its impact on quality. The section also reviews some curriculum related issues that are linked with the much debated industry-institute linkages. Also we look at global university rankings and the National Institute of Ranking Framework (NIRF) data of MHRD that gives a comparative idea of quality of various engineering institutions in India. In Section 6, an attempt is made to unravel a few important dimensions of financing engineering education by the government and households. The analysis of data on public expenditure gives us an idea on the priority given by the state to technical education, and also specifically to engineering education and how it has led to the expansion of the private sector. The National Sample Survey data gives a few important details on household expenditure -- expenses on fees and other items by students in different types of institutions and courses of study. These figures give an idea on the individual cost of engineering education in India. In this context we also refer to data collected from some selected institutions' websites on various types of fees (tuition and other fees) charged by some public and private institutions. Section 7 focuses on labour market issues related to engineering education in India and how this field of higher education is influenced by the changing nature of work, both in the national and global markets. The issues discussed include employment/unemployment and employability of engineers, demand-supply mismatches in the labour market, outturn of graduates, placement (employment in campus recruitment), and wages and differences by gender, type of institutions and discipline of study and finally, we look at some of the confusing signals one gets from the ever-dynamic labour markets. An attempt is made in the closing section to draw a few major conclusions and policy recommendations that emerge from the study.

2. Sources of Data

The study is based essentially on secondary database. The sources of data used in the study include: *All India Survey of Higher Education* (AISHE) reports that cover almost the entire higher education, and the *Analysis of Budget Expenditure on Education* (ABEEE) (both published by MHRD), All India Council for Technical Education (AICTE) annual reports and online data on its website, and annual reports of the University Grants Commission (UGC). Quite a bit of data compiled from AICTE website are also presented in the paper (some in the Appendix) for further use by researchers. For information on labour market aspects, we rely on *National Employability Reports* (Aspiring Minds), reports of the National Association Commerce (NASSCOM), Federation of Indian Chambers of Commerce and Industry (FICCI), and individual institutions' websites and also media reports. Besides these, the paper uses the disaggregated individual specific unit level data available in the latest three education rounds the National Sample Survey Organisation (NSSO) -- the 75th round conducted in July 2017 – June 2018 (NSSO 2018), the 71st round (Social Consumption: Education and Health) conducted in January-June 2014 (NSSO 2014), and the 64th round conducted in July 2007 – June 2008 for data on household expenditure on education (NSSO 2008). The 64th round (*Participation and Expenditure in Education*) covers a sample of 1,00,581 households (63,318 rural households and 37,263 urban households); the 71st round (*Education in India*) includes a sample of 65,926 households (36,479 rural households and 29,447 urban households) from all over India, and the the 75th round (*Household Social Consumption Expenditure on Education in India*) collected data from 1.1 lakh households (64.5 thousand in rural areas and 49.2 thousand in urban areas). Unlike the more 'general' or 'normal' rounds, the focus of these three rounds of data was to collect information on three important issues related to education, in addition to many other household level characteristics in detail: participation in education, family expenditure, often referred to as private expenditure, incurred by households on education, incentives provided by the government, and the extent of educational wastage in terms of dropout and discontinuation along with the causes behind them. These surveys also provide data on the number of adults by the level of education attained, including higher education by discipline of study. Therefore, the NSS data would help us to get some specific information about the engineering graduates that are not available from the MHRD, UGC, AICTE and other government organisations. Using NSSO data, the paper attempts to examine student attendance in engineering education by income quintiles. The variations in the household spending on higher education are shown by gender, location (rural-urban), household consumption expenditure quintile, and type of institution. However, the findings from the NSSO data should be interpreted with caution as the sample size is small as we have restricted it to only engineering education, and that also varies from round to round. Our attempt to look at some issues at regional and state level from NSSO data ended up with too small sample size and therefore it is omitted.

3. Growth of Engineering Education in India: Trends and Patterns

A modest beginning for the development of engineering education in India was made in the nineteenth century[3]. The first engineering college was established for civil engineers in Roorkee (Roorkee College earlier known by the official name of Thomson Engineering College) in Uttar Pradesh in the year 1847. India had a very little growth in engineering and technical education during the pre-independence period. However, with the increase in the demand for technical workers, particularly to execute public work plans such as roads, railway, and bridges led to the opening of few engineering colleges in the mid-1850s and early 1900s. Some of the earliest engineering colleges established in the pre-independence period include Poona Civil Engineering College at Pune (1854), Bengal Engineering College at Shibpur (1856), Banaras Hindu University (1916), Visvesvarayya College of Engineering (1917) and Harcourt Butler Technological Institute, Kanpur (1920) (Bhatt, 2010). The training of all these colleges was primarily confined to the field of civil engineering. By Independence in 1947 there were only 44 engineering colleges in the country with an intake capacity of 3,200.

The importance of technical, especially engineering education was well recognised in independent India. Just two years before independence, that is, in 1945 the Sarkar Committee was appointed to suggest options for advanced technical education in India. The Sarkar committee recommended the establishment of higher technical institutes based on the Massachusetts Institute of Technology in the four regions of India. In the opening address to the IIT at Kharagpaur in 1951, the first Minister of Education of the Independent India Maulana Abul Kalam Azad stated, "One of the first decisions I took on assuming charge as Minister was that we must improve the facilities for higher technical education in the country [and] that we would ourselves meet most of our needs… I look forward to the day when the facilities of technical education in India will be of such a high level that people from abroad will come to India for higher scientific and technical training" (quoted in Kripal, 1990, p. 187). Going by the recommendation of the Sarkar Committee, the Government of India established five Indian Institutes of Technology (IITs) at Kharagpur (1950), Bombay (1958), Kanpur (1959), Madras (1960) and Delhi (1961) (Delhi was added on to the original four). The All India Council for Technical Education was set up in 1945 to oversee all technical education (diploma, degree and post-graduate) in the country. Government of India expanded the base for engineering education extensively in the post-Independence period through successive five-year plans, particularly with the establishment of IITs, and Regional Engineering Colleges (later named as National Institutes of Technology). Many engineering colleges have been established after independence, with the aim of making India a large industrialised country, and that this would require far more engineers than those produced by older institutions. The first three decades witnessed setting up of a big network of engineering institutions consisting of engineering polytechnics, regional

3 A brief history of engineering education in India is available in the Rao Committee report (2004), Singh and Singh (2014), and the Ministry of Education website - https://www.education.gov.in/hi/technical-education-hi (accessed 21 November 2020). Also see, among many, AICTE (1999).

colleges, national institutes and universities in India. As Bhargava (2001, p. 77) rightly observed, after achieving independence, "the Indian leaders in the government and the planners immediately realised the importance of developing engineering education in the country to ultimately build its industry, roads, dams, communication system, power and drinking water facilities and other infrastructure in general."

Engineering education was considered as the foundation for improvement of overall quality of life of people and to raise the living standards of the people and the nation. The growth of technical education system in India is linked with the economic growth and in the 1990s it was considered essential for the expansion of knowledge economy. The report of the High-Power Committee for Mobilisation of Additional Resources for Technical Education (AICTE, 1994) mentions that "Technical education is one of the most crucial components of Human Resource Development. It is a basic and essential input for national development and for strengthening our industry, economy and the quality of life of our people" (p. 2). The economic liberalisation launched in 1990s gave impetus to the growth of Information & Technology (IT) industry. As a result, starting from the 1990s demand for technical education in India rose significantly and engineering education became an attractive option to students as India started outsourcing IT and engineering services to the world, and employment opportunities in this field started growing exponentially (UNESCO, 2010; Dubey et al., 2019). Economic liberalisation and growth of service sector (relating to IT services) led to a high demand of engineering graduates in the country (Dubey et al., 2019). Rates of return to engineering education became very attractive. Based on NSSO data, Carnoy et al. (2010) has found that graduate engineers earn much higher than graduates in general higher education, and the rates of return are also high. According to these estimates, the private rates of return for graduate male engineers range from 20.4 per cent to 36.8 per cent, under alternative assumptions in 2006. Social rate of return ranged between 16 per cent and 18.6 per cent. These are much higher than returns to graduates in general higher education. The high rates of return provide main explanation for the rapid growth in private demand for engineering education. Some experts point to what they call the 'engineering boom' that started in 1995 and peaked in 2000s, triggered by the IT phenomenon. Responding to the demands of the labour market, MHRD (2011b) recommended upgradation and expansion of engineering institutions in the country, and the government initiated a significant expansion of engineering institutions for the second time during the Eleventh Five Year Plan (2007-2012), when 8 new IITs, 7 new Indian Institutes of Management (IIMs), 10 new NITs, 20 Indian Institutes of Information Technology (IIITs), 2 new Schools of Planning and Architecture (SPAs), 3 Indian Institutes of Science Education and Research (IISERs) and many other technical institutes were set up in the country. With the increase in the requirement of more engineers, particularly in the IT sector during early 1990s, many new private engineering colleges in the self-financing mode were established. Government engineering colleges were not sufficient to feed the industry's appetite for engineering and therefore, many private engineering institutions came up and this may be one of the reasons that IT as major subjects are offered in all most all private engineering colleges that were established in early 1990s in India. Further, in the changing nature of work environment all over the world (World Bank, 2019), engineering skills in the area of ICT, artificial intelligence, and other similar fields of engineering and technology gained big premium. With the expansion of Indian software service industry in 1990s, there was a growing demand for engineering graduates in the national and global markets at an unprecedented level. Accordingly there has had been an exploding demand for engineering education.[4]

During the last seven decades, engineering education in India has contributed immensely to growth and development specifically to the success of the industrial development of the country. The high growth of engineering education, particularly information technology and related strands of engineering has profoundly impacted every aspect of human life, and contributed to "breaking old barriers and building new interconnections in emerging global village" (Kasturirangan, 2004, p. 74). It enabled India very significantly to strengthen its service sector, particularly IT-enabling or IT-dependent service sector (Dossani and Patibandla, 2012). India's exports of IT services, essentially software services amounted to 40 per cent of total export of services in 2018-19. The surplus generated by these exports at US$81.9 billion in 2018-19, could offset 45.5 per cent of the trade deficit in goods (RBI 2020a). Nowadays the role of engineering and technical education is considered critical to India's aspirations of strengthening its reputation as a major competitor in the global knowledge economy (Blom and Cheong, 2010). Engineers are considered as "the backbone and form the core of a nation to enable it become a leading country in the world" (Bhargava, 2001, p. 77).

Thus, economic globalisation, emergence of knowledge markets associated with knowledge economies, changing payoffs to engineering graduates, and changing overall pay-structure of various professionals resulted in a large demand for engineering manpower by the IT industries and others and dramatically changed the technical education landscape of the country. In short, as a result of a multitude of factors there has been a phenomenal expansion and the extremely narrow base of engineering education with which independent India started has emerged into a large network of 2,373 institutions with more than 4 million students in 2018-19. With such a growth, "India has emerged as a major player in the world in the field of Engineering Education, and Indian engineers have contributed significantly to the economic and technological development of many foreign lands, not only in the Information Technology sector but also in general engineering services and in hi-tech research and development in solid state electronics, communications and embedded systems" (Biswas et al., 2010, p. ix).

Another important outcome has been that with the rapid growth the elite nature of engineering education slowly vanished to a great extent. The expansion of engineering education in India has attracted new waves of lower-income students to meet their aspirations for getting trained in technical fields (Loyalka et al., 2014). The social aspirations of the middle class and the opening up of economic opportunities due to globalisation on the one hand, the availability of student loans, and the introduction of new policies such as fee-reimbursement and financial assistance on the other have enabled huge numbers of students from the low and middle income classes to opt for

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4 According to a report of the Queen Elizabeth Prize for Engineering Foundation (2016) while just 20 per cent of 16 to 17 year-olds from the UK and 30 per cent from USA are interested in engineering career, the rate is as high as 80 per cent in India, the highest in the world. https://qeprize.org/news/recognising-engineering

studies in engineering education in India.[5] An engineering degree is a preferred option for most senior secondary school graduates, and not just academically bright and economically well-off students. With the expectation of higher returns in Indian and global labour markets from engineering studies, and also high returns in the marriage market in the form of dowries (Mishra, 2011),[6] the demand for engineering education has become very diverse. An engineering degree is also viewed as a passport for entry into prosperous western labour markets. Access to engineering education is seen as an aspiration for social mobility and to reach a higher level of social status. Engineering education that was considered as an exclusive space for Indian elites till the 1990s has seen a turn by catering to the new ambitions of middle-class families. There was greater aspiration among new middle-class parents to send their offspring for engineering/technical studies, with the expectation that it would improve their own socioeconomic status in the society. In fact, parental aspirations and resultant pressures were higher than the students' aspirations.[7]

The net result was that: overall access to engineering education improved dramatically. Enrollments in engineering & technology have increased from 96 thousand in 1975-76 to 4.1 million in 2018-19. In 2018-19, enrollments in engineering & technology constituted 13 per cent of the total enrollments in higher education. The corresponding figure was a little around 3 per cent in 1960-61, as shown in Table 1. The growth in enrollments has probably been faster than anywhere else in the world, and India is now regarded as having the second largest number of engineering students in the world, producing about 9 lakh graduates a year (2017-18). Around 25 per cent of the world's engineers are produced in India (Madheswari and Mageswari, 2020, p. 215); and India is regarded as the world's number one country in producing engineering and science graduates (National Science Foundation 2018). However, at the same time it is important to examine the nature of the growth of engineering education and its overall effects. The growing demand for technical education coupled with the inability of the state to invest further in technical education, has led to the liberalisation of technical education (Mani and Arun, 2012) and resultantly the private sector seized the opportunity and almost invaded the engineering education sector. In 1947 there were only two private unaided colleges of engineering in India; the number could increase to 15 by 1980. But between 1980 and 1990, the number increased by ten times, and the curve went on a steep rise thereafter.

5 See Reddy and Reddy (2019) for an account of how fee reimbursement scheme in Andhra Pradesh lead to explosion in numbers of enrollment and institutions in Andhra Pradesh.

6 In the marriage market, engineering degrees, particularly from IITs are highly valuable (Mishra 2011). Parents of the girls with degree would pay a reduced amount as dowry to the grooms' parents, while boys with degrees raise the amount of dowry they demand from the brides' parents.

7 In an interesting case of discussion with 1000 engineering studies, a "majority of students confessed that they never wanted to pursue engineering but did so because of parental pressure" (Rao, 2019).

Table 1. *Growth of Engineering Institutions and Enrollment in India*

Year	Institutions			Enrollments		
	Higher Education	Engineering Education	Share of Engineering in Higher Education (%)	Higher Education ('000)	Engineering Education ('000)	Share of Engineering in Higher Education (%)
1950-51	606	53	8.75			
1960-61	1864	100	5.36	1,048.00	37.00	3.53
1965-66	2298	103	4.48	1,728.77	85.60	4.95
1970-71	3299	107	3.24	3,001.21	90.03	3.00
1975-76	4124	109	2.64	2426.11	96.06	3.06
1980-81	4,396	149	3.38	2,752.44	128.94	4.68
1985-86	5,427	242	4.46	3,605.02	176.54	4.90
1990-91	6,323	277	4.38	4,924.87	216.84	4.40
1995-96	8,188	355	4.34	6,574.00	315.72	4.80
2000-01	11,568	678	5.86	8,399.44	529.47	6.30
2005-06	20,769	1,562	7.52	12,043.05	795.12	6.60
2008-09	25,951	2,237	8.62	15,768.42	1,313.70	8.33
2012-13	37,204	3,371	9.06	21,501.15	3,333.16	15.50
2015-16	42,188	3,364	7.97	34,584.78	4,885.13	14.13
2018-19	42,846	3,124	7.29	37,399.39	4,076.28	10.90
Growth Rate*	6.46	6.18	-	6.36	8.44	-

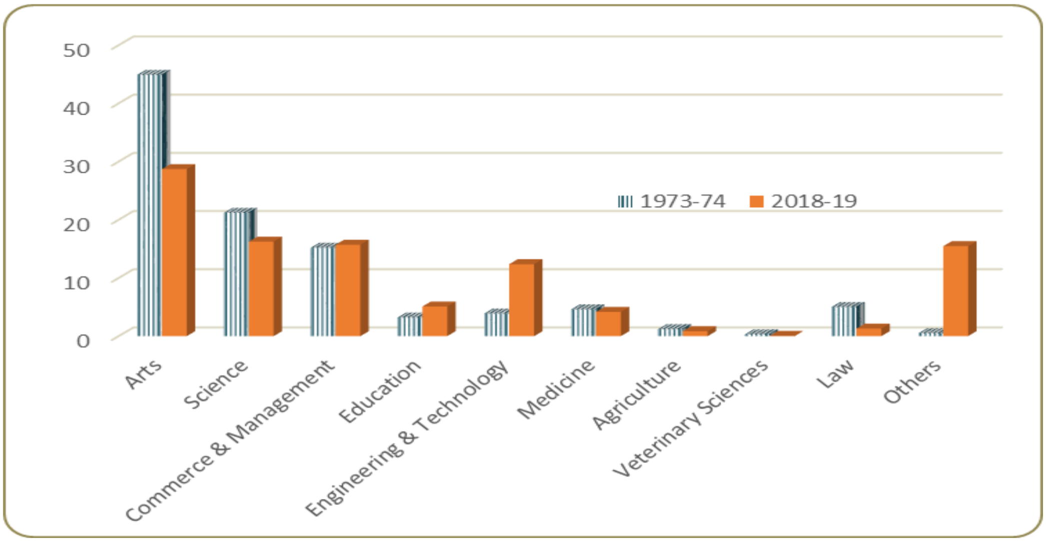
* Compound rate of growth per annum (%)
Source: UGC *Annual Report* (Various Years)

Thus, starting from the late1980s, the private sector started slowly participating in engineering education and increased the pace very fast, as the government adopted a 'low public cost' strategy promoting private self-financing (unaided) engineering colleges and universities. This strategy immensely helped the government in expanding access to engineering education, and at the same time building its political legitimacy, and all with little public investment (Carnoy et al., 2010). Private engineering colleges and 'institutions deemed to be universities', known briefly as deemed universities, under the self-financing mode, have been established in big numbers in a very short period, and today the Indian engineering education system is characterised by the preponderance of private (self-financing) colleges and deemed universities. It is important note that the growth of private sector in engineering education in India, can be explained in terms of 'excess demand' and not 'differentiated demand' (Weisbrod, 1977; James 1987, 1993).

The private sector, which accounted for just 15 per cent of enrollments in 1960, by 2019 accounted for 86 per cent of admissions and around 86 per cent of all engineering institutions in India (Kapur and Mehta, 2004; AICTE, 2019). In states like Andhra Pradesh, Kerala, Karnataka, Tamil Nadu, Telangana, and Maharashtra, the percentage of private engineering colleges in the total engineering colleges was more than 95 per cent in 2019. This meteoric growth of the private sector has been in response to the growing aspirations of the middle class coupled with the opening up of the Indian economy. As the government engineering institutions do not have the scope to accommodate the increasing demand, private actors played a dominant role, helped by an easy permissions system of state governments and an equally easy approval mechanism of the AICTE, the apex body for technical education in India. Several private registered trusts and societies, including mainly those with commercial interests, have contributed to this phenomenal growth of engineering education in the country. In a sense, the private sector has displaced the public sector in higher education, more specifically in engineering education, leaving no space for the public sector to function, not to speak of it to re-emerge as an important player in higher education in the country. Unlike philanthropy-based private institutions, these self-financing private institutions exploit the weaknesses of the system, including the ineffective governance and regulation by the state, imperfections in the market, and attitudes of gullible parents; and function similar to for-profit higher education sector that has grown in USA wherein students/families actually buy higher education services in the education bazaars (Kirp, 2003; Ley, 2006; Kinser and Levy, 2007; Hodgman, 2010). The net result of all this is that the basic intrinsic values of higher education such as its positive externalities, the social purpose and the nation-building role that higher education ought to serve and above all the public good nature of higher education have tended to disappear in favour of pecuniary values (Tilak, 2009).

As discussed above, higher education in India has experienced a substantial growth in terms of the number of institutions and student enrollments during the last five decades. But all disciplines of higher education have not grown at the same pace. Data on discipline-wise distribution of enrollment in higher education reveals some interesting points: first, enrollment in the arts and humanities programmes is the highest among all disciplines in higher education, and this feature continues for the last five decades, but the relative share has declined from 45 per cent in 1973-74 to 38.6 per cent in 2018-19 (see *Figure 1*). Second, the enrollments in engineering & technology as a proportion of the total enrollments increased from 3.9 per cent to 12.4 during the same period. This is the discipline which has experienced the highest growth. Other disciplines such as commerce & management, education and law also registered rise in respective shares over the period. But not only arts and humanities, but also sciences, medicine, agriculture and veterinary sciences suffered during this period, experiencing declining shares in total enrollments.

Figure 1. *Changing Distribution of Enrollments among Major Areas of Study in Higher Education in India (%)*

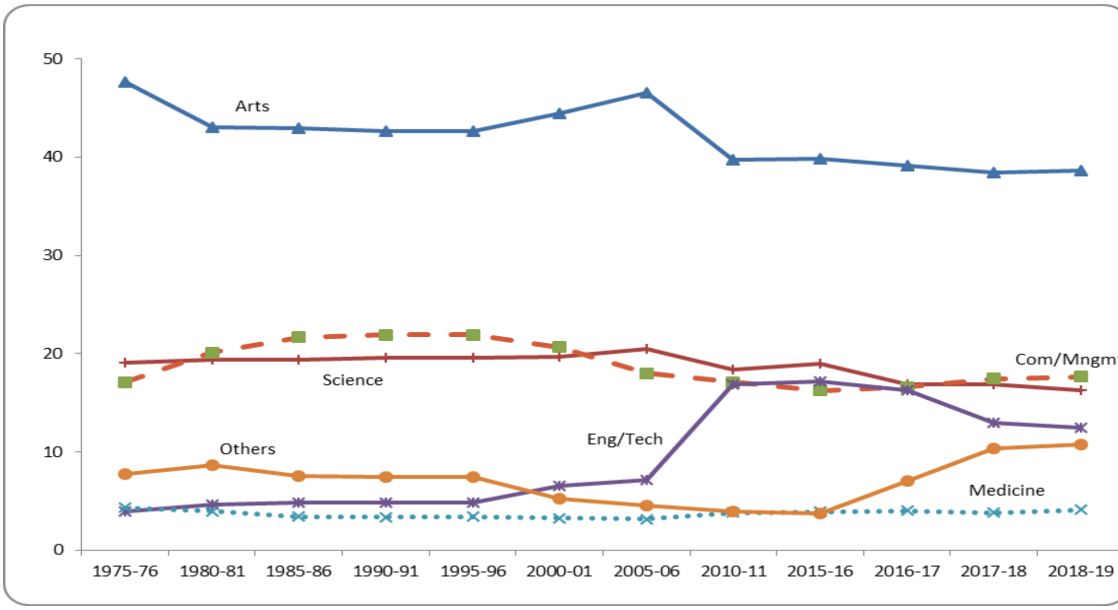


Source: UGC (1975-76) for data on 1973-74, and MHRD (2019) for 2018-19.

The time-series data presented in *Figure 2* show that the trends are not smooth over the period. The decline in the relative share of arts began in the mid-1970s itself. After 2005-06, the fall was a little bit sharp. Commerce and management faculties enjoyed a good share, in fact, an increasing share until 1990-91, and ever since then a short phase of decline started which continued until 2005-06. Between 2005-06 and 2018-19, it experienced a phase of slow and steady growth. The trend line in case of the sciences was more or less static until 2001-01; the share marginally increasing by 2005-06, but the rising trend could not continue later.

Of all the major disciplines, it is in the case of engineering & technology that we find five distinct phases during the period 1975-76 to 2018-19. During the first two decades, that is, 1975-76 to 1995-96 there was a very slow but steady growth; then during the next decade the slope changed to a marginally higher level. This phase was followed by a big surge between 2005-06 and 2010-11, when it reached its peak; it could maintain that level between 2010-11 and 2016-17. But in response to national and global economic problems including specially employment, serious cracks affected the engineering education sector during the last three to four years when demand for engineering education began to decline, and colleges were being closed. The relative share of engineering & technology education fell sharply from nearly 16 per cent in 2015-16 to below 11 per cent in 2018-19. Will this downward trend be a short phase or a long one? It is difficult to make any predictions. But given the increasing importance of technology in national and global development, one can expect that the trends will be reversed; but it is difficult to predict how soon will it happen.

Figure 2. *Trends in Enrollments in Major Disciplines in Higher Education in India (%)*



Source: UGC *Annual Reports* and *All India Survey of Higher Education* (various years)

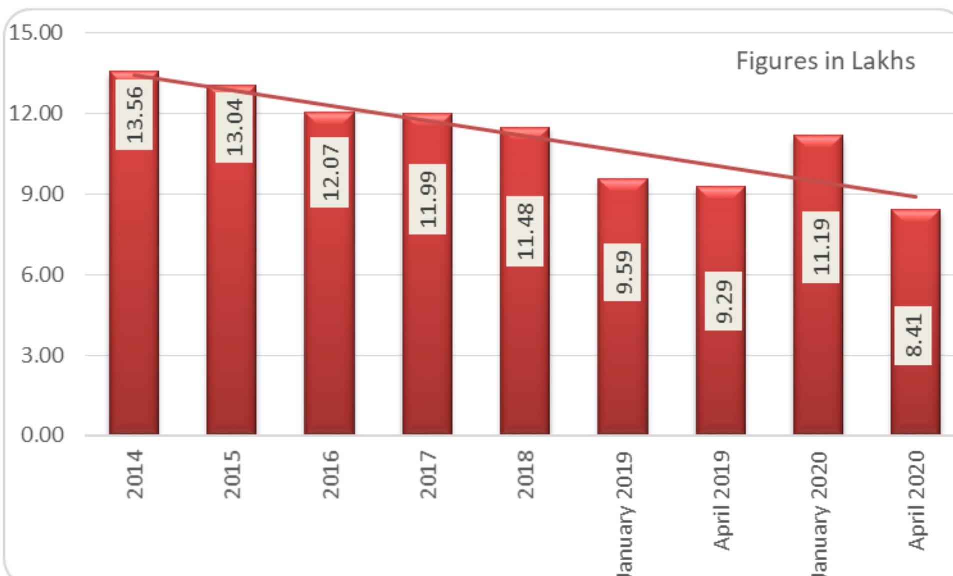
On the whole, engineering & technology education registered a very significant growth, compared to other disciplines and higher education as a whole, as shown in *Table* 1. The number of engineering institutions increased from a meagre 53 (in 1950-51) to 3,124 in 2018-19, a growth by 59 times over the last 69 years (*Table* 1). Likewise, student enrollment in engineering studies has gone up from 37 thousand to 4.1 million (an increase by 110 times) during 1960-61 and 2018-19. The share of enrollments in engineering studies in overall higher education has also gone up from a little below four per cent (1960-61) to 11 per cent in 2018-19.[8] The rate of growth of both institutions and enrollments in engineering education was quite high. However, recent years have seen a decline in the number of engineering institutions from 3,371 in 2012-13 to 3,124 in 2018-19. Similarly, the share of engineering in enrollments in higher education reached a highest proportion of 15.5 per cent in 2012-13 and declined afterwards. While higher education as a whole grew at a rate of growth of 6.4 per cent per annum between 1960-61 and 2018-19, the enrollments in engineering education increased at a rate of growth of 8.4 per cent during this period of nearly two-and-a-half decades. Similarly, number of colleges and universities in overall higher education increased at the rate of growth of 6.5 per cent, as compared to 6.2 per cent in case of institutions of engineering education. The

8 This corresponding figure was nearly 16 per cent and the enrollments were 4.9 million in 2015-16, which thereafter declined to 4.1 million in 2018-19.

number of universities and colleges for engineering & technology has grown unchecked, particularly during the last three-four decades. As a result, there seem to be too many. It is widely being recognised that India has too many engineering institutions, and there is a need to control the growth of the institutions. While some have suggested closure of some of the institutions, some (MHRD, 2003; World Bank, 2013) suggested that the number needs to beat least kept constant, and no new colleges be allowed to be opened.

More than enrollments, it is the number of registrants for entrance may reflect the demand for engineering education more accurately. The decline in demand for engineering education after 2014 is abundantly clear from the decline in the numbers relating to the national level common entrance examination, known as the Joint Entrance Examination (JEE) (*Figure 3*). The ranks obtained in the JEE are used not only by the IITs, NITs and other national institutes, but also often states and some specific institutions rely on JEE scores/ranks.

Figure 3. *Declining Number of Registrants for Joint Entrance Examination for Admission in Engineering Studies, 2014-2020*



Source: https://www.shiksha.com/b-tech/jee-main-exam

In general, the massive expansion of engineering education in India is mainly due to the increased level of participation by the private sector. It is argued that the expansion of the private sector and the emergence of a new educational economy in India, particularly in engineering and technical education, has resulted in widening inequalities in educational opportunities. In 2012-13, private institutions were 91.5 per cent of the all the under graduate level engineering institutions in the country, with an enrollment share of 93.1 per cent (*Table* 2). There has been a marginal decline in engineering education in the recent years. The share of the private sector in enrollments has come down to 86.7 per cent with an intake capacity of 85.5 per cent of the total engineering intake in 2018-19. While the private sector obviously reacts to market signals, a detailed study is needed to understand the investment strategies of private players in higher education that would provide useful insights on the changing investment strategies in higher education in India.

The expansion of the private sector in engineering education varies widely across different states in India. For instance, in some states/union territories such as Andhra Pradesh, Telangana, Uttar Pradesh, Madhya Pradesh and Maharashtra, the share of private institutions to total engineering institutions is higher than the national average (see *Table* 3).

Table 2. *Growth of Institutions and Intake by Type of Institution in Engineering Education in India*

	Institutions			Intake (in thousands)		
Year	Government	Private	Total	Government	Private	Total
2012-13	286	3085	3371	106.9	1445.2	1552.1
	(8.5)	(91.5)	(100)	(6.9)	(93.1)	(100)
2013-14	308	3075	3383	118.9	1515.4	1634.3
	(9.1)	(90.9)	(100)	(7.2)	(92.7)	(100)
2014-15	310	3090	3400	122.8	1582.6	1705.4
	(9.1)	(90.9)	(100)	(7.2)	(92.8)	(100)
2015-16	312	3052	3364	118.8	1512.7	1631.4
	(9.3)	(90.7)	(100)	(7.3)	(92.7)	(100)
2016-17	332	2961	3293	122.0	1435.1	1557.1
	(10.1)	(89.9)	(100)	(7.8)	(92.2)	(100)
2017-18	347	2878	3225	127.7	1348.8	1476.4
	(10.8)	(89.2)	(100)	(8.7)	(91.4)	(100)
2018-19	413	2711	3124	199.028	1205.9	1404.8
	(13.2)	(86.8)	(100)	(14.2)	(85.8)	(100)

Source: Compiled by the authors from AICTE Database

Of the total 2,711 private engineering institutions in the country, more than 16 per cent are located in Tamil Nadu alone, and the corresponding figure is 11.3 per cent each in Andhra Pradesh and Maharashtra. Similarly, with respect to intake in private engineering institutions these states enjoy an advantage, with the intake rates being higher than national average.

Table 3. *State-wise Intake in Government and Private Engineering Institutions in India (2018-19)*

State and Union Territories	Institutions			Intake		
	Government	Private	Total	Government	Private	Total (in 000's)
Andhra Pradesh	16	289	305	9790	146376	156.2
	(5.3)	(94.8)	(100)	(6.3)	(93.7)	(100)
Assam	11	8	19	2415	2670	5.1
	(57.9)	(42.1)	(100)	(47.5)	(52.5)	(100)
Bihar	20	18	38	4990	6030	11.0
	(52.6)	(47.4)	(100)	(45.3)	(54.7)	(100)
Chhattisgarh	7	39	46	1930	17052	19.0
	(15.2)	(84.8)	(100)	(10.2)	(89.8)	(100)
Delhi	9	8	17	3938	5160	9.1
	(52.9)	(47.1)	(100)	(43.3)	(56.7)	(100)
Gujarat	20	106	126	11325	50231	61.6
	(15.9)	(84.1)	(100)	(18.4)	(81.6)	(100)
Haryana	18	112	130	6181	35692	41.9
	(13.9)	(86.2)	(100)	(14.8)	(85.2)	(100)
Himachal Pradesh	4	13	17	900	4293	5.2
	(23.5)	(76.5)	(100)	(17.3)	(82.7)	(100)
Jammu & Kashmir	6	5	11	1785	2160	3.9
	(54.6)	(45.5)	(100)	(45.3)	(54.8)	(100)
Jharkhand	8	12	20	2750	3771	6.5
	(40.0)	(60.0)	(100)	(42.2)	(57.8)	(100)
Karnataka	24	169	193	14720	88179	102.9
	(12.4)	(87.6)	(100)	(14.3)	(85.7)	(100)
Kerala	46	114	160	15114	40731	55.8
	(28.8)	(71.3)	(100)	(27.1)	(72.9)	(100)
Madhya Pradesh	15	171	186	6304	72609	78.9
	(8.1)	(91.9)	(100)	(8.0)	(92.0)	(100)
Maharashtra	30	333	363	9515	134546	144.1
	(8.3)	(91.7)	(100)	(6.6)	(93.4)	(100)
Odisha	10	84	94	6836	33609	40.4
	(10.6)	(89.4)	(100)	(16.9)	(83.1)	(100)
Puducherry	3	14	17	1260	6660	7.9
	(17.7)	(82.4)	(100)	(15.9)	(84.1)	(100)
Punjab	10	87	97	6175	29739	35.9
	(10.3)	(89.7)	(100)	(17.2)	(82.8)	(100)
Rajasthan	19	98	117	7895	37898	45.8

	(16.2)	(83.8)	(100)	(17.2)	(82.8)	(100)
Tamil Nadu	56	477	533	58975	238525	297.5
	(10.5)	(89.5)	(100)	(19.8)	(80.2)	(100)
Telangana	13	226	239	3874	114819	118.7
	(5.4)	(94.6)	(100)	(3.3)	(96.7)	(100)
Uttar Pradesh	28	225	253	9948	93997	103.9
	(11.1)	(88.9)	(100)	(9.6)	(90.4)	(100)
Uttarakhand	8	21	29	3420	7095	10.5
	(27.6)	(72.4)	(100)	(32.5)	(67.5)	(100)
West Bengal	19	74	93	5183	31530	36.7
	(20.4)	(79.6)	(100)	(14.1)	(85.9)	(100)
All India	413	2711	3124	198928	1205892	1404.8
	(13.2)	(86.8)	(100)	(14.2)	(85.8)	(100)

Source: AICTE Database

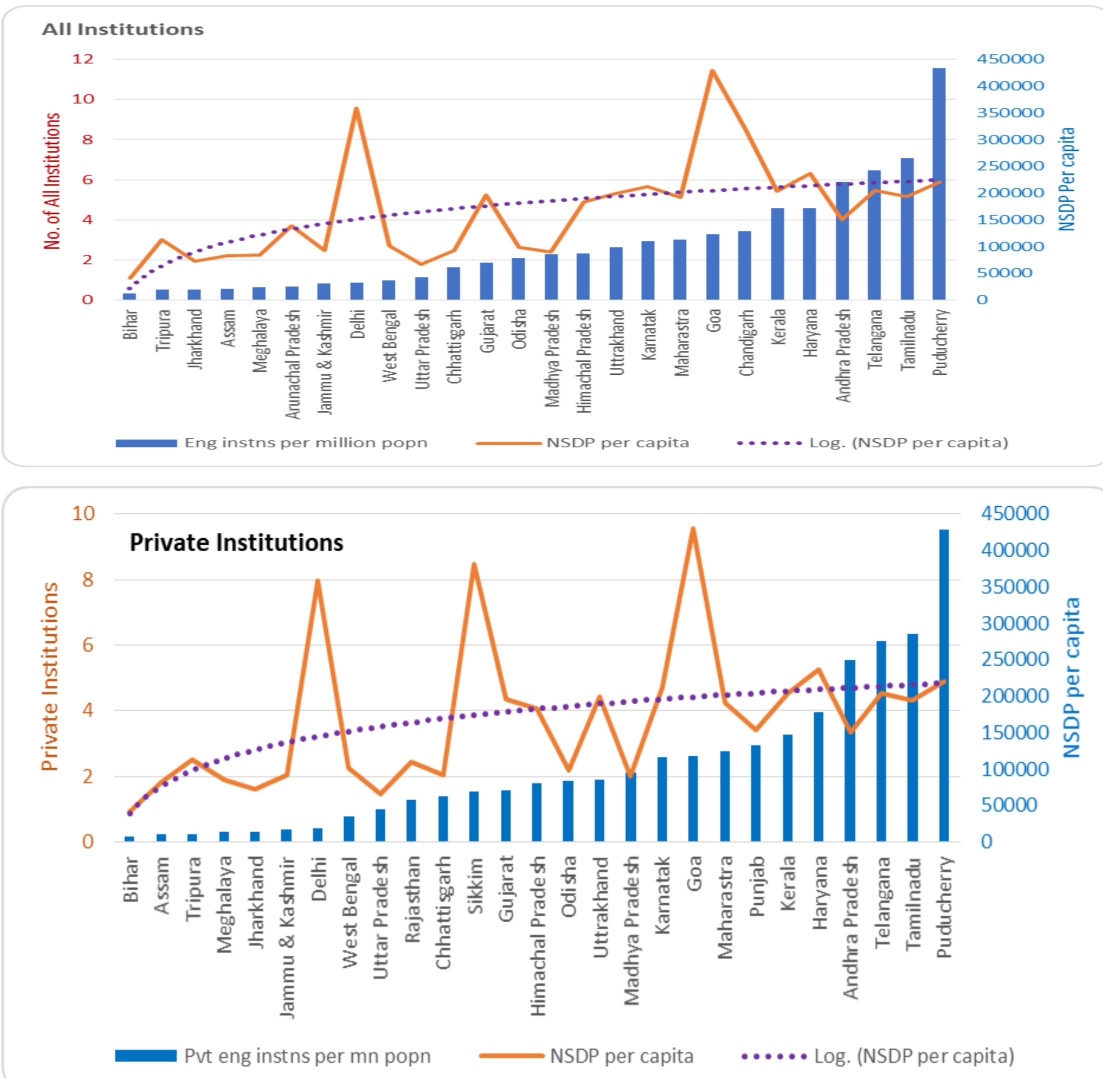
On the other hand, government engineering institutions in states like Delhi, Bihar, Assam, Jammu & Kashmir[9] and Jharkhand have higher intake levels. A majority of the economically better-off states (with per capita Net State Domestic Product higher than the national average) have a higher share of private engineering institutions than their counterparts, that is, states with low per capita national state domestic product (NSDP) with very few exceptions. At the macro-level, a direct relationship seems to exist between economic growth (NSDP per capita) and private participation in engineering education and also between total number of engineering institutions (per one million population) and NSDP per capita, as the logarithmic trend lines in *Figure 4* make it clear. The simple coefficient of correlation between NSDP per capita and all institutions is 0.69, and it is 0.47 between NSDP per capita and number of private institutions.

Apart from the level of economic development, is there any other factor that explains the growth of private sector? There may be several socio-political factors behind the growth or lack of growth of private sector in the states. The state policy also matters. Keeping these aside for a while, we wish to identify quantifiable factors, if any. First, we note that other variables like population of the age-group 18-23, which is the main pool from which demand for higher education emerges, or government expenditure on engineering education, inadequacy of which will encourage the private sector to take advantage of the situation and open private institutions, are not found to be statistically significant factors in explaining the variations between several states in the growth of all engineering institutions. State income per capita is the most important factor that positively influences the growth of the number of institutions, in addition to industrial production (gross value added as a percentage of gross state domestic product) which also influences positively the growth in the number of institutions (in 2012-13). But in

[9] Constrained by data availability, we refer to the state of Jammu & Kashmir, as it has been prior to recent reorganisation of Jammu & Kashmir.

another equation for 2018-19 we included rate of graduate unemployment,[10] which is also found to be having a positive effect on the number of institutions.

Figure 4. *Economic Growth and Number of Engineering Institutions (per One Million Population), 2018-19*



Source: Based on *All India Survey of Higher Education 2018-19* and *Census*

10 Graduate unemployment refers to all graduates, s we do not have data separately for engineering graduates by states. This was not available for 2012-13 also.

That is, higher the graduate unemployment, the higher would be the demand for education. With the inclusion of unemployment in the equation, industrial production has turned out to be not statistically significant. Second, we get similar results for the equation that is estimated to explain inter-state variations in private institutions (*Table 4*). After all, as the public sector institutions are generally small in number in every state, it is not surprising that the results are similar. However, in case of private institutions, industrial production turned out to be important both in 2012-13 and 2018-19. Further public expenditure is negatively related to growth in private institutions in 2012-13; the coefficient is statistically significant at 90 per cent level of confidence. As one expects, as the government expenditure on engineering education declines, private sector takes advantage and opens more and more institutions.

Table 4. *Factors that influencing Growth of Engineering Institutions*
(Dependent Variable: ln of Institutions per million Population)

	All Institutions		Private Institutions	
	2012-13	2018-19	2012-13	2018-19
Ln Net State Domestic Product per	1.2349***	0.9946***	1.1238***	1.0993***
capita (NSDP)	(0.431)	(0.309)	(0.451)	(0.303)
Ln Population (age-group 18-23)	-2.1668	-0.3686	-4.551*	-1.4316
	-2.108	(0.880)	(2.90)	(2.424)
Ln Gross Value Added from industry	0.4235**	0.0222	0.656***	0.4745**
% of GSDP	(0.209)	(0.029)	(0.241)	(0.278)
ln Public Expenditure on Education	-0.1783	-0.0032	-0.332*	-0.1209
as % of GSDP	(0.159)	(0.101)	(0.173)	(0.122)
Ln Graduate Unemployment Rate		0.8031**		-0.6751
		(0.416)		(0.537)
Intercept	-9.6964	-12.9716	-4.089	-12.6079
	(5.772)	(3.591)	(7.236)	(7.315)
Number of Observations	25	26	23	26
F-value	8.01	5.12	6.97	5.12
R-Square	0.531	0.553	0.525	0.552

Figures in ( ) are robust standard errors. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Source: Authors' calculations.

Many private institutions are not in a position to fully use their intake capacity. The admission rate as a proportion of sanctioned intake, which is also referred to as 'occupancy rate', has significantly gone down in the recent past -- from 62.4 per cent in 2012-13 to 51.1 per cent in 2018-19 (*Figures 4* and *5*). We notice regional[11] variations in this

11 AICTE has classified all states into seven regions: central region consists of Madhya Pradesh, Chhattisgarh and Gujarat; the eastern region consists of Mizoram, Sikkim, Odisha, West

too. Thus, in 2018-19 around half of the sanctioned seats remained vacant. As many as 61 per cent of the seats in the north-west region are vacant. In the country's western and southern regions, the enrollment of students in engineering courses is relatively better as the enrollments formed 59.7 per cent and 54.2 of the sanctioned intake respectively. Regional imbalances in the growth of private higher education (in terms of both institutions and enrollments) continue to be a major issue, recognised as a serious concern long ago in the National Policy on Education in 1986.

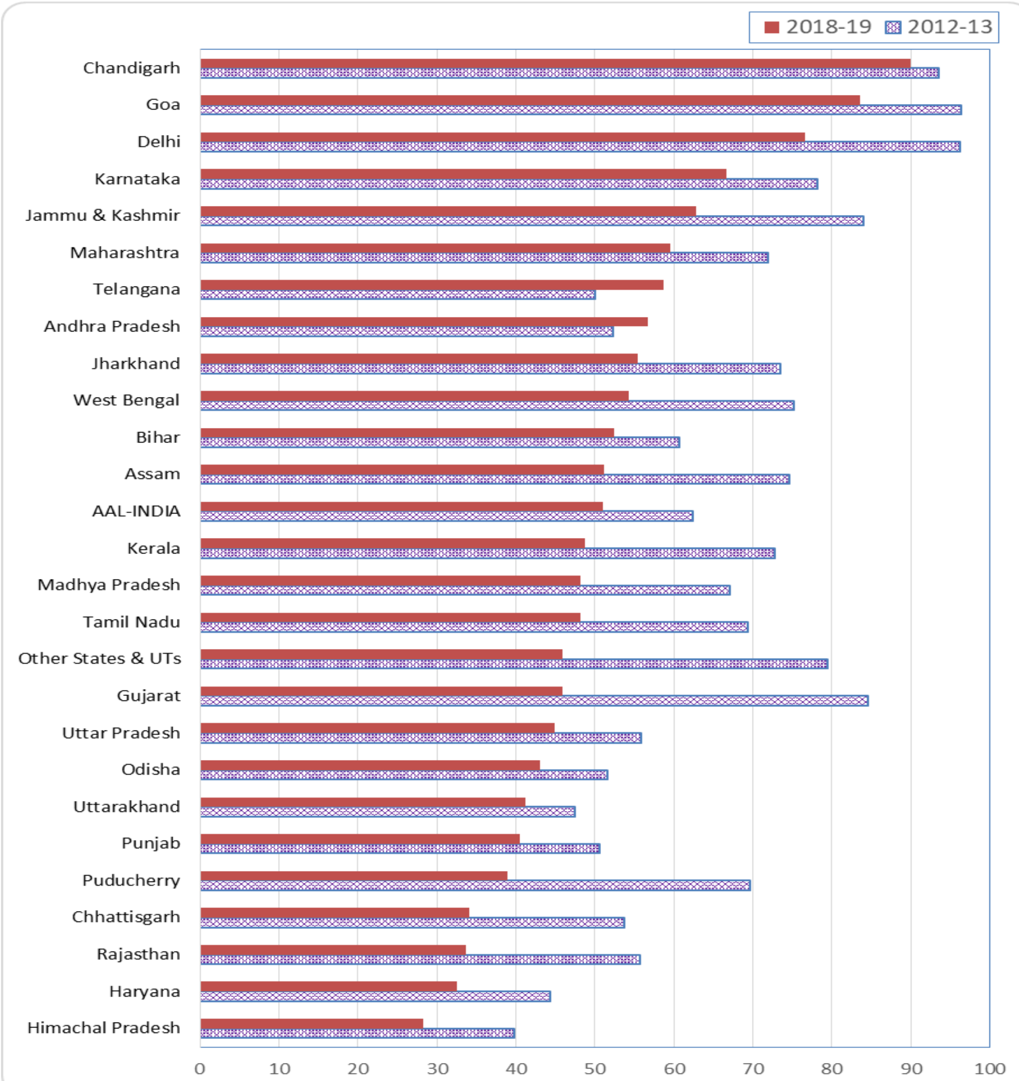
Similarly, enrollments as a proportion of intake capacities also vary widely across different states. For instance, in some of the states/union territories such as Delhi, Chandigarh, Goa, Karnataka and Telangana, this share is higher than the national average of 51.1 per cent in 2018-19 (*Figure 5*). Unexpectedly, states like Tamil Nadu, Kerala and Punjab, which are much ahead of others in case of growth of technical and professional education, fare poorly with enrollment as a proportion of intake below the national average. This ratio is the lowest (around 30 per cent) in Himachal Pradesh, Haryana, Rajasthan and Chhattisgarh. This proportion has declined over the past six years in all the states except in Andhra Pradesh and Telangana, where it is around 60 per cent, as can be seen from *Figure 5*.

Though the number of institutions and also the enrollments vary between states, one expects the variations to be minimum, if these indicators are standardised while measuring. So we considered number of institutions per one lakh population and enrollments per one million population. But even when the variables are thus standardised, we find wide variations between states, the coefficient of variation being 0.87 in case of institutions and 0.99 with respect to enrollments in 2018-19. Further, the inter-state inequality so measured increased in case of both between 2012-13 and 2018-19. The inequality in enrollments is higher than in the number of institutions (*Tables 5 and 6*).

This decline in demand for engineering education is clear in the fall in the number of institutions and the enrollments as shown in Tables 5 and 6. There is a 7 per cent fall in the number of institutions and 26 per cent decline in enrolments between 2012-13 and 2018-19. The decline has happened in both cases in almost all states and union territories, with very few exceptions. It is noticed that a large number of private engineering colleges in different regions are either closed or run the risk of being closed soon due to low enrollments.

Bengal, Tripura, Meghalaya, Arunachal Pradesh, Andaman & Nicobar islands, Assam, Manipur, Nagaland and Jharkhand; the northern region includes Bihar, Uttar Pradesh and Uttaranchal; the north-west region includes Chandigarh, Haryana, Jammu & Kashmir, New Delhi, Punjab, Rajasthan and Himachal Pradesh; southern region includes Andhra Pradesh, Pondicherry and Tamil Nadu; the south-west region includes Karnataka and Kerala; and western region includes Maharashtra, Goa, and Daman, Diu & Dadra Nagar Haveli. The southern and south-west regions together are considered as southern region here.

Figure 5. *Enrollment as a Percentage of Intake in Engineering Education in India, by States (2012-13 and 2018-19)*

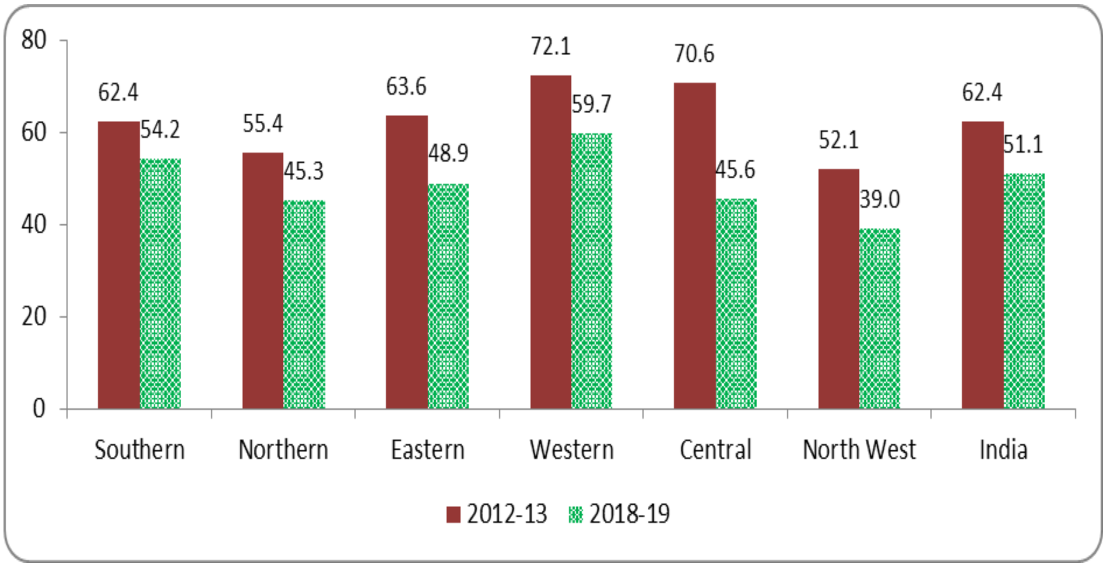


Source: AICTE Database

For instance, in the 2019-20 academic year, AICTE has approved 22 degree level private engineering colleges for 'progressive closure'[12] in the southern region. This figure was 24 in the academic year 2018-19. We refer to this further later.

12 'Progressive closure' means an institute cannot admit the students for the first year during the academic year for a progressive closure has been ordered. However the students (in the

Figure 6. *Enrollment as a Percentage of Intake in Engineering Education, by Region (2012-13 and 2018-19)*



Source: Based on AICTE Database

The decline in the student enrollment is largely in private engineering institutions and not in public institutions. The private ones did fairly well with rising student demand till 2010, but after the global economic slowdown in 2008, the impact of which was begun to be felt from 2010 onwards, clearly departing from early trends, there is a decline in the demand for engineering and other IT related areas of study across the globe, a phenomenon which is quite significantly visible in India. It was reported in the media that many private engineering colleges have shut their gates for new admissions, and the space is being used for running supermarkets, private schools, and gymnasiums in recent years in states like Uttar Pradesh, Haryana, Andhra Pradesh and Telangana. In 2018-19, 105 engineering colleges were closed (AICTE, 2018). Additionally 59 engineering colleges offering under graduate, post graduate and Diploma programmes are being closed in the current year (2020-21) by the AICTE. There are several private engineering colleges that are on AICTE's radar for low admissions, and they are running the risk of being closed at any time. According to AICTE data, of the 1.41 million BE/BTech student places available in 3,124 engineering colleges across the country, close to half (49 per cent) were not filled up in the academic year 2018-19; and the corresponding figure was 53 per cent in case of private-unaided/self-financing engineering institutions. The embarrassing reality is that thousands of student places in several self-financing engineering colleges have remained vacant over the years. Several engineering colleges in the country are tainted now as 'failed' institutions as they did not get enough revenues to survive.

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second year of studies onwards who are already on rolls) will continue their studies until they complete their four-year programme.

Table 5. *Number of Engineering Institutions in India, by States, 2012-13 and 2018-19*

	Institutions		Per one Lakh Population		Change (2012-13 minus 2018-19) in		% Change in Institutions
	2012-13	2018-19	2012-13	2018-19	No. of Institutions	Per One Lakh Population	
Andhra Pradesh	357	305	71.5	58.7	-52	-12.8	-14.57
Assam	14	19	4.4	5.6	5	1.2	35.71
Bihar	22	38	2.1	3.2	16	1.2	72.73
Chhattisgarh	50	46	19.3	16.2	-4	-3.0	-8.00
Delhi	18	17	10.5	8.7	-1	-1.7	-5.56
Gujarat	110	126	17.9	18.8	16	0.9	14.55
Haryana	159	130	61.7	46.0	-29	-15.7	-18.24
Himachal Pradesh	21	17	30.3	23.4	-4	-6.9	-19.05
Jammu & Kashmir	8	11	6.5	8.4	3	1.9	37.50
Jharkhand	14	20	4.2	5.4	6	1.3	42.86
Karnataka	192	193	31.1	29.6	1	-1.5	0.52
Kerala	153	160	45.5	45.8	7	0.3	4.58
Madhya Pradesh	226	186	30.6	22.9	-40	-7.7	-17.70
Maharashtra	369	363	32.5	30.0	-6	-2.5	-1.63
Odisha	98	94	23.1	21.0	-4	-2.1	-4.08
Puducherry	14	17	109.5	115.6	3	6.2	21.43
Punjab	103	97	36.8	32.7	-6	-4.0	-5.83
Rajasthan	137	117	19.7	15.3	-20	-4.3	-14.60
Tamil Nadu	513	533	70.6	70.7	20	0.1	3.90
Telangana	341	239	96.6	64.7	-102	-32.0	-29.91
Uttar Pradesh	320	253	15.8	11.4	-67	-4.4	-20.94
Uttarakhand	35	29	34.2	26.3	-6	-7.9	-17.14
West Bengal	83	93	9.0	9.7	10	0.6	12.05
All India	3,371	3,124	27.5	23.7	-247	-3.8	-7.33
Coef. of Variation			0.847	0.874			

Source: Based on *All-India Survey of Higher Education* (relevant years) and Census of India

Table 6. *Enrollments in Engineering Education per One Million Population, 2012-13 and 2018-19*

	Total Enrollments		Per 1 Million Population		Change (2012-13 minus 2018-19) in		% Change in Enrollments
	2012-13	2018-19	2012-13	1018-19	Enroll-ments	Per one Million Population	
Andhra Pradesh	93,004	88,451	1,862	1,703	-4,553	-159	-4.9
Assam	3,190	2,605	101	77	-585	-24	-18.3
Bihar	4,732	5,783	45	49	1,051	5	22.2
Chhattisgarh	13,356	6,460	515	228	-6,896	-287	-51.6
Delhi	7,252	6,972	422	359	-280	-64	-3.9
Gujarat	45,998	28,213	749	421	-17,785	-328	-38.7
Haryana	29,254	13,621	1,135	482	-15,633	-653	-53.4
Himachal Pradesh	3,253	1,466	470	202	-1,787	-268	-54.9
Jammu & Kashmir	2,086	2,478	168	189	392	21	18.8
Jharkhand	4,311	3,611	128	98	-700	-31	-16.2
Karnataka	74,085	68,637	1,200	1,052	-5,448	-149	-7.4
Kerala	40,664	27,227	1,209	779	-13,437	-430	-33
Madhya Pradesh	66,865	38,012	905	469	-28,853	-436	-43.2
Maharashtra	1,12,424	85,747	989	709	-26,677	-281	-23.7
Odisha	22,937	17,391	541	389	-5,546	-152	-24.2
Puducherry	4,682	3,087	3,661	2,100	-1,595	-1,561	-34.1
Punjab	22,184	14,552	792	491	-7,632	-300	-34.4
Rajasthan	34,756	15,429	499	202	-19,327	-296	-55.6
Tamil Nadu	1,78,493	1,43,165	2,457	1,900	-35,328	-557	-19.8
Telangana	86,746	69,708	2458	1,886	-17,038	-572	-19.6
Uttar Pradesh	81,553	46,686	402	210	-34,867	-191	-42.8
Uttarakhand	6,834	4,333	669	393	-2,501	-275	-36.6
West Bengal	25,625	19,906	278	207	-5,719	-72	-22.3
All India	9,67.829	7,17,617	789	544	-2,50,212	-245	-25.9
Coef. Variation			0.931	0.986			

Source: Based on *All India Survey of Higher Education* and *Census of India*.

Several institutions have discontinued their programmes in specific branches of engineering due to low enrollment. A detailed survey (Chopra, 2018) conducted in 2017 reveals that the IT stream which was the most favoured one earlier, has emerged as the least popular branch, with 770 institutes discontinuing the programme between 2012-13 and 2016-17. The second place goes to the branch of electricals and electronics which was discontinued in 635 colleges. Many other disciplines were also discontinued: computer science in 234 colleges, mechanical engineering in 185 colleges, and civil engineering in 139 colleges. The maximum number of institutions that discontinued the programme in IT were in Telangana (157), followed by Andhra Pradesh (128) and Tamil Nadu (104). The closure of more IT departments in the country has been directly related to the global economic slowdown of 2008 that affected the IT sector the most. Several workers engaged in the IT sector lost their job and hardly any new recruitment has taken place in this field.

The oversupply of engineering manpower in the country has disturbed the entire ecosystem of engineering. Getting admission in engineering studies was a socially prestigious for both students and parents in the early 2000s, but this has changed drastically within a decade. The massive expansion of engineering education, specifically self-financing engineering colleges in the country has changed the higher education structure altogether. Engineering education which was being talked about only by a few educationists has now become the elephant in discussion rooms. The expansion in engineering education is reduced so drastically that the conduct of entrance examination for this field at the national as well as state and institutional level has become more or less a ritual with the number of students in the rank list practically matching the number of admission places available, except of course in prestigious public institutions such as the IITs and NITs. The overall imbalance in or mismatch in the demand for admissions and availability of student places in engineering education is very high. Until recently, the demand used to be much above the supply, too many people chasing too few places, as students clearing their senior secondary (grade 12) board examination in mathematics and science streams used to aspire for an admission in engineering studies. But there has been a fall in the demand in the recent years to such a level that supply now exceeds demand. AICTE data shows that in 2019-20 there are close to 1.3 million places for admission in undergraduate engineering studies in India, while only 0.9 million students took the national entrance examination of JEE.

Newly established self-financing engineering colleges find it difficult to run their institutions as their revenues are shrinking due to low enrollments. These colleges, which almost exclusively depend on student fees, are now adopting, apart from fair and unfair marketing communication tools like sponsored news items in print and electronic media, student fairs, advertisements in newspapers to taxis (Singh, 2016), many desperate measures — from offering fee concessions to diluting admission criteria; from paying middlemen to bring in students to hiring under-qualified faculty, to in some cases as reported, letting out part of their campuses to corporate houses. With a decline in student enrollments, colleges increasingly depended on middlemen. However, due to the informal and unregulated nature of the phenomenon it is difficult to map out the growth of middlemen engaged to get students into the engineering colleges and related aspects. But some media reports (Chopra, 2018; Sengupta, 2011) reveal that middlemen in some cases, fashionably known as consultants, make informal arrangements with schools and get the contact details of all their grade 12 pupils and reach them as soon as the board examinations are over. These middlemen spread their net to neighbouring states as well to 'hook' potential students. For example, for the student admissions in engineering education in Uttar Pradesh, middlemen have begun fanning out to Bihar in search of aspirants. For them, Bihar is currently the perfect hunting ground as there are a smaller number of engineering colleges there and students are happy to apply to colleges in Uttar Pradesh.

It has been reported extensively in the media that as a large number of student places in private engineering colleges remained vacant after the counselling processes are over, colleges have started providing direct admission to students who have not even appeared for any entrance examination, which is otherwise compulsory. The rank list in engineering education is prepared based on a ridiculously low pass percentage in the entrance examinations. As reported by M.T. Reju, the Commissioner of Entrance Examinations, Kerala (The Hindu, 09 July 2017), a student needs to score just 20 out of a total/maximum marks of 960 to make it to the rank list which means that those who score a mere two per cent marks actually qualify to be admitted in engineering education! In this context, it is intriguing to analyse why and how an engineering degree that was considered quite prestigious at some point of time till recently is now in the doldrums. The other important question that needs to be asked in this context is: what led to this situation? Among the more important factors that have been discussed to explain this situation in the literature and also in media reports is the role of self-financing colleges. Secondly, graduates coming out of the system are found to be lacking knowledge of the basics of engineering and therefore cannot be gainfully employed in the labour market, the blame going partly back to the institutions that offer poor quality education. Thirdly, a poor and ineffective governance system is found to be responsible for the mess.

The proliferation and wholesale privatisation of engineering education in India has led to many more problems (Dubey et al., 2019). A few important ones include: the inequality in accessing engineering education, the decline in the quality of engineering education, and the failure of graduates to get gainful employment in the labour market. All these factors are related and are discussed in detail in the following sections of the paper.

4. Inequalities in Engineering Education

Despite significant improvement in demographic and social diversity in higher education, inequality still remains an important challenge. Inequality in education has several dimensions: regional, gender, social, economic and academic. Tilak (2015) has shown that inequalities in higher education by gender have got narrowed in India over the years to minimum levels; inequalities by caste also improved at an impressive rate, though the situation is far from satisfactory; regional disparities were reduced, but the improvement is very modest. But Tilak (2015) also found that inequalities between the rich and the poor have been very high and they have actually got widened over the years. We shall examine whether in case of engineering education the situation is similar or different. The issue of inequalities in the growth of engineering education in India is discussed here focusing on four major dimensions in this section: regional/state, gender, caste and the discipline of study.

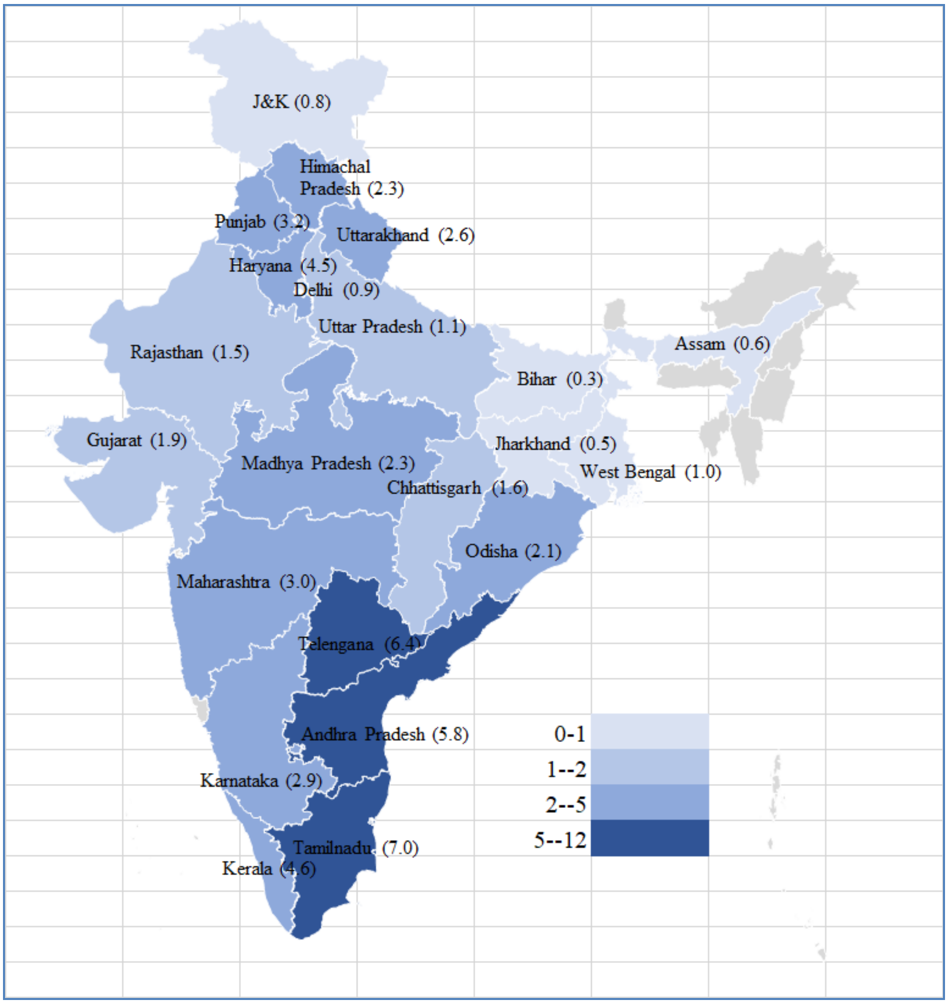
Geographic Disparities: Inter-Regional and Inter-State

Regional imbalance continues to be a major issue despite the huge expansion of higher education in India in recent years even though it was seriously taken up as a major issue in the National Policy on Education (Government of India, 1986, p. 6), when it stated that "steps will be taken to facilitate inter-regional mobility by providing equal access to every Indian of requisite merit, regardless, of his origins as [far as] the higher and technical education is concerned." With the initiatives taken by some states in the late 1980s and early 1990s, viz., Karnataka, Maharashtra, Tamil Nadu and Andhra Pradesh to permit private institutions on self-financing basis, one witnesses a spate of new institutions coming up in these states. When the other states found that the initiatives of those states paid rich dividends in terms of funding and growth of institutions, many other states adopted similar approaches, and in no time the phenomenon of setting up self-financing engineering institutions (and other institutions of higher education), and in no time, it went viral all over the country. But the states that took the initiatives first continue to maintain the lead. By 2000-01, regional inequalities became very sharp, and the U R Rao Committee (AICTE, 2003) took note of it and strongly argued for measures for balanced regional development. But no special attention was given to the problem. Presently around two-thirds of India's engineering institutions at undergraduate level are located in the states of Tamil Nadu, Karnataka, Andhra Pradesh and Maharashtra even though they account for less than one-third of the total population of the country. The southren region has almost half of the of the total enineering institutons , whereas the eastern region has only a tiny number (*Figure 5*). According to the latest statistics available from AICTE, there are around 1447 degree level engineering institutions (46.6 per cent of the total institutions in India) in 2018-19 in the southern region, which consist of five states and one union territory namely Andhra Pradesh, Karnataka, Kerala, Puducherry, Tamil Nadu and Telangana, whereas there are only 226 institutions in the four major states of the eastern region that includes Assam, Jharkhand, Odisha and West Bengal (7.2 per cent of the total institutions in India).

Interestingly, ten states and two union territories in the eastern and northern regions (Bihar, Jharkhand, Odisha, West Bengal, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Uttarakhand, Uttar Pradesh, Delhi and Chandigarh), accounting for 45.3 per cent of India's population, have only about 17.4 per cent of the total engineering institutions, with an intake capacity of 15 per cent. The eastern region is far behind the southern region and behind other regions in the country in terms of number of engineering institutions.

In fact, if we look at the geographic concentration of engineering institutions, we note a very high degree of regional imbalance. As *Figure 7* shows, Tamil Nadu, Telangana and Andhra Pradesh have the highest numbers of engineering institutions per one lakh population: 70 in Tamil Nadu, 64 in Telangana, and 58 in Andhra Pradesh. On the other end, states like Bihar and Jharkhand have just 3 and 5 respectively per one lakh people! The figures relating to Assam and Jammu & Kashmir are also close to these states' numbers.

Figure 7. *State-wise Engineering Institutions per One Million Population in India (2018-19)*



Source: Based on AICTE Database and Census of India

The region-wise students' intake for student admissions and actual enrollments also reveals more or less a similar pattern. Six southern states account for 49.3 per cent of the total intake (and 55.8 per cent of enrollment) in degree level engineering institutions in 2018-19, while the eastern region has only about 6.5 per cent of the total intake (and 6.3 per cent of enrollments) in India. Ten out of the 28 states and 8 union territories, namely, Tamil Nadu, Andhra Pradesh, Maharashtra, Uttar Pradesh, Telangana, Karnataka, Madhya Pradesh, Gujarat, Kerala, and Haryana together account for 80 per cent of the total student seats for admission in the country (*Table* 3). The statistics clearly suggest that the glaring regional imbalance that exists in the field of engineering education in India leads to an oversupply in some regions and states and shortages in others (Rao, 2003; WENR, 2007). A careful look at the growth of institutions reveals that the regional imbalance is not only due to the establishment of a large number of private colleges in the southern region and lack of the same in other regions, but also due to imbalanced public supply of government engineering colleges (*Table* 8).

Table 7. State-wise *Concentration Ratio of Engineering Institutions*

	2012-13	2018-19	Change
Andhra Pradesh	2.583	2.549	-0.034
Assam	0.160	0.231	0.071
Bihar	0.086	0.146	0.060
Chandigarh	0.822	0.929	0.107
Chhattisgarh	0.691	0.664	-0.026
Delhi	0.349	0.332	-0.017
Goa	1.310	1.253	-0.057
Gujarat	0.643	0.792	0.149
Haryana	2.082	1.857	-0.225
Himachal Pradesh	1.134	1.077	-0.057
Jammu & Kashmir	0.237	0.392	0.155
Jharkhand	0.161	0.235	0.074
Karnataka	1.092	1.270	0.178
Kerala	2.032	2.456	0.424
Madhya Pradesh	1.095	0.944	-0.151
Maharashtra	1.145	1.248	0.103
Odisha	0.869	0.928	0.059
Puducherry	4.309	4.635	0.326
Punjab	1.271	1.414	0.142
Rajasthan	0.682	0.588	-0.094
Tamil Nadu	2.797	3.481	0.684
Telangana	3.407	2.758	-0.649
Uttar Pradesh	0.558	0.459	-0.099
Uttrakhand	1.176	1.102	-0.074
West Bengal	0.316	0.390	0.074
Other States and Union Territories	0.133	0.289	0.156

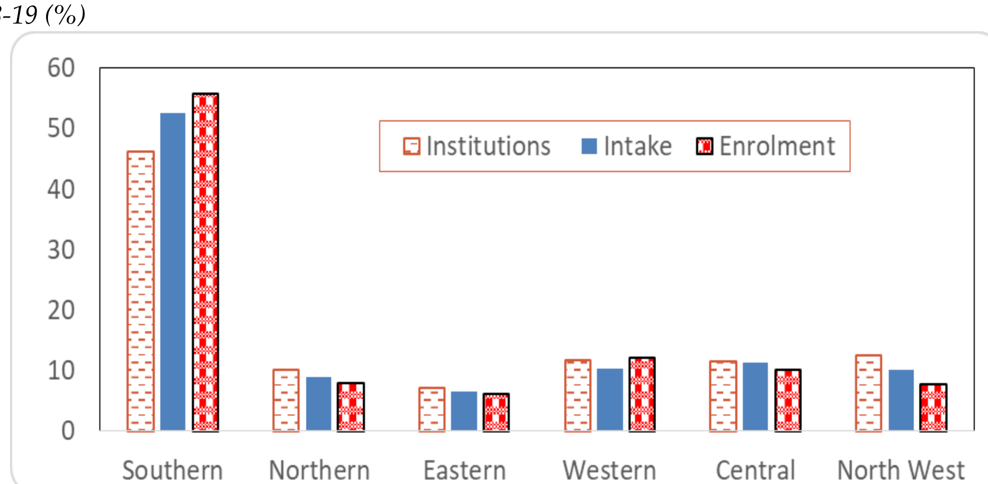
Concentration Ratio: See the text

Source: Based on *All-India Survey of Higher Education* and *Census of India*

The inter-state inequalities in the distribution of the educational institutions can be analysed in the form of a concentration ratio. The concentration ratio is the distribution of institutions in relation to the distribution of population.[13] If the value of the ratio equals one, the distribution of institutions are proportionate to the distribution of population; if the ratio is above 1, it shows over concentration, and if it is below 1, the state is underserved in relation to population. Such a ratio is estimated here 2012-13 and 2018-19 to note the concentration and the change therein (*Table 7*). The ratio ranges between 0.86 in Bihar and 4.31 in Puducherry in 2012-13. In 2018-19 also these two were at the two extreme ends in terms of concentration. There is a very high concentration in Puducherry, Telangana and Tamil Nadu with a ratio above 3. Tamil Nadu which was the third in concentration ratio among the major states in 2012-13, rose to second in 2018-19. There are as many as 12 states with over concentration and about the same number with under provision. Between 2012-13 and 2018-19, one does not find any significant change in concentration, implying that no special effective measures were taken to improve regional balanced development or clearly to deconcentrate the regional growth of engineering institutions in the country.

If we look at regional distribution across major regions in the country, we note that that southern region prospered well in terms of number of engineering institutions; and all other regions – northern, western, central and north-west lag far behind. Eastern region figures at the bottom. This is true with respect to number of institutions, intake, and enrollment in engineering education (*Figure 8*).

Figure 8. *Regional Concentration of Institutions, Intake and Enrollment in Engineering Education, 2018-19 (%)*



Source: Based on AICTE Database

13 The concentration ratio is defined as the number of institutions in a state as a percentage of the total number of institutions in the country as a ratio of population in a state as a percentage of the total population in the country. See Varghese et al (2018). This is similar to the coefficient of inequality defined by Naik (1971).

Further, we note from *Table 8* that it is in Southern, northern and western regions where private sector dominates over the public institutions; while in eastern, central and north-western regions, the shares of the private sector are marginally lower than those of the public institutions; but in these regions, the overall numbers are also small. Between 2012-13 and 2018-19, the southern region has a steady share in institutions, (46.6 per cent in 2011-12 and 46.3 per cent in 2018-19), but its share in intake increased from 49.3 per cent to 52.6 per cent.

Table 8. *Regional Concentration of Engineering Institutions and Intake in India, by Management (2012-13 and 2018-19)*

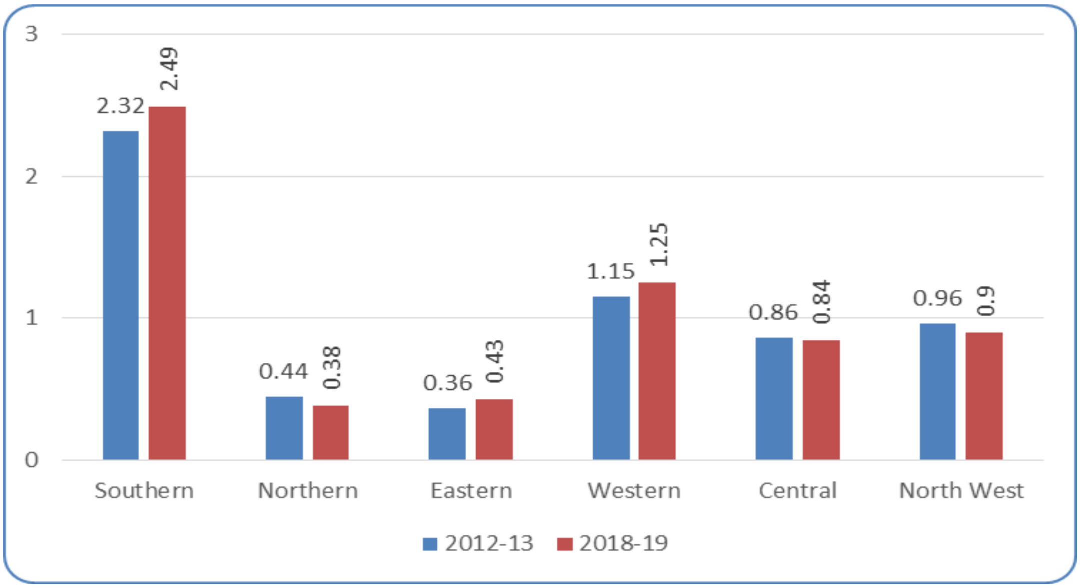
	Institutions			Intake		
Regions	Government	Private	Total	Government	Private	Total
2012-13						
Southern	35.3	47.6	46.6	37.4	50.2	49.3
Northern	10.5	11.3	11.2	9.3	10.9	10.8
Eastern	14.0	5.6	6.2	9.9	5.4	5.7
Western	8.0	11.4	11.1	7.2	10.4	10.2
Central	15.4	11.1	11.5	19.4	10.9	11.5
North West	16.8	13.0	13.3	15.5	12.1	12.3
All-India	100	100	100	100	100	100
	(286)	(3085)	(3371)	(106.9)	(1445.2)	(1552.1)
2018-19						
Southern	38.26	47.55	46.32	52.15	52.68	52.61
Northern	13.56	9.74	10.24	9.23	8.88	8.93
Eastern	13.56	6.57	7.23	8.64	5.94	6.32
Western	7.51	12.43	11.78	4.99	11.23	10.35
Central	10.17	11.66	11.46	9.83	11.60	11.35
North West	16.95	11.91	12.58	14.34	9.53	10.21
All-India	100	100	100	100	100	100
	(413)	(2711)	(3124)	(198.9)	(1205.9)	(1404.8)

Note: Figures on intake for All-India are in thousands.

Source: AICTE Database

We also note that the regional concentration has got intensified between 2012-13 and 218-19, with the ratio (in *Figure 9)* increasing in case of southern, and western regions. Though there is a small increase in case of eastern region, it is too small; northern region and north western region's disadvantage also increased.

Figure 9. *Ratio of Regional Concentration Ratio of Engineering Institutions*



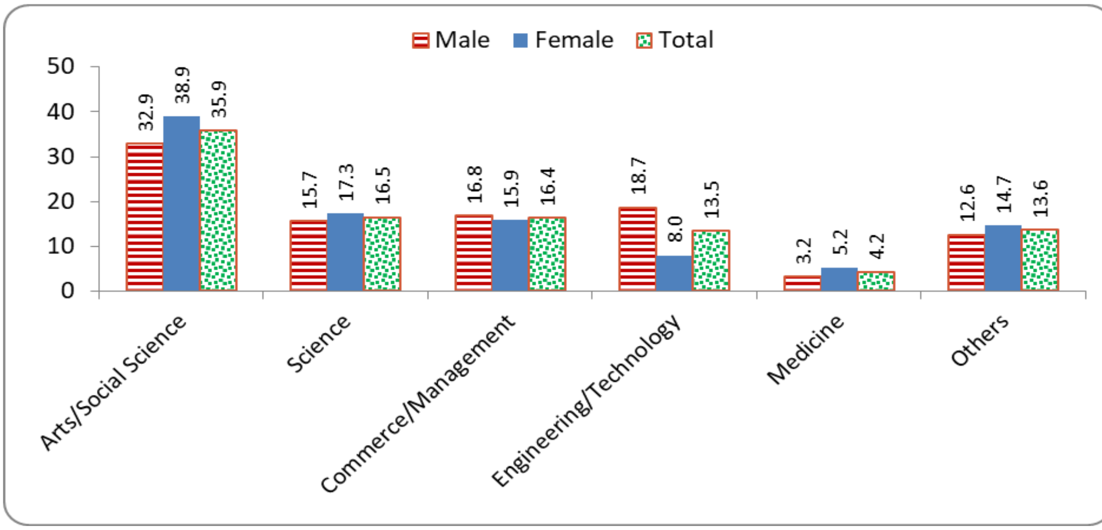
Source: Based on *All India Survey of Higher Education 2012-13* and *2018-19*.

Regional and inter-state disparities have thus been very sharp in the growth of engineering education. This would result in a lack of access to a majority of students in those states where institutions are few, and in avoidable migration of students from those regions to the other regions where engineering education facilities are relatively easily available. Obviously students, who migrate, have to necessarily spend higher amounts on travel and engineering studies as a whole. Further location of the higher education institutions in some of these backward states will help in boosting economic and social development. Special efforts may be needed to correct the high degree of regional disparities and to ensure a regional balanced development in higher education.

Inequality by Gender

Over the decades, there has been a phenomenal growth in the enrollment of female students in higher education in India, and their share in total enrollment has reached 48.6 per cent in 2018-19, suggesting achievement of near gender parity (*Table 9*). Of the total enrollment of 37.4 million students in higher education in India, 18.2 million are women in 2018-19 (MHRD 2019). The gross enrollment ratio in higher education among girls is the same as in case of males (26.4 per cent among females, and 26.3 per cent among males). But the picture is not the same with respect to all branches of higher education. In the arts, social sciences, basic sciences and medicine the representation of females is higher than males, while in commerce, management and engineering & technology female enrollment is less than males' (*Figure 10*). For instance, out of the total student population among males in higher education, 18.7 per cent are pursuing engineering studies, while only 8 per cent of females do the same.

Figure 10. *Distribution of Enrollments in Higher Education across various Branches, by Gender (2018-19)*



Note: "Others" include: education, law, agriculture, physical education, veterinary & animal sciences, hospitality & tourism, journalism & mass communication, library & information science, and several other interdisciplinary areas of study.

Source: *All India Survey of Higher Education 2018-19*

In case of engineering education, women constitute nearly 30 per cent of the enrollments in 2018-19. This marks a big increase from a meagre below one per cent in 1961-62 with an annual average growth rate of 15.7 per cent (*Table* 9). This rate of growth in women's enrollment in engineering education in the last four decades is higher than the growth in their enrollment in overall higher education which is 8.3 per cent. However, the enrollment of females in engineering is still not at par with males'. Often, it is argued that engineering and technical education is a masculine domain and hence out of reach for women. Those who support this line of argument point to the perseverance of certain untenable social myths like 'women are emotional, while technology is strictly logical and hence, both do not go together'. There is also the view that men are good at mathematics and machines, while women have no clue about these areas (Rao, 2007, p.187). But all this does not seem to be true, though quite a few studies have found that technical and professional education is by and large, dominated by males more than general education, in which females constitute a larger proportion (Salim, 2008; Ghuman et al., 2009). Nevertheless, the improvement in the participation of women in engineering education during the last four decades perhaps highlights the gradual rise of interest of women in this discipline of study. According to a study of the QEPEF (2016), in India where women of the emerging middle class are increasingly fighting for equal rights, only 29 per cent of the population consider engineering as masculine, while an amazing 30 per cent consider it as feminine.

Table 9. *Women Enrollment in Higher and Engineering Education in India*

Year	Higher Education		Engineering Education	
	Total (in lakhs)	% Share	Total (in 000's)	% Share
1961-62	1.9	17.8	0.3	0.8
1970-71	4.3	14.4	0.9	1.0
1975-76	6.0	24.5	2.1	2.2
1980-81	7.5	27.2	5.0	3.0
1985-86	10.7	29.6	12.2	6.9
1990-91	14.4	29.2	17.1	7.9
1995-96	21.9	33.3	26.4	8.4
2000-01	30.1	35.9	109	20.6
2005-06	44.7	37.1	186	23.4
2010-11	70.5	41.5	801	28.0
2015-16	134.7	47.3	1360	27.8
2016-17	141.6	48.1	1365	28.5
2017-18	174.4	47.6	1234	29.0
2018-19	181.9	48.6	1193	29.3
Growth Rate*	8.33	-	15.65	-

* Compound rate of growth per annum

Source: *Selected Educational Statistics* (Various Years), UGC *Annual Report* (Various Years), and *All India Survey of Higher Education* (Various Years)

Inequality by Caste

Despite much overall improvement, caste is considered one of the important social barriers in accessing higher education, quality higher education in particular and quality engineering education more particularly. As a result, one finds wide variations in the access to higher education between different social groups in India. In 2018-19, the gross enrollment ratio in higher education is 23 per cent for scheduled castes (SCs), and 17.2 per cent for scheduled tribes (STs), as compared to the ratio of 26.3 per cent for all at the all-India level (MHRD, 2019). Furthermore, it is generally felt that engineering and technical education in India has been highly selective in terms of providing access to the disadvantaged sections of the society such as SCs and STs (Rao, 2006), as it is relatively more expensive than other subjects and it also requires a strong academic background at the school level.

The percentage of enrollment of SCs in engineering education is 11 per cent in 2018-19, which was merely 3.8 per cent in 1985-86, registering an increase by three times. Similarly, the enrollment of STs in engineering education has increased from one per cent in the total enrollment to 2.8 per cent in a period of over 30 years (*Table 10*). Ghuman et al., (2009) using the data collected from a primary survey of 2,085 students in rural Punjab found that as high as three-fourth of the total students coming from rural backgrounds, studying in different professional education programmes belonged to the forward castes. It shows that while students from rural areas access professional education in large numbers, the socially backward groups lag far behind others. The access to engineering education among females belonging to different disadvantaged social groups appeared to be far worse. Being women belonging to scheduled groups means a double disadvantage. Currently only 7.7 per cent of SC females and 0.7 per cent of ST females are accessing engineering education in India (*Table 9*). As Varma and Kapur (2010) found, a large number of students belonging to upper and middle castes/classes get admitted to the IITs in India. It was also pointed out that once admitted, students belonging to the upper and middle castes and classes are likely to have a much more positive experience and higher success rate than those belonging to lower castes and classes. IITs have been the most coveted institutions, and are regarded as the exemplars of merit. In fact, they are said to be so meritocratic that some criticise them as 'upper caste institutions' (Subramanian, 2019), as education at the IITs has been for the privileged sections of Indian society, though the situation is gradually, but slowly, changing.

Table 10. Enrollment of *Scheduled Castes and Scheduled Tribes in in Engineering Education*

	Scheduled Castes			Scheduled Tribes		
Year	Male	Female	Total	Male	Female	Total
1985-86	3.61	0.22	3.83	0.99	0.04	1.03
1990-91	5.70	0.67	6.36	1.12	0.08	1.19
1995-96	3.91	0.46	4.37	1.61	0.18	1.79
2000-01	5.23	1.67	6.90	2.26	0.33	2.59
2005-06	15.06	5.38	20.44	5.31	1.88	7.19
2010-11	5.64	2.33	7.97	1.91	0.64	2.57
2015-16	7.26	2.85	10.11	1.89	0.62	2.51
2018-19	7.65	1.96	11.04	2.07	0.74	2.81

Source: *Selected Educational Statistics* (Various Years), UGC *Annual Report* (Various Years), AISHE (Various Years)

Table 11. *Enrollments in the First Year of Engineering Degree Studies: Distribution by Social Category (2012-13 to 2018-19)*

Year	Scheduled Castes	Scheduled Tribes	Other Backward Classes	General/ Open category	Minorities	Total
2012-13	10.73	2.47	35.95	44.05	6.80	100 (9.67)
2013-14	11.73	2.61	35.91	42.85	6.91	100 (9.44)
2014-15	12.65	2.60	35.81	41.83	7.11	100 (8.75)
2015-16	12.71	2.85	36.10	40.99	7.34	100 (8.55)
2016-17	12.53	2.82	35.67	41.12	7.85	100 (7.86)
2017-18	13.04	2.78	36.23	40.47	7.47	100 (7.50)
2018-19	11.72	2.68	35.12	43.08	7.40	100 (7.17)

Figures in ( ) are absolute figures in lakhs.
Source: AICTE Database

The enrollment of students in the first year of engineering education by different social groups shows that there has not been much improvement over the last seven years (2012-13 to 2018-19) for which data are available (*Table 11*). In 2012-13, 10.7 per cent students were enrolled in the first year of the under graduate engineering programme; and this number has increased marginally to 11.7 per cent in 2018-19. The respective figures for ST students are 2.5 and 2.7 per cent. The improvement seems to be very small. Interestingly, the enrollment of students from the forward caste groups has declined from 44.1 per cent to 43.1 per cent during the same period. Minorities and STs too gained marginally.

If one looks at the regional distribution of the enrollment of students in the first year of engineering education, it is clear that the central and the northern regions fare poorly showing with the lowest rates of enrollment of SCs (7.8 per cent in the central region) and STs (0.8 per cent in the northern region) (*Table 12*). In the states like Bihar, Goa, Puducherry and Uttarakhand the proportion of SCs in the enrollments in engineering education is less than one per cent in 208-19. Similarly, in states such of Bihar and Uttar Pradesh, and also in relatively better-off states like Haryana, Kerala, Puducherry, Punjab, and Uttarakhand the enrollment of STs in engineering education is less than one per cent. STs constitute a small proportion of the total population in some of these states. The regional mapping of students in engineering education in India will provide clear insights to understand the specific dimensions of caste inequalities intersecting with regional disparities in accessing engineering education by various social groups.

Table 12. *Region-wise Pattern of the of Enrollments in the First Year of Engineering Studies in 2018-19, by Social Category*

Region	Scheduled Castes	Scheduled Tribes	Other Backward Classes	General/ Open Category	Minorities	Total
Southern	12.02	2.09	42.83	34.45	8.60	100 (400.3) [55.8]
Northern	16.48	0.81	29.19	46.88	6.64	100 (56.8) [7.9]
Eastern	12.78	7.90	13.58	61.19	4.54	100 (45.0) [6.3]
Western	9.82	1.57	33.50	48.59	6.52	100 (86.9) [12.1]
Central	7.87	5.53	28.45	53.62	4.53	100 (72.7) [10.1]
North West	11.79	2.62	14.55	64.09	6.94	100 (56.0) [7.8]
All-INDIA	11.72	2.68	35.12	43.08	7.40	100 (717.6)

Figures in ( ) are absolute figures in thousands.
Figures in [ ] regional distribution in per cent.

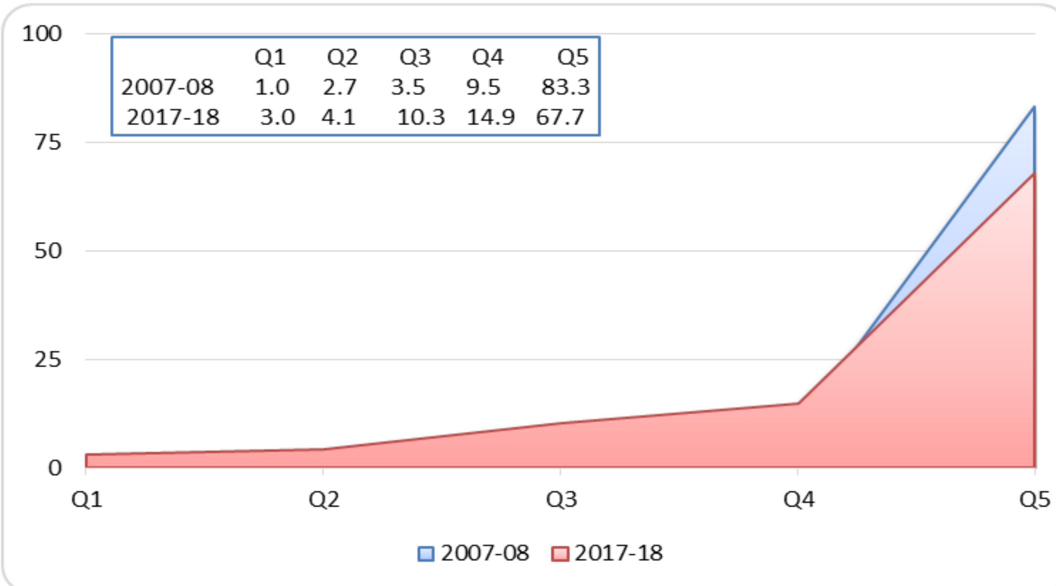
Source: AICTE Database

To conclude, while there has been progress over the years in improving the participation of disadvantaged sections in engineering education, which can be attributed to the Constitutionally-guaranteed reservations for disadvantaged strata of the society, the situation is not very satisfactory, even after 74 years of independence.

Unequal Participation by Economic Classes

NSSO provides data on the enrollment of students in various levels of education by average per capita monthly consumption expenditure of households. Considering household consumption expenditure as reflective of income levels of the households, we can analyse the enrollment pattern in engineering education by economic levels of households. *Figure 11* shows the extent of inequalities in enrollments in engineering education. About 80 per cent of the students belong to the top income quintile and about 7 per cent is accounted by the bottom 60 per cent of the population in 2007-08. The situation marginally improved by 2017-18: the share of the top quintile coming down to 68 per cent; the bottom two quintiles accounting for 7.1 per cent, and the third quintile accounting for another 10.3 per cent.

Figure 11. *Distribution of Enrollments in Engineering Education, by Household Quintiles (%)*



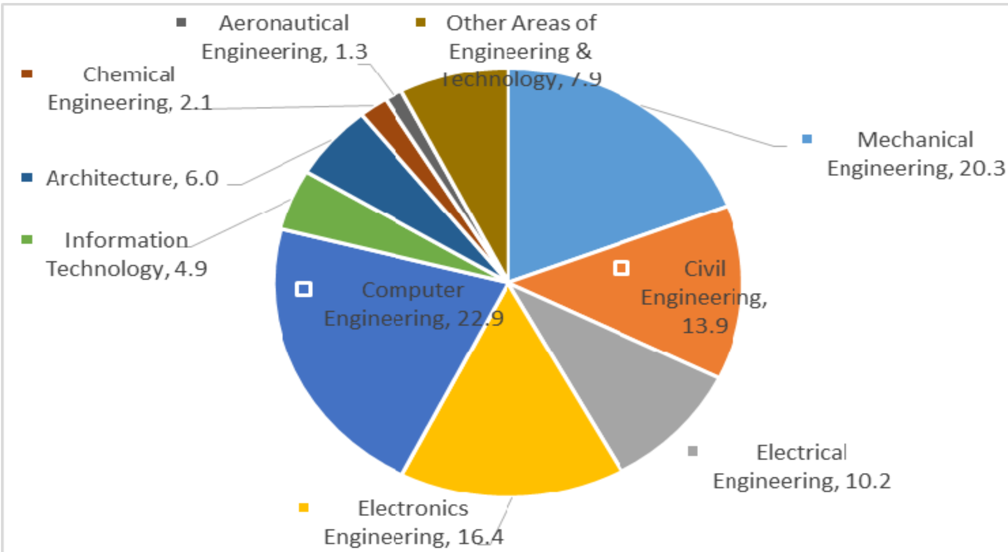
Source: Based on NSSO data

Still a high degree of inequality persists. After all, engineering education is expensive and public support in the form of scholarships, reimbursement of fee schemes, fee-waivers and loans is not effective enough to mitigate inequalities. As we see later, even the bottom expenditure quintiles have to spend considerable amounts to take up engineering studies.

Disciplinary Imbalance

We have already seen that the growth of higher education in India has been uneven, creating a more imbalanced system of higher education in terms of different branches of study. Within the broad stream of engineering also, we notice a high degree of imbalance between several sub-streams, as the growth of student enrollments in engineering education has varied significantly by different sub-disciplines. The engineering stream has 17 sub-streams like electronics engineering, computer engineering, mechanical engineering, electrical engineering etc. It is clear from *Figure 12* that the top five sub-streams in terms of enrollments in 2018-19 are computer engineering with 8.8 lakh students, mechanical engineering with 7.8 lakh students, electronics engineering with 6.3 lakh students, civil engineering with 5.4 lakh students and electrical engineering with 3.9 lakh students enrolled. In information technology/computer application stream, there were 7.5 lakh students enrolled. These five disciplines account for more than 80 per cent of the total enrollments in engineering education. Distribution of enrollments across 17 sub-streams of engineering in 2010-11 and 2018-19 is given in *Table 13*.[14]

Figure 12: *Most Popular Areas of Engineering & Technology, 2018-19*
(As a Percentage of Total Enrollments in Engineering Education)



Source: Based on *All-India Survey of Higher Education 2018-19*.

Economic liberalisation in the 1990s gave a major push to the Indian software services industry which further boosted the demand for engineers trained in electronics and IT-related disciplines such as computer science and engineering, electronics and communications, and IT. These streams were considered as more popular branches among the students. Traditionally popular branches such as electrical, civil, and mechanical engineering have gone considerably down in student preferences. The boom in the IT sector in the early 1990s led to the opening-up of several electronics and IT-related fields of study in newly established engineering colleges in India. Engineering colleges established after the introduction of policies of economic liberalisation started offering mainly electronics and IT-related streams. As Banerjee and Muley (2008) noted, the newly established engineering institutions concentrated on the disciplines related to the areas of computer engineering and IT-related areas. As a result, India has produced larger numbers of computer science and IT engineers more than in other disciplines. This was clearly linked with the labour market expectations of the engineering graduates as

[14] It will be valuable to examine the trends before 2010-11, but we do not have such detailed information by sub-streams for the earlier periods.

degrees in electronics and IT-related degree programmes helped them to secure jobs relatively easily and quickly as compared to degrees in traditional subjects like civil and mechanical engineering. However, by 2010-11, the situation seems to have reached a peak, and the IT boom seems to have ended; after 2010, we notice a declining trend in the demand for these popular branches of engineering education.

Table 13. *Enrollment in Engineering (First Degree) Programmes, by Sub-Stream (%)*

	2010-11	2018-19	Change
Computer Engineering	22.25	22.85	0.60
Mechanical Engineering	16.64	20.32	3.68
Electronics Engineering	25.34	16.39	-8.95
Civil Engineering	8.65	13.93	5.28
Electrical Engineering	13.46	10.23	-3.23
Information Technology	11.45	4.88	-6.57
Architecture	..	2.11	..
Chemical Engineering	1.36	1.33	-0.02
Agriculture Engineering	0.215	0.552	0.34
Aeronautical Engineering	..	0.441	..
Food Technology	..	0.349	..
Metallurgical Engineering	0.313	0.249	-0.06
Mining Engineering	0.093	0.198	0.10
Marine Engineering	0.189	0.109	-0.07
Dairy Technology	0.066	0.078	0.02
Planning	..	0.024	..
Engineering & Technology Total	100.0	100.0	
Total in Million	1.11	3.85	17.1

Totals include others, not listed here.
Source: MHRD (2011a, 2019)

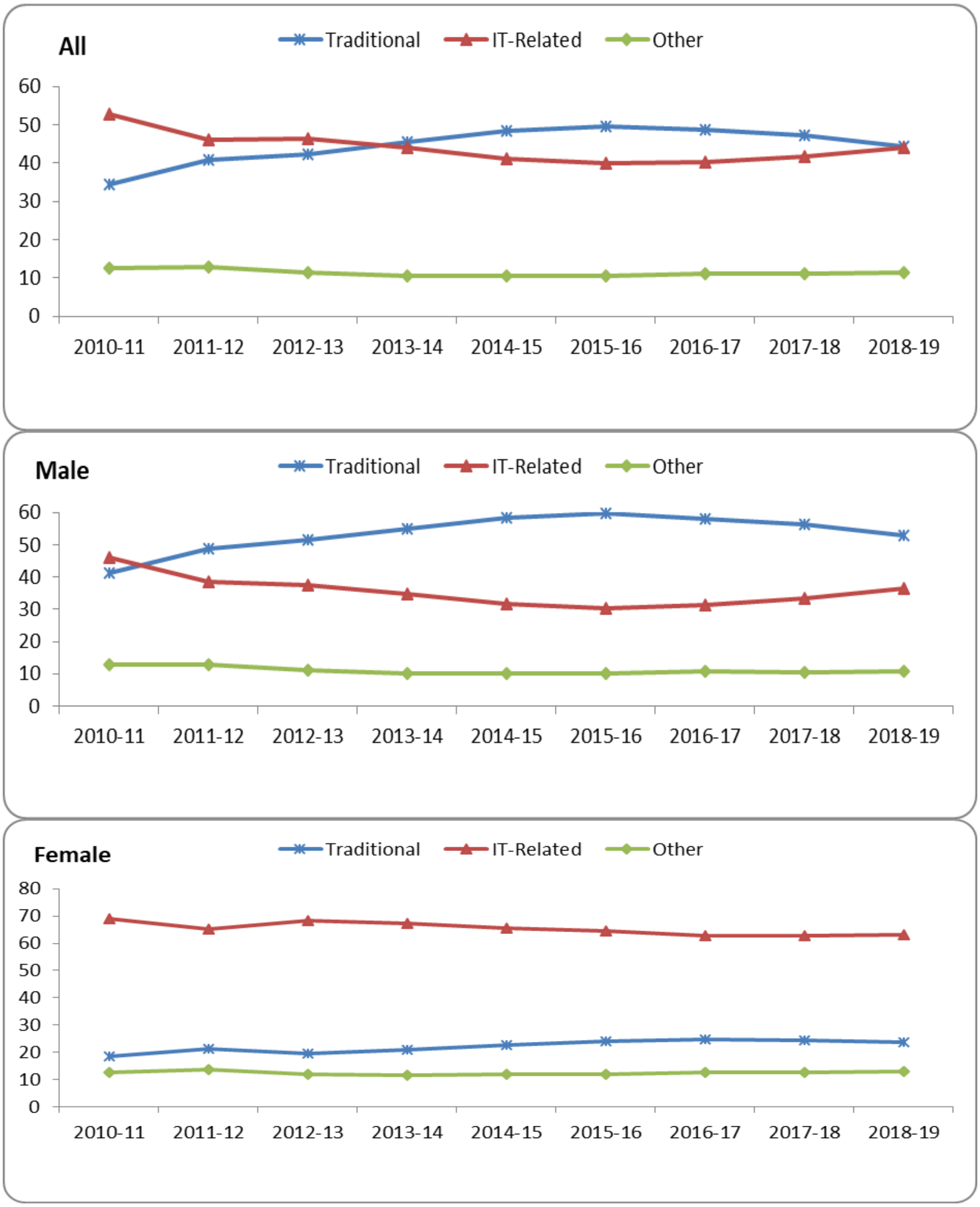
As per available data, after 2010-11, some new sub-streams were added to the stream of engineering & technology. By 2010-11 electronics engineering, computer engineering were at their peak in terms of enrollments, together accounting for 48 per cent of enrollments in all areas of engineering. Information technology accounted for 11 per cent of enrollments. But by 2018-19, the share of electronics engineering declined by 9 per cent points – from 25 per cent to 16 per cent; and the share of IT by 7 per cent points from 11 to below five per cent. Computer engineering did not register much change during this period. In contrast, civil engineering and mechanical engineering improved their relative positions.

The several sub-streams of engineering can be classified into three major groups: (a) 'traditional' streams which includes mechanical, civil and electrical, (b) 'modern' (electronics and IT-related) streams that include electronics and communication, computer science, and information technology, and (c) other areas of engineering, which cover chemical, aeronautical, metallurgical, agriculture, food technology, mining, marine, dairy technology, etc. We use this classification for graphic presentation in Figure 7. The share of enrollment in traditional streams has increased from 34.5 per cent in 2010-11 to 44.5 per cent in 2018-19, while the enrollment share in IT-related fields (electronics and communication, computer science, and IT) has declined from 52.7 per cent to 44.1 per cent during this period. The proportion of enrollments in other fields of engineering (chemical, aeronautical, metallurgical, agriculture, food technology, mining, marine, and dairy technology) has not changed much between 2010-11 and 2018-19. The curve has been more or less flat throughout (Figure 13). The enrollments in electronics and IT-related disciplines were at the lowest level in proportions in 2015-16 (39.9 per cent), but later picked up and the share has gone up to 44.1 per cent in 2018-19. Interestingly, within modern branches, the lowest level of enrollment was observed in the branch of information technology as compared to electronics and computer engineering. The share of IT was 6.4 in 2012-13, and 4.9 per cent in 2018-19. As already noted, the corresponding figure was 11.5 per cent in 2010-11. The crisis in the IT sector that started in 2008 has its own effect on the demand for electronics and IT-related disciplines of study, and the effect can be observed till 2015-16. Within traditional disciplines, mechanical engineering has been high in demand (20.3 per cent) and the demand for electrical engineering the lowest (10.2 per cent) in 2018-19.

A look at this pattern by gender gives us interesting insights into changing perceptions. As expected, more than half of the males in engineering education (51.5 per cent) were pursuing studies in traditional areas of study such as mechanical, civil and electrical in 2018-19, while the corresponding figure was 23.8 per cent for females. Female enrollment in electronics and IT-related strands such as electronics, computer science and IT (63.2 per cent) is significantly higher than male enrollment in these streams (36.5 per cent). So women's demand for modern disciplines of engineering has not suffered much, as women tend to continue preferring IT related subjects to traditional ones. Electronics and IT-related subjects are considered fashionable by many. Many view that only those who cannot get admission in modern IT related subjects choose traditional branches. According to 2018-19 data, among the traditional subjects, men prefer mechanical engineering to others, whereas women prefer engineering civil. But among the IT-related programmes, both prefer computer science engineering.

The occupancy rate or the enrollment as a proportion of intake has decreased in case of almost all disciplines. The occupancy rate was 44 per net in case of electronics engineering in 2017-18, 58 per cent in computer science engineering, and 60 per cent in computer engineering. The rates for mechanical and civil engineering were 47 and 48 per cent respectively. It is higher in bio-medical engineering and chemical engineering, agricultural engineering, above 60 per cent. In all, it was only 50 per cent.

Figure 13. *Growth in Enrollments in Engineering Education, by major Categories of Sub-Streams (%)*



Source: Based on AICTE Database

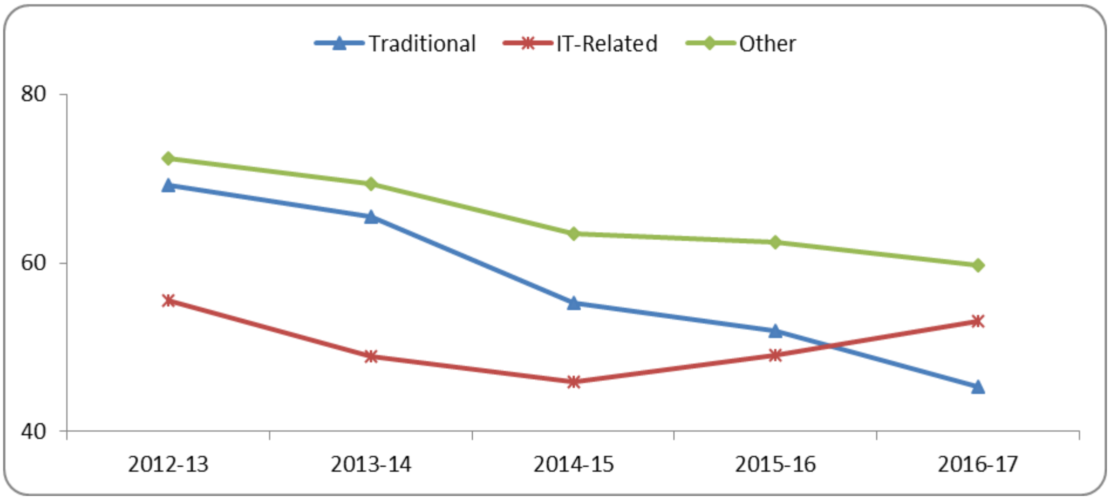
Table 14. *Stream-wise Distribution of Enrollments in Engineering Education by Gender (%)*

	2012-13			2018-19		
	Male	Female	Total	Male	Female	Total
Mechanical Engineering	26.39	2.93	19.64	27.10	3.61	20.32
Civil Engineering	12.51	6.91	10.90	15.33	10.47	13.93
Electrical Engineering	12.47	9.77	11.69	10.43	9.75	10.23
Traditional Total	51.37	19.61	42.23	52.86	23.84	44.48
Electronics Engineering	18.55	29.57	21.72	13.09	24.52	16.39
Computer Engineering	14.05	28.58	18.24	19.24	31.74	22.85
Information Technology	4.80	10.31	6.38	4.04	6.94	4.88
Modern Total	37.40	68.46	46.34	36.37	63.20	44.12
Other Engineering & Technology	7.69	7.82	7.72	5.87	6.18	5.96
Architecture	0.77	2.06	1.14	1.41	3.82	2.11
Chemical Engineering	1.19	1.00	1.14	1.43	1.11	1.33
Aeronautical Engineering	0.48	0.25	0.41	0.48	0.33	0.44
Agriculture Engineering	0.27	0.36	0.30	0.51	0.66	0.55
Metallurgical Engineering	0.25	0.18	0.23	0.27	0.20	0.25
Food Technology	0.16	0.18	0.17	0.29	0.49	0.35
Mining Engineering	0.17	0.01	0.13	0.27	0.02	0.20
Marine Engineering	0.16	0.01	0.12	0.14	0.02	0.11
Dairy Technology	0.05	0.05	0.05	0.07	0.09	0.08
Planning	0.01	0.02	0.02	0.02	0.04	0.02
Others Total	11.22	11.93	11.43	10.76	12.96	11.40
Total (Traditional + Modern + Others)	100	100	100	100	100	100

Source: AICTE Database

It appears in those disciplines where the sanctioned intake is small, occupancy rate is relatively high, and vice versa. In *Figure 14*, we note the trends in occupancy rate across the three broad groups of disciplines between 2012-13 and 2016-17. But within these three groups of disciplines, there is an increasing trend in the enrollment in modern strands after 2015-16. The share has increased from 49 per cent in 2015-16 to 53 per cent in 2016-17. It may be reflective of the revival of the IT sector in India which has brought new opportunities for the engineering graduates. According to AICTE data, the share of placements to enrollments in IT-related streams jumped from 12 per cent in 2012-13 to 47.9 per cent in 2016-17. This may also be partly due to the shutting-down of several private engineering colleges across the country, as discussed earlier, due to a low demand for engineering education in India.

Figure 14. *Enrollment as Percentage of Intake in Major Categories of Sub-Streams in Engineering Education*



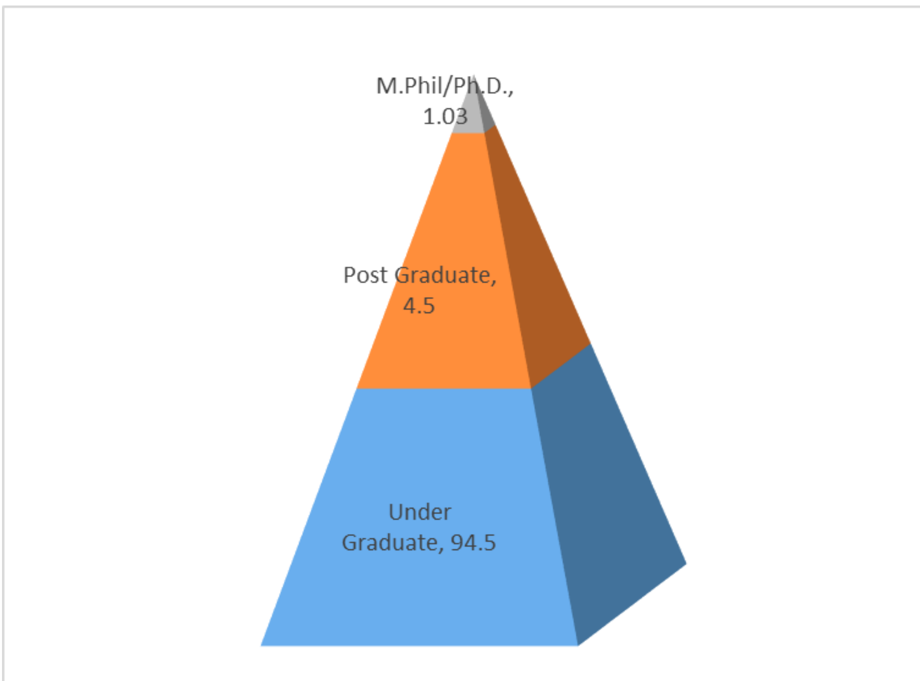
Source: Based on AICTE Database

Level-wise Imbalance

The other kind of imbalance that one notices is a very high proportion of students in first degree studies, and almost nil in master's and research programmes. This is similar to the pattern in the entire higher education sector, but the degree of imbalance is much higher in case of engineering education. In higher education, enrollments in undergraduate programmes form about 80 per cent, while enrollment in PhD programmes account for less than 0.5 per cent of the total, while the remaining nearly 20 per cent is accounted by students in master's level programmes (post graduate and MPhil. studies). But in case of the pyramid of engineering education, as high as 94.5 per cent of the students are enrolled in under graduate programmes, 4.5 per cent in postgraduate and about one per cent in PhD programmes. MPhil programmes are rather rare in engineering studies (*Figure 15*). The PhD studies is of particular interest, because most teaching and research positions require a PhD degree. Certainly, the number of graduate engineers who go on to masters' and doctoral studies in engineering in India is not keeping pace with the growing economy, and this needs to be stepped up significantly.

That very few students in engineering studies opt for post graduate and research programmes has been highlighted by many as a major weakness that results in a restricted supply of teachers in engineering institutions, and also limited research and development in critical and emerging areas of engineering and technology. The problem with respect to critical shortage of teachers in engineering subjects is already felt. There is need to initiate special efforts to encourage first degree graduates to pursue master's and research programmes in engineering & technology. A committee appointed by MHRD (2009) recommended that all higher education institutions should become 'integrated' institutions necessarily offering undergraduate, post graduate and research programmes, like the IITs. This might create and nurture research interests in young minds, and enhance transition rates between the three levels, improving not only teaching in institutions, but also creating better environment for knowledge development and dissemination. A similar recommendation has also been made by the Dr Kasturirangan committee (GOI, 2019) and this forms a provision in the National Policy on Education 2020 (GOI, 2020).

Figure 15. *Level-wise Imbalance (Distribution of Enrollments) in Engineering Education, 2018-19 (%)*



Source: Based on *All-India Survey of Higher Education 2018-19*.

5. Quality Concerns in Engineering Education

We have noted that engineering education has expanded very rapidly during the last few decades. However, the observed growth in enrollment rates are not matched by comparable improvements in quality, causing a serious problem in the country. Even though the quality of education has emerged as one of the most important concerns in higher education in India, at the same time it is widely agreed that quality in education is difficult to precisely define and measure. We can only look at some proxy indicators that are related to quality. The quality of engineering education in India thus can be understood, when we look at a few specific indicators.

First, at the top of the technical higher education pyramid is the small group of IITs, followed by NITs and IIITs, which are funded by the union government; in the upper middle of the pyramid are central universities and a small number of select state universities; the lower middle consists of government colleges in engineering and technology and government-aided private colleges; and at the bottom figure a very large number of private universities and colleges, which are funded substantially by the households and least by the state. The ones in the top of the pyramid are all considered 'elite,' well-funded, highly selective and autonomous institutions designed to greatly increase the high end of the engineering and technical cadre in the country. The top and the middle clusters of the institutions are funded by the government and are supplemented by fee contributions from the students. Thus India has a few institutions of excellence at the top of the pyramid and a large number of colleges and deemed universities at the bottom of appalling quality, which are under the purview of the states, but more significantly in the private sector. Even though we thus have a large number of colleges offering engineering education, only 298 colleges are autonomous. Though whether autonomy delivers greater quality is questionable, it is widely perceived that the status of autonomy is partly reflective of the quality of an institution, as it is granted only if the college satisfies quite a few parameters relating to performance of the college, quality imparted in the college, and overall capability of the college to function autonomously, apart from other factors such as infrastructure, and the quality of teachers. Secondly, accreditation is indicative of some dimensions of quality of institution and the programmes they offer to some extent, as some standards are ensured. Out of the total AICTE-approved institutions of technical education, only 2,414 institutions offer NBA-accredited study programmes in 2020, as per the information available on the AICTE website. Referring to the quality of engineering institutions in the country, Subbarao (2013) observes that hardly three per cent of the engineering graduates are from 'good' institutes. He also observes that post-graduate programmes need special attention; and leadership, dedication and autonomy are essential to improve the quality of engineering education. Thus with respect to obtaining autonomy, only a small number of institutions have been successful; and with respect to accreditation, a large number of institutions are yet to fulfil satisfactorily basic conditions.

Second, the government of India has recently launched National Institutional Ranking Framework, under which an institution is ranked based on a set of academic, extra-academic and other parametres. The parametres considered include teaching and learning resources, research and professional practices, graduate outcomes, outreach and inclusivity, and finally perceptions of peer groups (academics and employers). The NIRF ranks higher education institutions in general and engineering institutions separately. Like any typical ranking system, the higher the rank of an institution, one would expect the institution to be of a higher quality and standards. There are 23 IITs, 31 NITs, 25 IIITs, a few technological universities and more than 4,000 institutions offering engineering education in the country. According to the NIRF 2020, as shown in Table 15, only the IITs, some NITs, and a few universities, figure in the top 20 institutions of engineering. A large number of institutions are nowhere in the ranking system.

Table 15. *Top 15 Institutions in National Institute of Ranking Framework (NIRF) 2020*

	Rank in Overall	Rank in Engineering
Indian Institute of Technology Chennai	1	1
Indian Institute of Sciences, Bengaluru	2	
Indian Institute of Technology Delhi	3	2
Indian Institute of Technology Bombay	4	3
Indian Institute of Technology Kharagpur	5	5
Indian Institute of Technology Kanpur	6	4
Indian Institute of Technology Guwahati	7	7
Jawaharlal Nehru University New Delhi	8	
Indian Institute of Technology Roorkee	9	6
Benaras Hindu University Varanasi	10	
Calcutta University	11	
Jadavpur University	12	17
Amrita Viswa Vidya Peetham	13	20
Manipal Academy of Higher Education	14	
Indian Institute of Technology Hyderabad	15	8
Indian Institute of Technology BHU	26	11
Anna University, Chennai	20	14
Indian Institute of Technology Indore	23	10
National Institute of Technology Tirichirapalli	24	9
Indian Institute of Technology Mines Dhanbad	22	12
National Institute of Technology Suratkal	33	13
Vellore Institute of Technology	28	15

Source: MHRD: NIRF
https://www.nirfindia.org/2020/OverallRanking.html
https://www.nirfindia.org/2020/EngineeringRanking.html

Third, at the global level, the picture is more dismal. Not even one Indian institution figures in the top 100 institutions of higher education in the global rankings of universities. Eight IITs from India are placed in the top 1000 global list of the Quacquarelli Symonds (QS) rankings 2021, with the IIT Bombay (IITB) in the top, with the world ranking of 172. A few IITs figure in the top 500 institutions three of which figure below the rank of 200. While global ranking mechanisms have their own weaknesses, they nevertheless reflect some key dimensions of quality of universities, stressing the need for policy focus on raising quality and standards in Indian institutions

(Tilak, 2016a). *Table 16* gives an idea of where some of the well-known Indian institutions of technical education stand in world rankings.

Table 16. *Indian Institutes in QS Rankings of World Universities, 2020/2021*

	Rank among All 2021	Rank in Engineering & Technology 2020
Indian Institute of Technology Bombay	172	44
Indian Institute of Sciences Bangalore	185	103
Indian Institute of Technology Delhi	193	47
Indian Institute of Technology Madras	275	88
Indian Institute of Technology Kharagpur	315	86
Indian Institute of Technology Kanpur	350	96
Indian Institute of Technology Roorkee	383	156
Indian Institute of Technology Guwahati	470	233
University of Delhi	501-510	342
Anna University		373
Vellore Institute of Technology		401-450
Birla Institute of Technology & Science, Pilani		451-500
Indian Institute of Technology Hyderabad	601-650	
Jadavpur University	651-700	
O P Jindal University	651-700	
Savitri Bai Phule Pune University	651-700	
University of Hyderabad	651-700	
Manipal Academy of Higher Education	751-800	
Anna University		

Source: QS World University Rankings 2021

In the case of global ranking of institutions of engineering & technology, however, 5 IITs figure in the top 100, two of which, namely the IIT Bombay and the IIT Delhi, figure in the top 50. Many other institutions rank very poorly in the global rankings. Not only advanced countries, but also developing countries like China, and small countries like Singapore perform better than India in these global, as well as engineering & technology specific university rankings. The problem is that the government seems to be focusing its efforts to raise quality on a limited group of institutions like the IITs and the NITs that produce actually a small proportion of graduate engineers.[15] IITs that produced 10 per cent of engineering graduates in the country in the 1970s and early 1980s, accounted for only 0.5 per cent of graduates around 2011 (MHRD 2011c). But even this strategy of focusing on IITs for improving excellence faces difficulties because of a faculty crunch, and the limited public investments on research and development in these institutions (Carnoy et al., 2010).[16]

The fourth important indicator that reflects the quality of education is the employability of graduates. Several studies reveal that a majority of engineering graduates in India do not possess the required skills and are therefore not suitable for employment (Mani and Arun, 2012; Loyalka et al., 2014; Choudhury, 2019). *The Annual Employability Survey 2019* (Aspiring Minds 2019) reveals that 80 per cent of Indian engineers are not fit for any job in the knowledge economy, and a similar observation was made by the National Association of Software and Services Companies (NASSCOM) and McKinsey study in 2005. The employability prospects of Indian engineering graduates have worsened in the past one-and-a-half decade: as a majority of them are not qualified enough for employment in engineering sector or in any sector.[17]

The overall pathetic situation is clear: less than 2 per cent of the colleges have scored above 50 per cent of marks in the NIRF; less than 5 per cent of the engineering graduates pass graduate attitude test in engineering (GATE); less than 5 per cent of the engineering programmes are accredited by NBA with 'full accreditation' (VIF, 2019).

Why and how is engineering education so engulfed with unacceptable levels of poor quality teaching? Who is responsible for this? Is the expansion of engineering education leading towards a decline in its quality? What are the strategies being adopted by regulatory authorities (specifically by AICTE and NBA) to address this issue? What are the efforts made at the institutional level to improve the quality? These are some critical questions that need to be examined to understand quality related issues.

It is widely noted that the exponential growth in engineering education in India has led to the supply of sub-standard graduates and this issue has become quite serious in recent years (Dubey et al., 2019). India's engineering education system has a few bright spots of excellence, engaged in both teaching and research like the IITs, NITs, and IIITs, but is surrounded by a sea of substandard colleges that primarily aim at selling quickly poor quality degrees in the market. Such quality institutions exist both in the public and private sector, but predominantly in the public sector. The IITs figure, as already noted, in the global university rankings of the Times Higher Education (THE)/QS.

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15 The IITs and NITs together account for just three per cent of enrolments, but get 50 per cent of government funds (Sharma, 2018).

16 In general the investment in science and technology in India is very low, compared to many other developing and developed countries. In terms of the resultant indicators also India fares very poorly.

17 Some issues relating to labour market and engineering education are discussed in the next section.

The alumni of the IITs, for example, command national and global labour markets in science and technology. Likewise, India's second tier engineering institutions like the NITs and several established government engineering colleges are also well-regarded, and have good faculty and student bodies.

On the whole, government or government-aided private colleges perform far better imparting superior quality education than self-financing colleges. This is also clear from the students' preference for public versus private institutions. The meritorious students and talented teachers prefer public to private institutions (Loyalka et al., 2014). The quality of engineering education also depends on the institutional cultures that result in different experiences for students of similar educational and familial background (Malish and Ilavarasan, 2016), and in the Indian context, public engineering institutions are found to be successful in nurturing students better. The system of engineering education in the public sector in India has had very bright centres of excellence.

As Loyalka et al. (2014) noted, in India a minority of engineering students receive high quality training in elite institutions while the majority of students receive low quality training in non-elite institutions that are mostly managed by the private sector. It is also said that the problem of quality is largely with these engineering institutions run by the private sector and they are often established as family enterprises. Enrollment in many private technical and professional colleges is declining partly due to the questionable quality (Varghese, 2015). It is widely acknowledged that the deterioration of the quality of engineering education in India is largely due to the unregulated expansion of the private engineering colleges, as they tend to combine low quality with profiteering. Only two private higher education institutions with a specific focus on engineering and technical education (Manipal Academy of Higher Education and Amrita Vishwa Vidyapeetham) from India have been included in the top 1,000 global list of 2020 QS World University ranking. Similarly, the NIRF 2020 for engineering & technology subjects finds that only two private institutions, viz., Vellore Institute of Technology and Amrita Vishwa Vidyapeetham figure in the top 20, while all the others in the top 15 are public institutions.

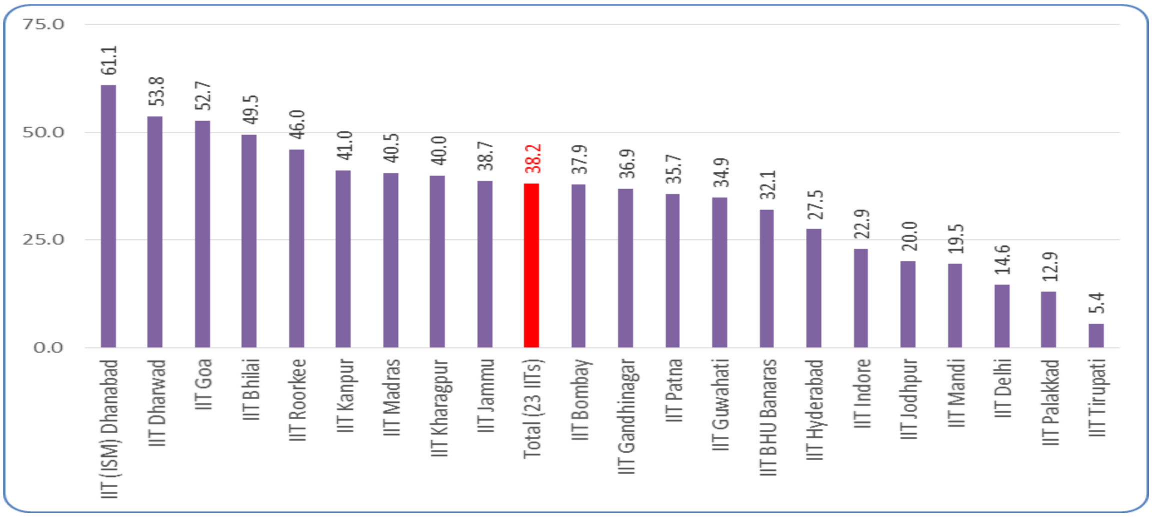
With the massive expansion of engineering education, students with a much lower entrance examination score get admission in self-financing colleges, and therefore the entry level examination is not ensuring admission of only meritorious and quality students. An investigative status report in the Times of India (December 13, 2017) reveals that there are 'middlemen' forming an integral part of the ecosystem created by an uneven growth in private engineering colleges. This phenomenon appeared over the last decade when a majority of the student places are lying vacant. With falling demand, with fewer and fewer students ready to take admission as degrees are getting steadily devalued, many self-financing colleges hire the services of middlemen to lure students. This is becoming a part of an unstated but widely prevalent admission mechanism. Engineering colleges, desperate for students increasingly depend on these brokers for survival. Given the informal and unregulated nature of the sector, it is difficult to map the role and growth of the middlemen engaged in the engineering education, and also it is hard to obtain authentic official details on this interesting aspect. But the Times of India 2017 report in the context of Uttar Pradesh, where 65 per cent student seats were lying vacant, offers some interesting evidences. The commission charges paid to middlemen for getting students to some colleges ranges from Rs 25,000 to Rs 60,000 per student; and in some cases, colleges also offer a share of their annual revenue to them. The middlemen might also be charging students for their 'special' services. This appears to be a profitable activity for these agents as each of them easily earns around Rs 10 lakh a year, and it is also beneficial for the academically weak students who have given up any hope of joining engineering college. The presence of middlemen sourcing students for college admissions reflect a deplorable situation, resulting in the rapid and steep lowering of standards of engineering education in the country. The student's aptitude has little to do with his/her chances of getting into an engineering college, as anybody with 45 per cent marks in the senior secondary board examination — the minimum eligibility norm prescribed by AICTE for admission to undergraduate engineering studies —can be assured of admission if she/he is ready to pay fees to the college and a commission to an agent. In the Times of India (2017) survey, one middleman bluntly stated that meritorious students would never take admission 'through us'. It was economically rich students with ranks at the bottom, who approached them. Since colleges are desperate, they even grant admission to students "who have barely any understanding of mathematics. I'm not sure if these students learn anything at all". The existing regulatory mechanism does not cover such issues and clearly tough guidelines of regulatory mechanism and their implementation are needed to tackle these and similar concerns. With such imperfect and corrupt practices, the so called competitive entrance examination loses value, not being able to prevent a large number of low quality students from entering into engineering education. Low quality inputs in the form of such students, obviously produce poor quality graduates.

In addition, we discuss below four important aspects relating quality of education: shortage of faculty, production of PhDs, recruitment of fake faculty, and excess supply of engineering education.

Shortage of Faculty

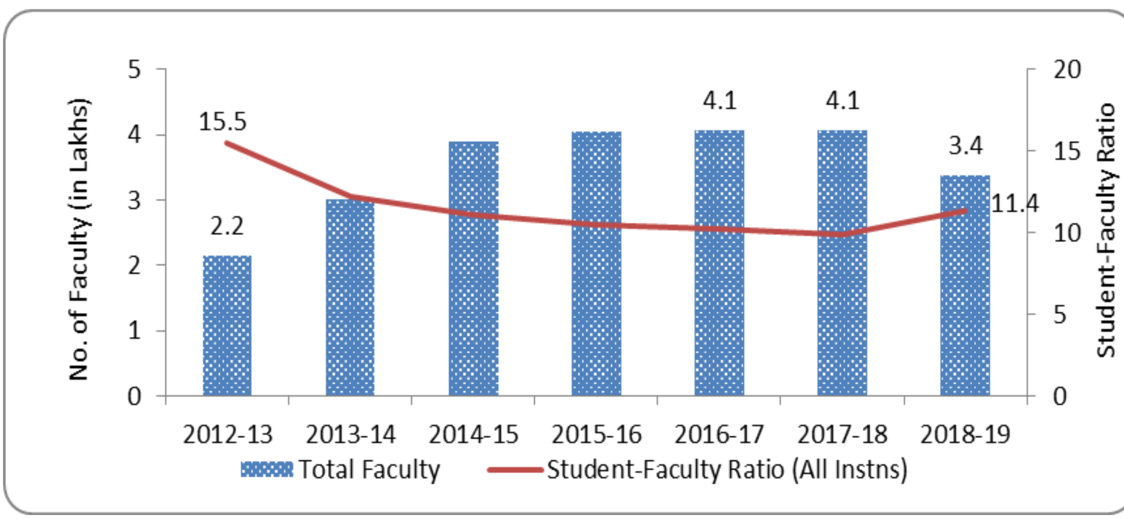
The quality of education critically depends upon the teacher. After all, it is the teacher who is considered the pivot of the education system. Unfortunately, the entire higher education system in India suffers from an acute shortage of faculty. Functioning with very limited faculty, it falls far below the minimum requirements. The problem, which was evident for the past two-three decades, has got compounded over the years. It has been reported that in 2020 as many as 32,581 faculty posts in Indian universities are lying vacant in 2020, representing 18.4 per cent of total sanctioned strength, according to the information provided by the Union Minister of Education in the Parliament. In the centrally-funded higher education institutions, as many as 7,500 posts of teachers are lying vacant. The percentage of vacancy of teachers, it has been estimated, ranges between 30 and 50 per cent in the state universities. Even IITs suffer a severe degree of shortage of faculty (Figure 16). The 23 IITs together have a teacher vacancy of 38.2 per cent. The vacancy rate ranges from below 5 per cent in IIT Tirupati to above 60 per cent in IIT (ISM) Dhanbad. The problem is as grave in NITs, and other national institutes as well as state institutes of engineering and technology.

Figure 16. *Faculty Vacancy as a Percentage of Total Sanctioned Strength in IITs, 2019*



Source: Kalra (2019).

Figure 17. *Faculty in Engineering &Technology Institutions in India*



Source: AICTE Database

According to the AICTE data, there has been a major decline in the size of faculty in the under graduate level engineering colleges, by about 69,000 between 2017-18 and 2018-19) (*Figure 17*). As a result, in many colleges, even the first (bachelors') degree holders are engaged in teaching activities, while a doctoral degree is an essential condition. World Bank (2013) found that hardly 20 per cent of the regular faculty in Andhra Pradesh hold PhD degrees. All this also poses problems in enhancing research capacity in engineering institutions. Not only we need teachers in good numbers with PhD degrees, but also there is need to set up extensive professional development programmes for the teachers in engineering colleges, as whether a teacher is having MTech./ME or PhD degree she/he needs facilities for continuous upgradation of their knowledge and skills, as the AICTE committee (2002) suggested.

Production of PhDs and Quality of Faculty

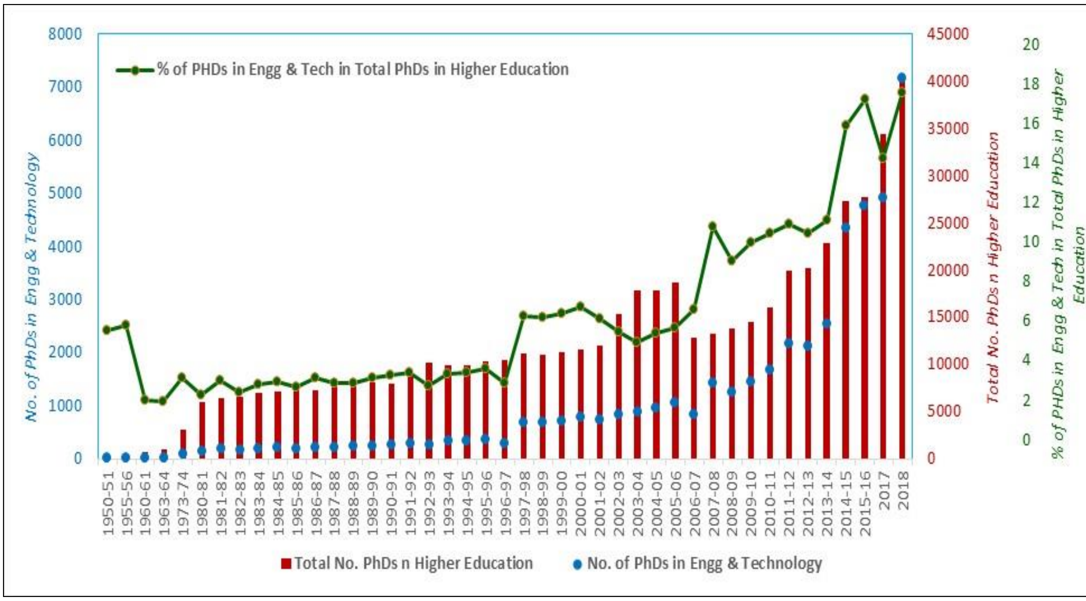
The faculty shortage is due to several factors: first a limited supply of qualified graduates. The number of PhDs in a field like engineering & technology is very limited; very few bachelor degree holders go to master's level studies and fewer to research programmes, as already been noted. A research degree (PhD) is an essential qualification for a teaching position in higher education. Although having a Doctoral degree does not necessarily imply that one will be a more competent teacher, there should be some connection between completion of a research degree and being able to teach a subject more competently than others. But many graduates are reluctant to enter the teaching profession, because of a poor academic environment on the one hand, and better opportunities in job market for first degree holders on the other. In fact, faculty vacuum and poor qualifications of faculty stem from the low number students pursuing PhD studies. So there is a big supply constraint. The public institutions have relatively a higher proportion of faculty with PhD degrees; and they also produce a high proportion of PhDs and graduates of high quality compared with private institutions. Added to the overall shortage is the inability of institutions to recruit faculty due to bureaucratic and legal hurdles. Another reason is the reluctance of many institutions, particularly private ones, to hire faculty in general and faculty with doctoral degrees in particular, as they need to incur higher levels of expenditures on account of salaries. These institutions try to do with a small number of teachers, less qualified ones and through different questionable practices. All this has increased the student-faculty ratio from 9.87 in 2017-18 to 11.39 in 2018-19 (*Figure 17*).

Availability of a small number of doctorate degree holders is considered as an important reason for the shortage of faculty. Only a small number of PhD degrees are awarded in engineering & technology, as shown in Figure 18. The corresponding number constitutes 18 per cent of the total number of PhDs awarded in India in 2018. This was below or around 5 per cent until 2005-06. It is only after 2006-07 onwards there has been an upward trend. The growth has picked up essentially during the last one decade, though the long term rate of growth (between 1950-51 and 2018) is also relatively impressive: 5.97 per cent per annum in case of degrees in engineering & technology compared to 3.19 per cent in case of doctoral degrees in all subjects. On the whole, while the total number of PhD degrees awarded in all subjects in India increased by about 222 times from 180 in 1980-81 to nearly 41 thousand in 2018,[18] the number of PhDs in

[18] India ranks fairly high among countries of the world in terms of number of PhD graduates. In 2014 US which was on the top produced 67,449 doctoral graduates. About 40 per cent of new

engineering increased by a whopping more than 700 times from a meagre 10 to 7,160 during this period (Figure 18).

Figure 18. *Growth in the Number of PhD Degrees awarded in Universities in India*



Source: Based on UGC *Annual Reports* (various years).

While enrollment in engineering studies at the undergraduate level has increased at a compound annual growth rate of 9.7 per cent between 19975-76 and 1990-91, it was only 4.4 per cent in case of the growth of PhD outturns. A more or less similar trend is also observed between 1991-92 and 2010-11. However, a reverse trend has been observed during the last seven years (2011-12 to 2018-19) as shown in Figure 19. The rate of growth in PhD outturn is 18.6 per cent while it is 2.4 per cent in the case of under graduate enrollment in engineering education in India during this period.

The number of PhD degrees awarded in the discipline of engineering & technology in 2018-19 in India was 7,160 (Figure 20). This shows an increase of about 46 per cent in the number of PhDs awarded from the previous academic year i.e. 2017-18. However, still the number of PhDs awarded as a proportion of total under graduate outturn in India is less than one per cent (0.86 per cent), though it has gone up substantially in the recent years. This figure was merely 0.39 per cent in 2011-12.

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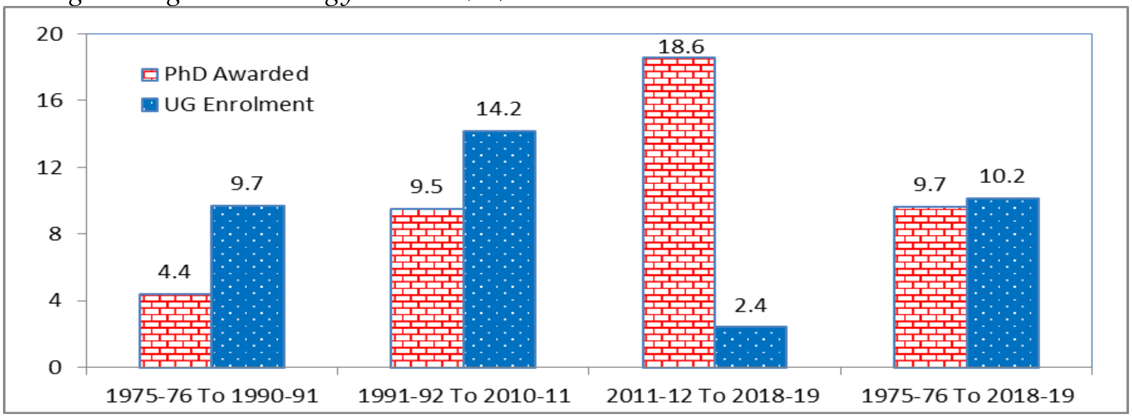
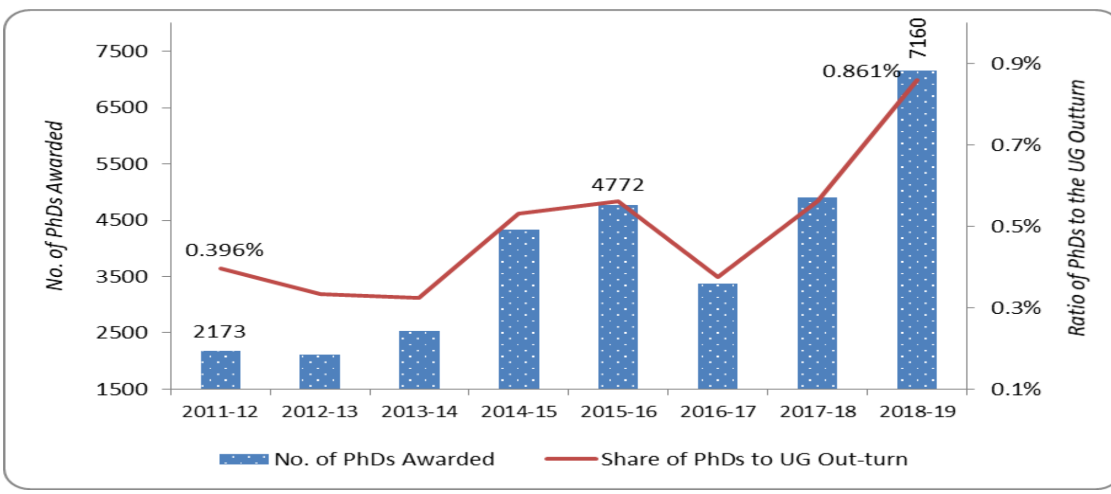
doctorates awarded in the OECD area are in science, technology, engineering and mathematics (STEM) (OECD, 2016).

Figure 19. *Rate of Growth in the Number of PhDs awarded and Undergraduate Enrollments in Engineering & Technology in India (%)*



Rate of growth: compound annual rate of growth (%)
Source: Based on UGC *Annual Reports* (various years)

Figure 20. *Growth in the Number of PhDs Awarded in Relation to Undergraduate Outturn in Engineering & Technology in India*



Source: *All India Survey of Higher Education* (various years)

The 7,160 – the number of PhD degrees awarded in engineering & technology in 2018, constitutes 18 per cent of the total number of PhDs awarded in India. This is a very significant growth. The sudden increase in the number of PhDs recently awarded may be due to the special efforts initiated by the government[19], but more importantly due to the gloomy labour market conditions for engineering graduates completing under graduate level studies. As a result of the later, instead of remaining idle, these graduates may be opting for higher studies with/without an expectation of better jobs, a phenomenon generally described as the 'baby-sitting' role of higher education, or 'diploma disease' (Dore, 1976). In this context, it is important to examine whether the increase in the PhD outturn will help in improving the existing faculty crunch in engineering education in India.

On the whole, there is still a lot to improve the situation with respect to doctoral research in India. Not only in number, is the quality of teachers also crucial. A tiny number of faculty members in engineering institutions hold PhD degrees, and in many self-financing colleges, Bachelor degree holders occupy teaching positions, formally or informally. Indian faculty in general including faculty in engineering institutions have very few research publications. The overall research productivity of faculty members in engineering education is quite low. Exceptions are very few. Part of the problem lies in the utter absence of a research environment. With poorly research oriented teachers, students also do not participate in research activities. Loyalka et al. (2016) observed that only about one-sixth of students in India participated in at least one faculty research project. All students do not necessarily take up internships, and industry-institute collaborations are also limited. Students get motivated by inspiring high quality teachers. A large number of private colleges have no qualified quality faculty in the numbers required, as the system itself is not producing them. Thus, India is experiencing a vicious circle in the supply of qualified faculty in the engineering education sector. A very good research environment in the institutions of higher education, and a through grounding of the students in the subject at undergraduate level are essential to promote quality doctoral research (Gupta, 2010). In case of both, a vast majority of institutions of engineering/technical institutions suffer from a huge deficit.

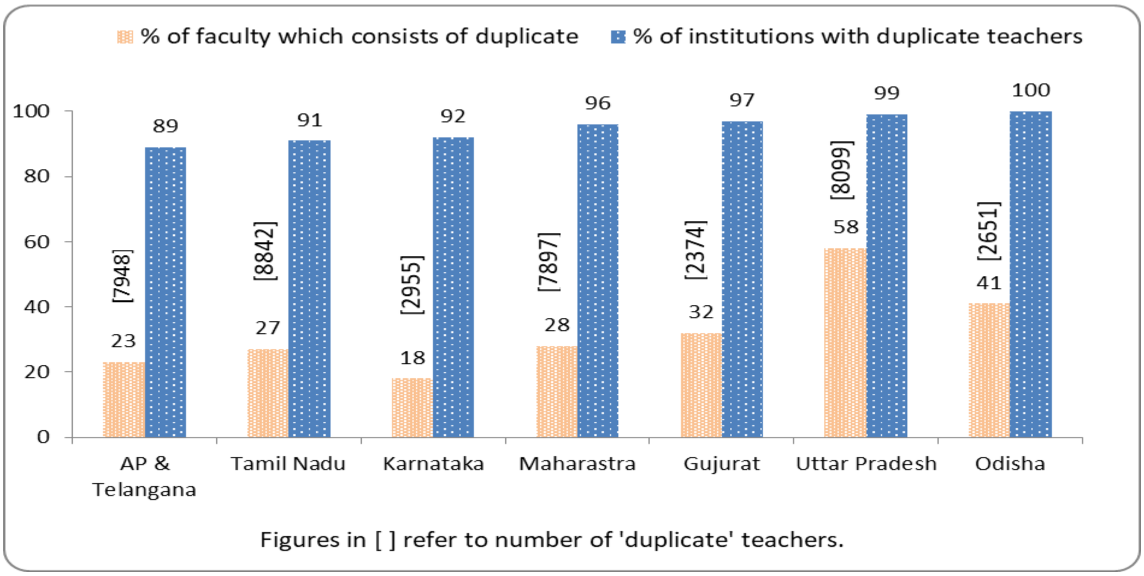
Recruitment of 'Fake Faculty'

Let's turn to the nature of faculty recruitment in the private colleges. There is no authentic information recruitment of faculty in several engineering colleges. Very few attempts have been made by individual researchers to explore and examine this area. In one such attempt made by an open data campaigner Rakesh Reddy Dubbudu and his team using AICTE data reveals some serious anomalies (May 11, 2015, The Hindu). Surprisingly, over 90 per cent of private engineering colleges in India have at least one teacher whose name also features on the rolls of another college, and there are at least 50,000 such 'duplicate' teachers. Colleges are expected to have their own full-time faculty, and not supposed to share faculty according to the AICTE guidelines. The state-wise picture on this is given in Figure 21. In Andhra Pradesh and Telangana, nearly a quarter of the total engineering faculty consisted of duplicate names, and about 90 per cent of the over 1,500 accredited engineering colleges in the states had at least one 'duplicate' teacher

19 In the recent years, the Government of India announced Prime Minister Research Fellowship Scheme for 1,000 BTech/BE graduates for pursuing doctoral studies in IITs and the Indian Institute of Science. Such measures are important, but still inadequate.

on their faculty. This is found to be alarming in Uttar Pradesh, as close to 60 per cent of faculty names consisted of duplications, while in Odisha it was 40 per cent. Almost every engineering college in these two states had at least one such case. Norms were being flagrantly violated by the engineering colleges in several states in the appointment of faculty and no action could be taken by the appropriate authorities, partly because of political support and economic power the managements of these colleges enjoy. After all, as Kapur and Mehta (2004) observed, the growth of private engineering colleges in the country engineering colleges is simply an artefact of politicians creating opportunities to collect rents.

Figure 21. *'Duplicate' faculty in engineering colleges in India (%)*



Source: Rukmini (2015) in *The Hindu*, May 10, 2015.

Excess Supply

Within engineering education, we have already noted excess supply: larger number of institutions than required, and admissions much below sanctioned intake levels. Now we look at the production of graduates in relation to the labour market requirements or absorption capacity of the labour market. We do not have detailed estimates of requirements of engineering manpower integrated with educational planning. But the high levels of unemployment of graduates imply that there is an excess supply of graduate engineers in India. We have also noted that every year about 1.5 million graduates – higher than the numbers produced by USA and China together -- are produced by the engineering education system in the country. This regarded as one of the largest numbers in the world. But quite paradoxically, according to the World Economic Forum (2020), India ranks 32 among the countries in terms of the availability of engineers and scientists. Not only advanced nations like USA, Canada, UK, Switzerland,

and Japan are ahead of India, but also India is behind many developing countries including Qatar which ranks 5, Malaysia (7), United Arab Emeritus (UAE) (3), Jordan (13), Chile (22) Ukraine (25), China (29) etc.[20] While these international comparisons are not necessarily perfect, due to variations in definitions and methods, they nevertheless suggest that India is not necessarily over producing engineer graduates, but producing large numbers of poor quality unemployable graduates. Some also believe that a rapidly growing economy like India would indeed require more and more engineer graduates. Further, while overall numbers may be high, there may be under production of graduates in specific areas and over production in some other areas, creating gluts and shortages in the labour market.

While we do not have elaborate labour market information, some relevant information is available on the education system. There are some projections of requirements of colleges and number of graduates, but they do not seem to have been taken into account while allowing the growth of colleges and sanctioning of intake in those colleges. For example, AICTE has projected that the country would need 1,400 engineering colleges with an intake of 500,000 by 2014-15 (Table 17) (TEQIP, 2002). But in 2014-15, there were 3,364 colleges with an intake of 17.1 lakh students. We have far exceeded in practice the projections made by AICTE for 2000, 2005, 2010 and 2015.[21] Thus there is a huge excess supply of institutions and thereby graduates.

Table 17. *AICTE projections: Programmed Requirement of Engineering Degree Level Institutions and Admission Capacity*

	2000	2005	2010	2015
No. of Institutions	838	1,000	1,200	1,400
Annual Intake	232,229	320,000	400,000	500,000

Source: TEQIP (2002).

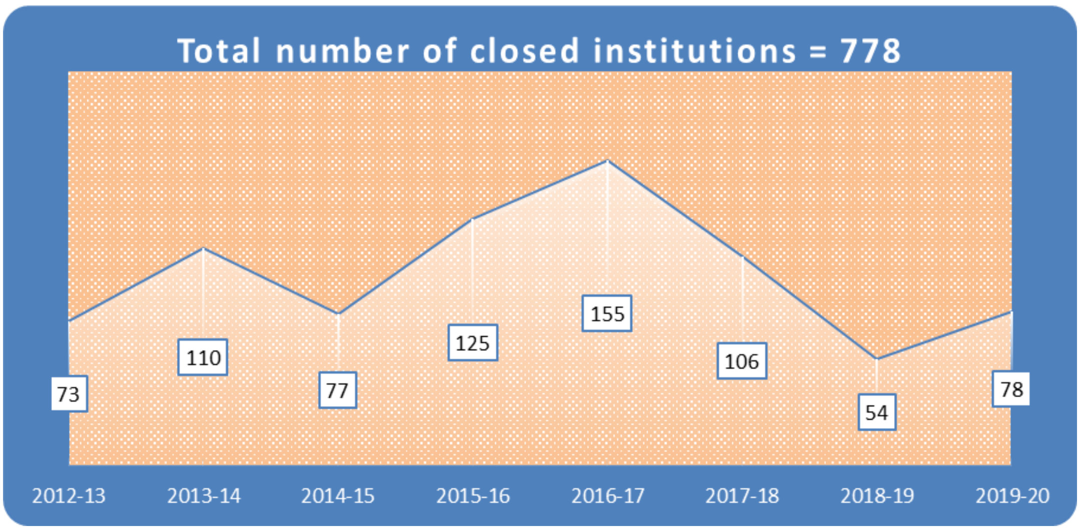
Not exactly keeping such projections in mind, nor in response to the malpractices adopted by these colleges, or the dubious quality of education they are offering, but essentially as enrollments are falling, AICTE is ordering closure of colleges. Several engineering colleges in the country do not find takers of admission, a tough situation for the owners of these colleges to run their programmes as their revenues shrink. So many colleges on their own might get closed. In a sense, the prevailing market forces compel such colleges with excess capacity or underutilisation of the capacity (admissions being much below the intake capacity approved), to close down and the owners of these colleges project themselves as victims of circumstances. As Figure 22 shows, during the

20 According to UIS statistics, countries like Russia, USA, Iran, Japan, South Korea, Indonesia, Ukraine, Mexico and France and Viet Nam are regarded as the top ten countries in terms of production of engineers (Interesting Engineering 2016). It appears data on India and China were not considered in these calculations.

21 Details on the basis and method of these projections are not available.

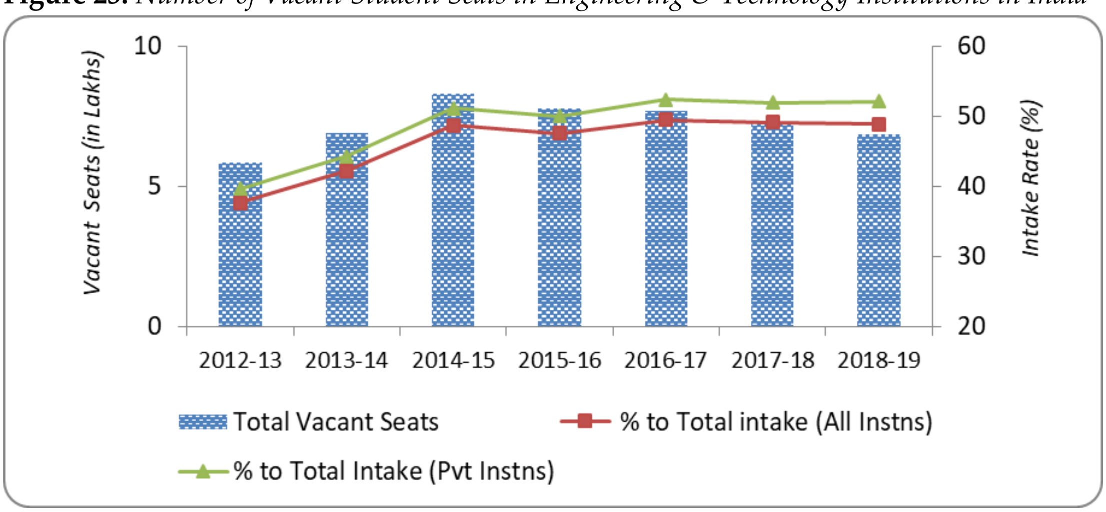
last eight years (2012-13 to 2019-20), AICTE has approved the progressive closure of 778 colleges across India. Still in 2018-19, as against the total intake capacity at undergraduate level of14 lakhs, the total enrollment was 7.2 lakhs which is just around 51 per cent. Thus, close to half of the approved student seats (6.9 lakh) have remained vacant without takers in several engineering colleges in the country in 2018-19.

Figure 22. *AICTE Approved 'Progressive Closure' of Engineering & Technology Institutions in India*



Source: AICTE Database

Figure 23. *Number of Vacant Student Seats in Engineering & Technology Institutions in India*



Source: AICTE Database

In the context of declining demand, will the closure of institutes help imparting better quality engineering education? It is widely viewed that the oversupply of engineering colleges in the country is affecting quality and hence, the closure of several colleges will help improve the situation. At the same time, it is necessary, but not sufficient. The ever widening gap between the supply of and demand for engineering graduates in India raises several important issues that need special attention for academia and policy makers. One vital aspect may be to examine changing parental aspirations in sending their children for an engineering education, given the gloomy labour market symptoms. Similarly, it would be edifying to listen to the owners who run private engineering colleges and who project themselves as victims of circumstances. Some of these issues that are linked with the quality concerns of engineering education in the country call for alternative policy options.

The only major consensus that we have is "A serious situation has arisen in recent years because of the mushrooming of a large number of private technical institutions and polytechnics. Barring some exceptions, there is scant regard for maintenance of standards;" (AICTE 2003), and that we should take major initiatives to maintain standards and improve the quality. The change needed in our engineering education system is to make the transition from primarily teaching institutions to teaching and research institutions (Banerjee and Muley, 2008). The National Policy on Education (2020) also strongly pleads for having integrated university campuses where there are common facilities for undergraduate, post graduate and research studies, so that close linkages between teaching and research are established. To improve the research ecosystem in engineering colleges, India needs to recruit qualified faculty, build advanced laboratory facilities, ensure enhanced societal and industry linkages, along with better curricula and pedagogical arrangements (including compulsory internship as part of training), and more importantly, a better regulatory structure. There is need to invest heavily in improving teaching and research environment in most institutions across the country, so that talented teachers and serious students get attracted. Compulsory internship for students can better the quality of technical education as it helps to bridge industry-institute collaborations on curricular issues, and also helps to provide ready-to-use professionals for the industry (Prabhu and Kudva, 2016).

While examining reasons for the low-quality engineering education imparted in India (specifically in self-financing colleges), several studies highlighted inadequate public funds, and glaring gaps in regulation, including alleged corruption.[22] India needs stronger regulatory measures to facilitate proper growth and expansion of engineering education and public policy needs to explore possibilities of evolving reliable and effective regulatory structures in India. Given the experience, ideas like 'self-regulation' or 'minimum regulation' that the National Policy on Education 2020 (MHRD, 2020) proposed, may not work in Indian higher education, with such a large network of private institutions. It is important to note that the kind of expansion that has taken place has led to a lack of accountability by private higher education providers.

22 We discuss issues relating to public funding in the following section.

Policy initiatives should aim at producing quality engineers with character and values who can be meaningfully employed in the labour market and contribute to the larger developmental goals of the country and society. Overall, engineering education in India fails to establish a robust technical ecosystem that can produce quality graduates.

6. Financing of Engineering Education in India

There has been a major shift in policies on financing of higher education in India during the last few decades. Declining public funding and advocating non-state funding of higher education, specifically passing the burden to households in terms of high fees and student loans, have been familiar trends. Higher education, which used to be heavily subsidised by the state (Tilak, 1993), is increasingly becoming dependent on the investment made by individual households,[23] with decline in general and specific public subsidies in higher education. Cost recovery measures, particularly student fees which have been used to generate more and more resources, have contributed to making higher education increasingly costlier for students, raising questions of the affordability of quality education. Student loans have not been significantly effective in mitigating the regressive effects of high fee levels. The problem of financing of technical education is also assuming different dimensions in quantum and nature since the beginning of the 1990s (Tilak 1999). The increasing presence of the private sector in engineering education is raising questions on equitable access to quality higher education. Households belonging to the lower and middle socioeconomic strata feel financially handicapped in sending their children to engineering studies. Further, it is expensive to maintain technical education at a high level of excellence (AICTE, 1994). Keeping the increasing cost of technical education in mind, the report of the High-Power Committee for Mobilisation of Additional Resources for Technical Education, AICTE (1994) has recommended that the tuition fee for government-funded and aided institutions should be revised to about 20 per cent of the recurring expenditure per student per year which was only about 1 to 5 per cent when this recommendation was made, but few seemed to adhere to the recommendations, as many raised fee levels much beyond this proportion.

Against this background, we discuss here two important issues: (a) public financing of technical [24] and also specifically some aspects of public funding of engineering education, and (b) household expenditure on engineering education.

Public Financing of Engineering and Technical Education

In the early 1960s, public funding and philanthropic contributions for higher education were a major part of the resource base of this sector in India and the funding

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23 Private sector investments are not referred to here mainly because, most of those investments are gradually recovered from students in the form of student fees.

24 Technical education in India covers programmes in engineering & technology, management, architecture, town planning, pharmacy, applied arts & crafts, hotel management and catering technology. As we note here, engineering education constitutes only a small part only, accounting for about 15 per cent of the total expenditure on technical education in the states/union territories (2014-15).

from private sources in terms of fees and other payments from students were negligible. So were investments in education by the non-philanthropic (or profit-seeking) private sector. With the introduction of economic reform policies in the early 1990s, broadly known as structural adjustment programme, the trend shifted in a big way towards the private funding of higher education in general and particularly in engineering education and almost all areas of technical education. Public support for higher education became weak in the decades following the economic reform era (Tilak, 2012, 2016b). It is argued that the beneficiaries of technical education are not only the students, but also the industry, the government and society at large and therefore, the financial inputs to technical education system are to be viewed as a long-term investment in the national economy and the cost of such education has to be shared by all the three beneficiaries (AICTE, 1994). Of the three, the student is seen as the main beneficiary and has to bear a very high proportion of the cost. The increasing size of the private sector has further led to the strengthening of this view.

We analyse public support towards engineering and technical education in India with the help of secondary data obtained from Analysis of Budget Expenditure on Education (MHRD). Data on public expenditure on higher and technical education are available in this important source in two separate statements: (a) 'university and other higher' education and (b) technical education.[25] Public expenditure in engineering education is included as a sub-head in the statement on technical education. The data provided in this document that we use here on engineering education is partial in nature as it only includes the expenditure made by governments in the states and union territories on 'engineering colleges and institutions' and does not include expenditures made by the union government on engineering education, including on the IITs and NITs. The IITs and NITs, along with central universities and other central institutions, are funded by the union government. This is briefly separately described here.

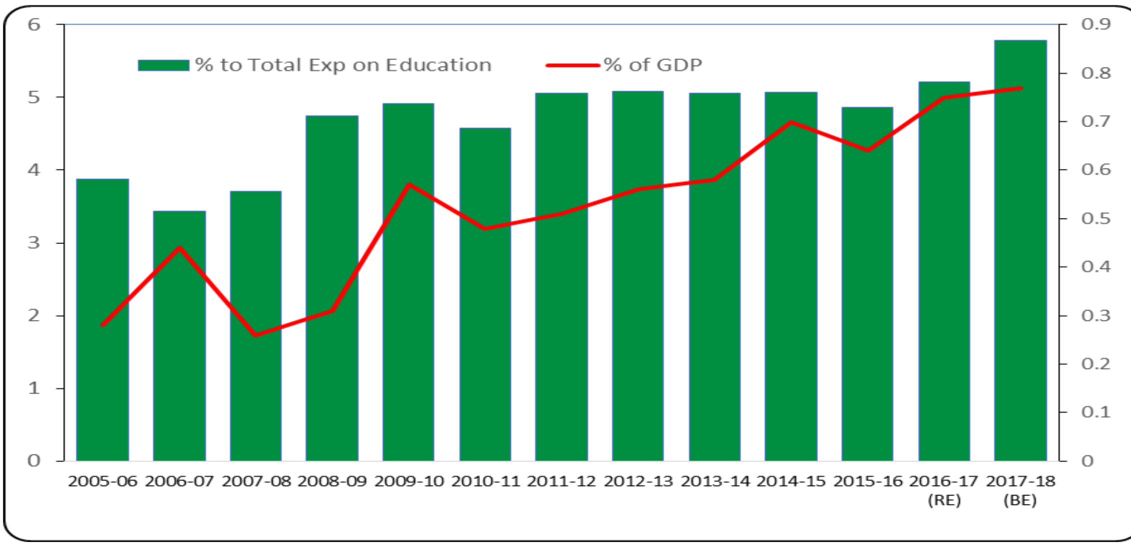
What is the relative priority accorded to technical education? In the gross domestic product (GDP), expenditure on technical accounted for a very small proportion. It was 0.3 per cent in 2005-06, which has increased to nearly 0.9 per cent in 2017-18, as per budget estimates.[26] In a sense, the priority given to technical education seems to be insignificant; but the education sector as a whole receives only about four per cent of the GDP. The Education Commission (1966) recommended an allocation of 6 per cent of national income to education by 1986, and the CABE Committee (MHRD, 2005) reiterated the same, and added that subject to fulfilment of this, at least 0.5 per cent of national income be allocated to technical education. It may not be proper to conclude that the

25 Expenditure on engineering and other departments of technical education in comprehensive universities, particularly on non-allocable overall heads, also gets included in the university and higher, and not in technical education. However, under technical education, we also find small amounts of 'assistance to universities.'

26 We have data until 2015-16 on actual expenditure, 'revised estimates' (RE) for 2016-17 and 'budget estimates' (BE) for 2017-18. It may be noted that generally budget estimates turn out to be much higher than actual expenditure, while the revised estimates are found to be close to, but still are marginally higher than actual expenditure.

share of technical education already exceeds the recommendation made by MHRD (2005), as the present share incudes expenditure on technical schools and polytechnics, which together account for above 35 per cent of the total, while, the recommendation refers to technical education at higher level; and the recommendation assumes a priori fulfilment of recommendation of allocation of 6 per cent of national income to education.

Figure 24. *Expenditure on Technical Education as a Proportion of Total Expenditure on Education and GDP (%)*



Source: *Analysis of Budget Expenditure on Education* (Various Years), MHRD

Another indicator of relative priority given to a technical education can be understood, when we look at the share of technical education in total expenditure on education. Such a proportion has increased from near 3.9 per cent in 2005-06 to 5.1 per cent in 2014-15, and then declined to 4.7 per cent in 2017-18 (see Figure 24). Public expenditure on technical education in real terms[27] has increased, as shown in Table 18, from ₹14,685 crores in 2005-06 to ₹1,01,714 crore in 207-18 (as per budget estimates). The actual expenditure was ₹72,764 crore in 2015-16. The increase at an annual rate growth of 17.5per cent has been very impressive, as it is in constant prices.

While the expenditure of the union government increased at 16.3 per cent, expenditure of states and union territories increased at 19.5 per cent. But the relative share of the union government has increased from about one-third to 50 per cent by 2009-10, and then declined to 41 per cent by 2017-18, while the relative share of the states and

27 Public expenditure in real terms/constant prices is estimated by using the Gross Domestic Product (GDP) deflators, considering 2011-12 as base year, data on which are collected from the *Handbook of Statistics on Indian Economy* (2019-20), Reserve Bank of India (RBI 2020b).

union territories in the expenditure has declined from 66 per cent to 59 per cent during this period. Note that this is the period during which several new technical institutions were set up by the union government.

Table 18. *Union and States' Public expenditure on Technical Education in India (Rs in crore in 2011-12 prices)*

	States & Union Territories	Union Government	Total	States & Union Territories	Union Government	Total
		Rs in crore			percent	
2005-06	9,696	4,989	14,685	66.0	34.0	100
2006-07	14,947	9,793	24,740	60.4	39.6	100
2007-08	9,435	7,355	16,791	56.2	43.8	100
2008-09	11,271	10,125	21,397	52.7	47.3	100
2009-10	20,743	20,875	41,618	49.8	50.2	100
2010-11	18,928	19,219	38,147	49.6	50.4	100
2011-12	23,975	20,386	44,361	54.0	46.0	100
2012-13	30,604	20,652	51,256	59.7	40.3	100
2013-14	31,225	25,932	57,156	54.6	45.4	100
2014-15	39,726	33,487	73,214	54.3	45.7	100
2015-16	41,950	30,814	72,764	57.7	42.3	100
2016-17 (RE)	56,540	36,087	92,627	61.0	39.0	100
2017-18 (BE)	59,556	42,157	1,01,714	58.6	41.4	100
Rate of Growth	16.33	19.46	17.50	..	..	..

Note: RE: Revised estimates; BE: Budget estimates
Rate of growth: annual average compound rate of growth
Source: *Analysis of Budget Expenditure on Education* (various years)

It is generally observed that the centrally funded institutions are reasonably better funded, though the funds made available to them also fall short of requirements, than many institutions funded by state governments or by others that come under the purview of the states. Such information like the union government's expenditure on technical institutions and other institutions was available in *Analysis of Budget Expenditure on Education* until 2013-14, but not for the later period. *Table 19* gives a few such details on select technical institutions for the period, for which data are available. The IITs and NITs account for more than half of the total union government budget on technical education. The corresponding proportion used be higher in the earlier years. The generous funding of these institutions can also be viewed as one of the main reasons for their better functioning and higher quality and standards. The funding pattern of IITs and NITs versus others strongly suggests that (a) quality education is costly and requires generous funding, and (b) it is public institutions that can provide quality education compared to the others.

Table 19. *Union Government Expenditure on Select Institutions of Total Technical Education* (Revenue Account) (₹ in cores) in Constant Prices

	1993-94	2000-01	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13 (RE)	2013-14 (BE)
IITs	142.1	505.0	657.7	649.6	638.6	709.6	730.4	894.0	1790.1	1777.7	1942.7	2322.9	2647.6	3850.1
% in Total	35.1	45.7	47.6	46.4	44.3	46.6	41.6	42.9	40.9	32.6	32.5	29.1	31.0	40.9
RECs/NITs	72.5	134.5	190.0	216.7	273.6	280.5	221.8	**	1196.0	1431.9	1389.5	1588.3	1612.0	2109.1
% in Total	17.9	12.2	13.8	15.5	19.0	18.4	12.6	**	27.4	26.3	23.3	19.9	18.9	22.4
AICTE	2.4	86.0	120.0	50.0	64.0	91.5	240.6	590.4	197.0	200.0	220.0	230.0	400.1	421.0
% in Total	0.6	7.8	8.7	3.6	4.4	6.0	13.7	28.4	4.5	3.7	3.7	2.9	4.7	4.5
TEQIP		**	45.0	100.5	82.5	5.0	50.8	27.2	2.6	3.0	5.0	183.1	197.6	400.0
% in Total		**	3.3	7.2	5.7	0.3	2.9	1.3	0.1	0.1	0.1	2.3	2.3	4.2
NITIE (M)		11.8	6.5	13.0	6.7	10.7	22.3	34.8	47.9	56.5	52.9	42.4	31.5	33.3
IIIT (A)		16.5	6.8	5.0	1.9	15.6	19.6	28.0	55.3	55.3	35.7	69.0	85.1	**
IIIT (J)		**	**	**	4.0	6.0	8.0	11.0	23.9	41.0	45.0	55.0	65.0	**
IIITDM(K)		**	**	**	**	**	1.0	2.0	2.0	5.0	20.0	75.0	80.0	**
Setting up of 3 new IITs		**	**	**	**	**	**	**	**	248.5	250.0	637.9	715.0	**
New NITs		**	**	**	**	**	**	**	**	14.8	25.0	80.0	140.0	**
Total Tech Edn*	405.2	1104.9	1380.6	1400.2	1441.7	1523.7	1757.2	2082.1	4371.5	5451.0	5970.4	7973.4	8545.3	9421.2

NITIE(M) NITIE Mumbai; IIIT (A): IIIT Allahabad; IIITM (G): IIIT & Management, Gwalior; IIIT (J): IIIT Jabalpur; IIIT D&M (K): IIIT Design & Management, Kanchipuram; *Totals include others not listed/or have been marked ** or left blank here.

Source: *Analysis of Budget Expenditure on Education* (Various Years), Ministry of Human Resource Development.

The expenditure of the states and union territories on technical education has increased from ₹1799 crores in 1991-92 to ₹7296 crores in 2015-16, that is, by about 4 times at a rate of growth of 7.1 per cent, while on engineering education it has increased at a rate of growth of 7.8 per cent during last two-and-a-half decades (Table 20). Interestingly, the share of public expenditure on 'engineering colleges and institutions' to total public expenditure on technical education in the states/union territories has declined from 21.9 per cent in 1991-92 to 19.1 per cent in 2015-16, which increased to 25 per cent in 2017-18, as per budget estimates.

Table 20. *Public Expenditure on Engineering and Technical Education in India (States and Union Territories) (₹ in crores) in 2011-12 prices*

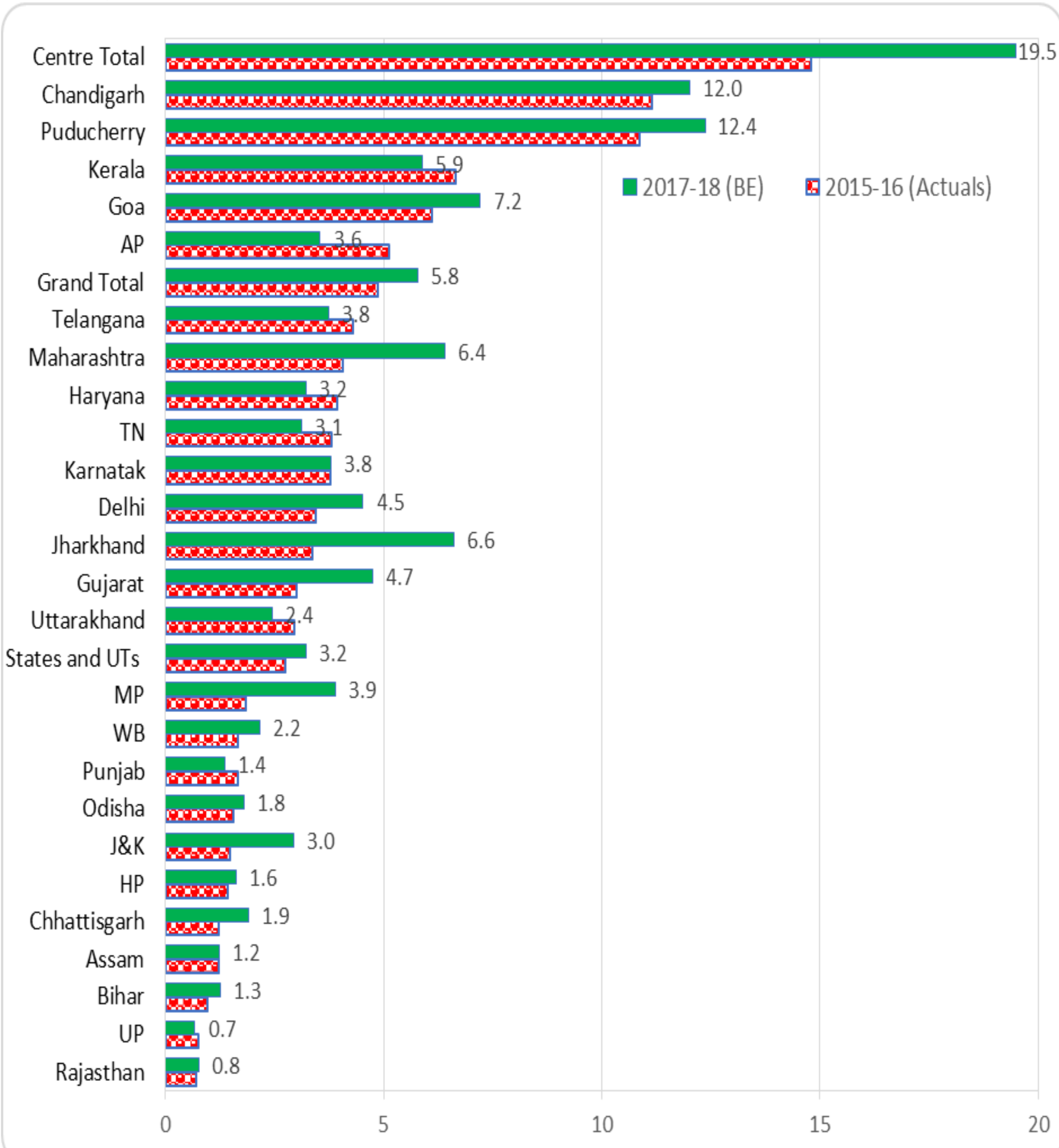
Year	Total Expenditure on Technical Education	Total Expenditure on Engineering Education	Engineering Education in Technical Education (%)
1991-92	1,799.8	394.4	21.91
1995-96	2,127.2	392.8	18.47
2000-01	2,877.9	557.0	19.36
2005-06	3,474.4	726.7	20.92
2009-10	4,659.1	711.4	15.27
2010-11	5,113.7	796.3	15.57
2011-12	5,691.6	856.6	15.05
2012-13	6,193.2	986.3	15.92
2013-14	6,666.0	1100.6	16.51
2014-15	7,560.0	1104.3	14.61
2015-16	7,296.0	1,393.0	19.10
2016-17 (RE)	8,671.0	1,338.0	15.40
2017-18 (BE)	10,622.0	2,774.0	25.80
Growth rate (1991-92 to 2017-18)	7.07	7.75	

Growth rate: Average compound rate growth per annum

Source: *Based on Analysis of Budget Expenditure on* Education (Various Years), *Selected Educational Statistics* (Various Years), UGC *Annual Report*s (Various Years).

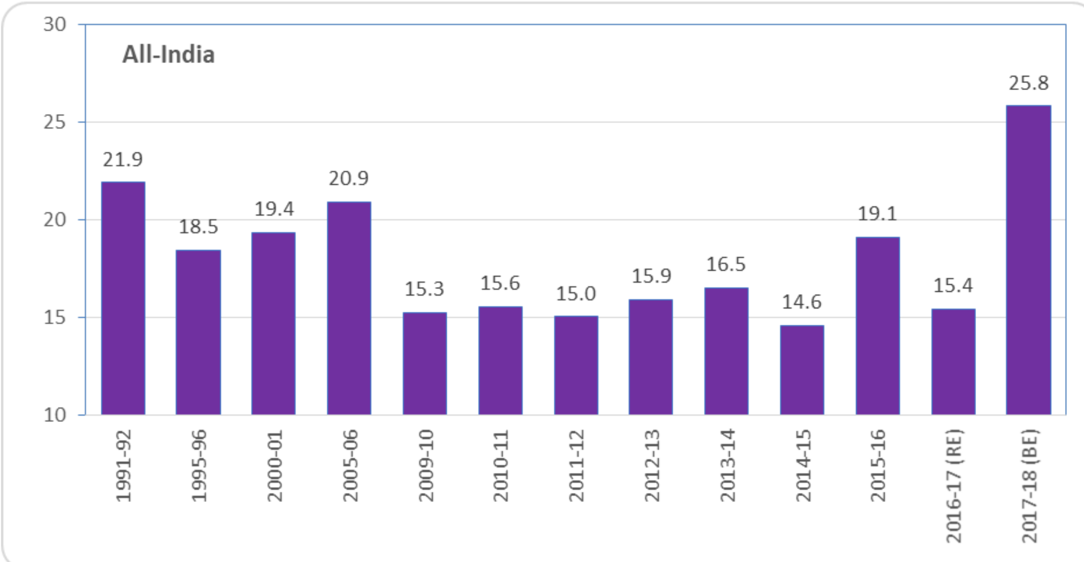
However, expenditure on technical education as a share of total expenditure on education varies widely across different states in 2017-18. It ranges from a meagre 0.8 per cent (Rajasthan) to the highest level of 19.5 per cent in Chandigarh (Figure 25). What states like Andhra Pradesh, Karnataka, Bihar, Gujarat, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, West Bengal, Tamil Nadu, and the North eastern states including Assam are spending on technical education is below the national average. In some of these states it is the private sector that dominates.

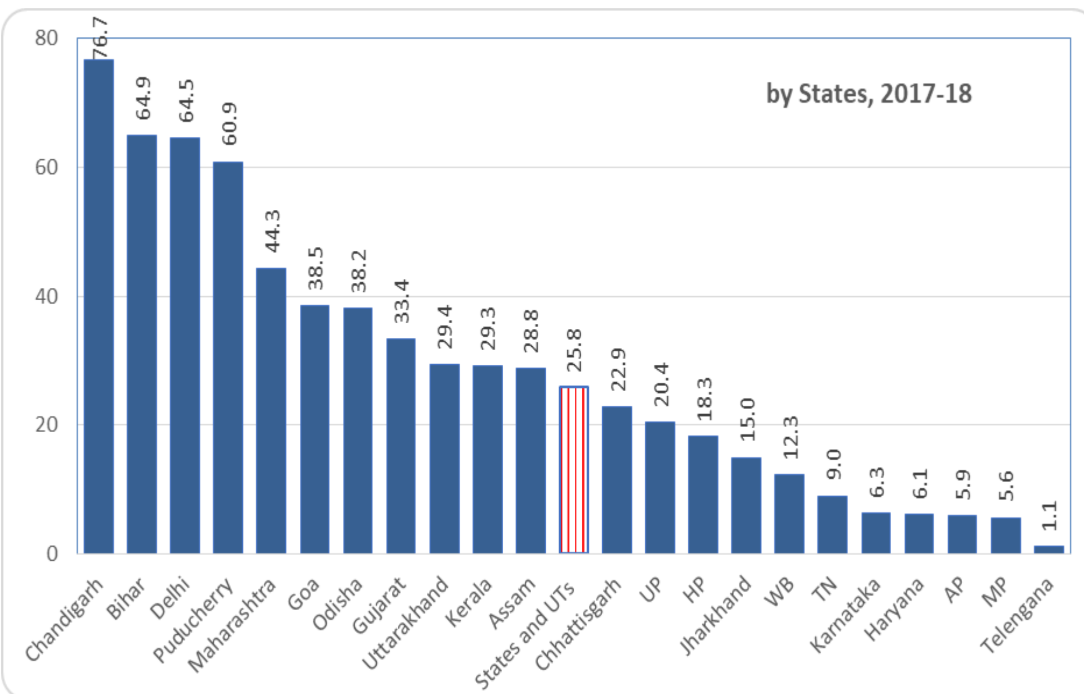
Figure 25. *Public Expenditure on Technical Education as a percentage of Total Expenditure on Education, 2015-16 and 2017-18*



Source: *Analysis of Budget Expenditure on Education (2015-16 – 2017-18*), MHRD

Figure 26. *Public Expenditure on Engineering Education as a percentage of Total Expenditure on Technical Education (States and Union Territories)*





Source: *Analysis of Budget Expenditure on Education* (Various Years), MHRD

The relative priority given to technical education in states varies very widely between states, as Figure 25 shows. It ranges from a meagre 1.1 per cent (Telangana) to the highest level of 76.7 per cent in Chandigarh in 2017-18. Chandigarh and Puducherry have been allocating above 10 per cent of the total expenditure on education to technical education. Then, in the second group of states we find Kerala, Goa, Maharashtra and Jharkhand which spend above 5 per cent but below 10 per cent. All others spend small amounts, and also very small proportions of the total expenditure on education on technical education. Rajasthan and Uttar Pradesh spend less than one per cent. States like Karnataka, Maharashtra, Tamil Nadu and Haryana have spent below the all-state average on technical education. It is interesting to note that the states with lower public expenditure on engineering education have experienced a sharp increase in the private engineering colleges. For instance, in Telangana (with lowest share in its public budget on engineering education allocated to technical education i.e., 1.1 per cent), the share of private engineering institutions is 96.7 per cent with an intake capacity of similar level, as discussed in Section 3.

In the budget on higher education, expenditures on scholarships and research have important implications. Expenditure on research will promote quality of education, and expenditure on scholarships promotes merit as well as access of the weaker sections to higher education. We do not have good data on public expenditure on research in technical education. So let us examine the expenditure on scholarships.

Public expenditure on scholarships has also implications for household expenditure on education, which is an aspect that is examined here in the subsequent part of this section. In the budget on higher education, financial assistance in the form of scholarships to students is an important item that is meant to promote participation of the disadvantaged sections in higher education, and thereby to improve overall equity in higher education. But scholarships form a very small part of the total expenditure on technical education: it was less than one per cent till 2005-06 which has increased to 3.9 per cent in 2017-18 (budget estimate). It has been below 4 per cent, except in 2016-17, and as per the 'revised estimate' it was 8.7 per cent. The overall budget expenditure on scholarships in technical education has increased at a rate of growth of 16 per cent -- from ₹9 crore in 1991-92 to about ₹400 crore in 2017-18 (Table 21).

Financial incentives in terms scholarships play an important role in improving access and retention of students, particularly those from marginalised backgrounds. Several studies, particularly in the international context, have found that the probability to enrol and continue in higher education increases with the availability of financial assistance to students (Schwartz, 1985; Moore et al., 1991; Monks, 2009; Glocker, 2011). Also, the National Policy on Education (1986) and National Knowledge Commission 2007 (Government of India, 2009) had recommended for a well-funded and extensive National Scholarship Scheme, to improve the access and retention of socially and economically underprivileged students in higher education. While scholarships and other measures of financial assistance to students have been used as an important measure of promoting equitable access to higher education for a long time, the allocation of public resources for scholarships has suffered a severe decline in India over the years (Tilak, 2004; Narayana, 2019). The need for higher financial assistance for students who take up studies in technical education is more rather than for those opting for general higher education. But public policy in India seems to favour a shift from scholarships to loans, considering the latter as a substitute to the former. This calls for an urgent discussion on the question of state support to engineering students in terms of scholarships, student loan and fee-reimbursement policies for a nuanced understanding of this critical issue.

Table 21. *Public Expenditure on Scholarships in Technical Education in India in Real Prices (States and Union Territories) (₹ in crores at 2011-12 prices)*

Year	Expenditure on Technical Education	Expenditure on Scholarship in Technical Education	Expenditure on Scholarships in Total Expenditure on Technical Education (%)
1991-92	1,799.8	9.0	0.50
1995-96	2,127.2	4.9	0.23
2000-01	2,877.9	7.3	0.25
2005-06	3,474.3	13.7	0.39
2009-10	4,659.1	167.6	3.60
2010-11	5,113.7	173.6	3.39
2011-12	5,691.6	261.9	4.60
2012-13	6,193.2	240.3	3.88
2013-14	6,666.0	203.9	3.06
2014-15	7,560.0	290.7	3.85
2015-16	7,296.0	304.3	4.17
2016-17(RE)	8,671.0	748.6	8.63
2017-18(BE)	10,622.0	415.1	3.91
Growth rate	9.56	15.88	

Source: *Analysis of Budget Expenditure on Education* (Various Years), *Selected Educational Statistics* (Various Years), UGC Annual Reports (Various Years).

We do not have similar details on scholarships on engineering education, but we can look at the relative place given to engineering education in the total expenditure on technical education in the states and union territories. The expenditure on engineering education has increased at almost the same rate of growth as expenditure on total technical education that is at around 7 per cent between 1991-92 and 2017-18. Engineering education accounts for about one-fifth of the expenditure on technical education. But the trend is not smooth; it has touched the lowest level of 15 per cent in 2011-12, when engineering education was at its peak in terms of demand and growth. As the private sector has opened more and more institutions, the government perhaps did not feel the need to raise its expenditure significantly on engineering education. With respect to this proportion we also find large variations across states. Chandigarh and surprisingly Bihar have spent about 65 per cent or more of the total education expenditure on engineering education, while on average, among all the states and union territories it was 25.8 per cent in 2017-18. Again, states such as Andhra Pradesh, Madhya Pradesh and Telangana figure at the bottom. These states along with Tamil Nadu, Karnataka and Haryana spend below 10 per cent. Perhaps these states spend on other branches of technical education.

Funding, fees, regulation, and many other aspects on which we note significant variations overtime and between several states, are clearly related to state-specific policies, which are conditioned by several factors such as socio-economic and political conditions, and not the least economic conditions, including state domestic product (SDP) per capita, fiscal resources, levels of industrialisation, and levels of living of the people, though the effects of engineering education are not necessarily confined to the boundaries of the states. A detailed understanding of these aspects is important, and requires state-specific studies.

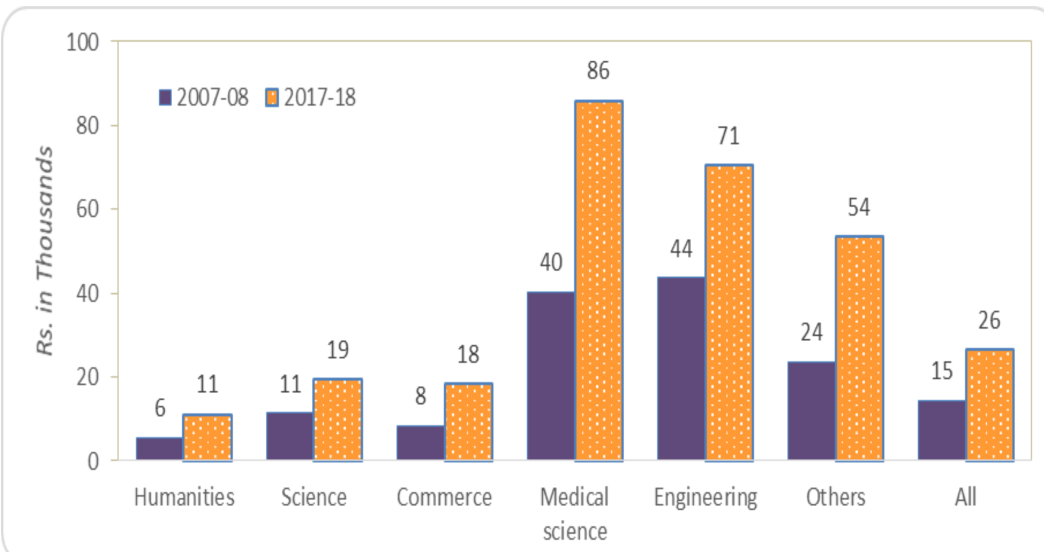
On the whole, the picture on public funding on technical education does not give a satisfactory picture. The absolute levels of expenditure, as well as relative priority accorded to technical education in national income, and in education budgets are small, and there is need to significantly step up, when the country is aiming at taking advantage of revolution in technology and at building a strong knowledge society. Several committees such as the AICTE (1994, 2003) made detailed suggestions on strengthening the resource base of technical education, which include: (a) raising public budgets both by the union government and state governments on technical education, (b) allocating sizeable proportion of resources for research and scholarships in technical education, (c) mobilising resources in the form of a technical education cess from the technical graduate employees and/or firms that employ the technical graduates, (d) raising resources through the corporate social responsibility provisions of public acts, (e) developing a special fund or an educational development bank for funding technical education with public (union and states) and private funds, (f) efficient and effective utilisation of resources, and (f) regulating student fees at about 20 per cent of the revenue expenditure of the institutions, besides pleading for combating the growing tendencies towards commercialisation of technical education. Some of these recommendations partly figure in the initiatives taken later by the government; but no significant increase in the resource base of technical education could be seen.

Household Expenditure on Engineering Education

Due to the increasing presence of the private sector in engineering education (and also in other professional and technical education), families sending their children to engineering education need to spend a significant share of their incomes on their children's education. Inequalities in household expenditure on education reflect inequalities in society between different sections of the society. Using data collected in a few education specific rounds of the NSS (64th in 2007-08,71st in 2014-15 and 75th in 2017-18), we analyse a few aspects of household expenditure on higher education in India. The NSS figures do not include expenditure on private coaching that families incur to prepare their wards to appear in different competitive entrance examinations for admission in engineering education. With this note, let us examine household expenditure on engineering education in India.

According to the NSS data the household expendiutre on higher education in India was around ₹26.4 thousand per annum per student that accounts for 19.3 per cent of the household's annual income in 2017-18, and this was ₹14.5 thousand a decade ago, that is, in 2007-08,[28] as shown in *Figure 27*.

Figure 27. *Household Expenditure on Higher Education per Student, by Major Area of Study (₹ per annum)*



Source: Compiled by authors based on NSS 64th (2007-08) and 75th round (2017-18) data.

We observe a significant variations in household's spending on different branches of study in higher education: the highest spending was made by families on their children's medical education (₹86 thousand), followed by engineering education (₹70.5 thousand) and then on 'other' disciplines (₹53.6 thousand) in 2017-18 – showing that medical education was the costliest discipline.[29] Humanities at

28 The amounts of expenditure reported in this paper are at constant prices, unless otherwise mentioned.

29 Areas of study are grouped into medicine, engineering, commerce, science, humanities and others (agriculture, law, management, education, chartered accountancy and related, IT/computer courses). The category 'others' is generated by taking some professional courses together as their sample size is very small.

₹11,161 figure at the other end of spectrum, commerce (at ₹18,478) and science (at ₹19,419) figure above humanities. So studies in medicine and engineering studies are 7.7 times and 6.3 times costlier respectively than humanities. This is apparent as even the tuition fees charged for professional studies are much higher than for general higher education studies, especially in private colleges and universities. Expenditures on other items are also normally higher in studies in engineering and medicine.

Notably, families sending their wards to pursue medical science have spent around half of their annual consumption expenditure, which is considered as a proxy of family income, towards their education in 2017-18; a decade earlier this amount was 59 per cent. In case of engineering education, families used to spend as high as 69 per cent in 2007-08 which came down to 46 per cent by 2017-18 (Table 22). The figures ranged between 10 per cent and 20 per cent in case of humanities, sciences and commerce. In the last one decade, the share of total family income that went e to higher education came down in all disciplines in higher education and also for overall higher education as well. A detailed discussion on this would unpack trends better, but that is beyond the scope of this paper. Still it may be noted that it is not because higher education became necessarily cheaper; but that families' household economic status – overall expenditure/income levels – went up. We have noted in Figure 22 that absolute levels of household expenditure on all disciplines increased over the years between 2007-08 and 2017-18.

Table 22. *Expenditure on Higher Education as proportion of Total Household Consumption Expenditure, across Major Areas (%)*

Course	2007-08	2014-15	2017-18
Humanities	11.1	10.3	10.6
Science	18.3	17.8	17.2
Commerce	12.4	13.8	14.2
Medicine	58.7	58.8	50.5
Engineering	69.0	51.5	45.8
Others	33.1	35.3	31.4
All	23.0	22.0	19.3

Source: Compiled by authors based on NSS 64th (2007-08), 71st (2014-15) and 75th round (2017-18) data.

The annual average household expenditure on undergraduate engineering education in India is reported to be around ₹70.6 thousand that accounts for 45.8 per cent of the total annual family consumption expenditure (Table 23). Out of the total household expenditure spent on engineering education, ₹54.8 thousand is incurred on fees (tuition fee, examination fee, library fee and other fees) and ₹18.1 thousand on non-fee items such as expenditure on food, accommodation, textbooks, transport, private tuition, mobile, internet and others. Fees have accounted for 36.7 per cent and expenditure on non-fee items constituted 9.1 per cent of the annual consumption expenditure of the family. The share of expenditure on fee to total household expenditure on engineering education is 73.8 per cent while it is 26.3 per cent on non-fee items. Households spend significantly higher amounts (and proportions) on fees as compared to non-fee items. This is mainly because of the higher levels of fees charged, particularly in private engineering institutions. However, households also spend a significant share of their total budgets on non-fee items.

Table 23. *Annual Household Expenditure on Engineering Education, per Annum per Student (2017-18)*

Items of Expenditure	Expenditure Per-Student (₹)	% of Total Spending on Engineering Education	% of Total Household Consumption Expenditure
Fee	*54,823*	*73.8*	*36.7*
Non-Fee items			
Books, Stationery and Uniform	5,973	8.0	3.0
Transport	6,733	9.1	3.4
Private Tuition	3,005	4.0	1.5
Other items	3,793	5.1	1.9
Total Non-Fee	*18,107*	*26.2*	*9.1*
Total (Fee + Non-Fee)	70,575	100	45.8

Source: Authors' calculations based on 75th round unit-level data of NSSO (2017-18)

Expenditures on food and accommodation, textbooks and other study materials, and transportation take a major share (66 per cent) of the household expenditure on non-fee items and the remaining 34 per cent is spent on private tuition, mobile, internet and other items. Private institutions charge higher amounts on students' food and accommodation also than public institutions, where these items are also partly subsidised.

Levels of household spending on engineering education vary across socioeconomic groups and across types of institutions. Households spend ₹71.9 thousand on the engineering education of their sons, more than their daughters which is around ₹67.1 thousand (*Table 24*). While such a pattern is normally explained in terms of a gender bias (Tilak, 2002; Kingdon, 2005; Azam and Kingdon, 2013; Saha, 2013; Kenayathulla, 2016; Wongmonta and Glewwe, 2016; Kumar, 2017; Kaul, 2018; Iddrisu et al., 2018; Datta and Kingdon, 2019), in the present case, this difference may be because of choice of college. It is possible that women are admitted in institutions that charge lower levels of fess, while men take admission in colleges that charge comparatively higher levels of fees. As a high fee is perceived to be equivalent better quality of education, this may reflect a different kind of parental bias in favour of sons. Interestingly, spending on non-fee items is reported to be higher for women (₹21.4 thousand) as compared to men (₹17 thousand). As a result, the gender difference in the total expenditure on education gets marginally reduced.

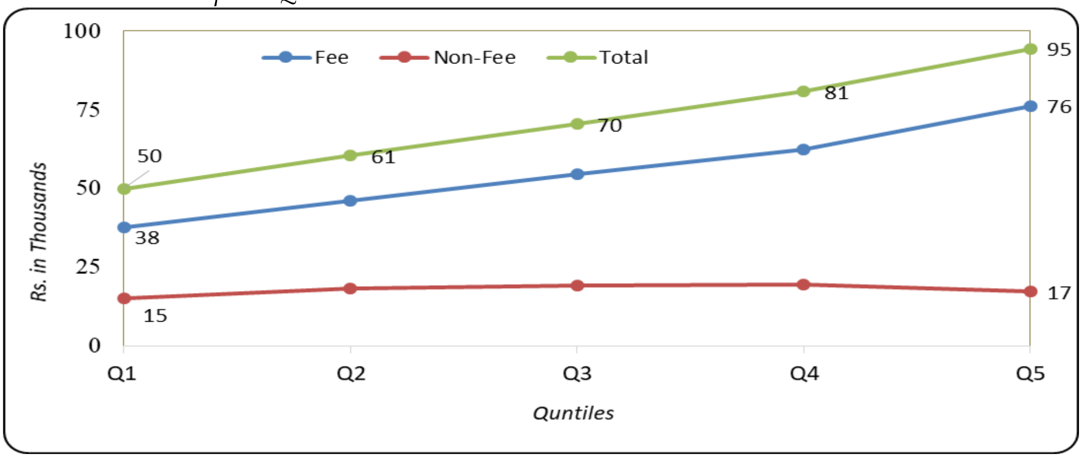
Table 24. *Annual Average Household Expenditure on Engineering Education, by Select Socio-Economic Groups and Types of Institutionn (₹)*

Category		Fee	Non-Fee	Total
Gender	Female	51,770	21,456	67,190
	Male	56,050	17,016	71,939
	Inequality (M/F)	1.08	0.79	1.07
Location	Rural	41,731	17,020	55,453
	Urban	59,916	18,520	76,455
	Inequality(U/R)	1.44	1.09	1.38
Caste	SC/ST	40,241	15,799	53,781
	OBC	50,582	17,065	65,862
	General	65,752	19,477	82,999
	Inequality (General/SC-ST)	1.63	1.23	1.54
Institution	Government	37,174	15,659	50,235
	Govt. Aided Private	55,071	19,832	70,955
	Private (unaided)	58,847	17,515	75,147
	Inequality (Private Unaided/Govt.)	1.58	1.12	1.50
Income Quintile	Q1 (Poorest)	37,600	15,151	49,999
	Q2	46,071	18,286	60,502
	Q3	54,548	19,371	70,429
	Q4	62,343	19,708	80,755
	Q5 (Richest)	76,201	17,297	94,507
	Inequality (Q5/Q1)	2.03	1.14	1.89
TOTAL		**54,823**	**18,107**	**70,575**

Source: Authors' calculations based on 75th round unit-level data of NSSO (2017-18)

Rural-urban disparities in household expenditures on education are significant. In 2017-18, urban households spent ₹76.4 thousand towards engineering education of their wards considerably higher than their rural counterparts (₹55.4 thousand), that is, there is a difference of 37.8 per cent between the two sectors in favour of urban areas. This gap in spending is largely attributed to the differences in tuition fees charged by higher education institutions (which is substantially high in urban areas); and there are not many variations in spending on non-fee items. Similarly, variations in household spending are also prevalent across caste groups. As expected, the highest spending has been made on engineering education by students belonging to the general category (₹83 thousand), as compared to the scheduled groups (₹53.7 thousand) in 2017-18. This shows a spending gap of 1.5 times between general category students and scheduled students.

Figure 28. *Household Expenditure on Fees and Other Items in Engineering Education, by Household Consumption Quintiles*



Source: Authors' calculations based on NSSO

Household spending on education also varies by type of institution (government, government-aided private, and private-unaided). This is as high as ₹75.2 thousand in private (unaided) institutions in 2017-18, which is about 50 per cent higher than the expenditure in government institutions. (₹50.2 thousand). This is apparent as tuition fee levels for engineering programmes are significantly high, especially in private institutions. The fees charged in private-unaided institutions was 60 per cent higher than the fees in public institutions.[30] Clearly, the directions of the fee regulatory commissions constituted in each state are rarely adhered to by these institutions. As Jadhav (2020, p. 79) observed, "There was absolutely no

30 Fees varies among the public institutions and also among private institutions. For example, even among the IITs, it ranges from₹1.11 lakh per student per semester in IIT Goa and ₹1.52 lakh in IIT Jodhpur (in 2020). In each state fees are prescribed in government and private institutions by a fee regulating committee. But they also vary between and within a state(s). The fee regulation committees prescribe fees for each specific private institution within a state, and hence very wide variations exist between different private institutions even within a state. For example, 'reported' fee levels varied between ₹.32,500 and ₹.77,500 among 23 sampled self-financing engineering colleges in Tamil Nadu in 2008 (Rani, 2010).

transparency whatsoever in the fees charged. Malpractices could not be controlled." In fact, malpractices are not confined to charging exorbitant fees from students.[31] There is an elaborate structure of rules and regulations on most aspects of running an institution, so that these institutions do not adopt to malpractices, and inter alia, maintain proper standards, ensuring quality of education. But they are often flouted by the private institutions.[32]

Household spending varies most with the economic status of the households which is measured in terms of monthly consumption expenditure in the present analysis. Household expenditure per student increases with each successive consumption expenditure quintiles. It ranges from ₹49.9 thousand for the lowest quintile to ₹94.5 thousand for the highest quintile in 2017-18 (*Figure 28*). The rich-poor gap in the spending on engineering education is estimated to be 89 per cent in 2017-18. The richest households spend almost double the expenditure of the poorest quintile. Interestingly, not only the total expenditure, but the fees paid by top quintile is also twice the fee paid by the bottom quintile. Rich students might prefer to opt for costly institutions which charge high fees under the assumption that the higher the cost, the better the quality of education, though the relationship between the two is yet to be proven.

7. Changing Labour Market Conditions and Engineering Education

The discussion on growth of engineering education in India remains incomplete, without a discussion on employment and related issues of engineering graduates. This is particularly important in the context of rapidly changing demand for engineering manpower and other conditions in the labour market in India and abroad. Technology is advancing at an unprecedented space across the world and has transformed the global labour market. The adoption of exponential technologies is disrupting industries by creating new markets and transforming existing markets through product or business innovations. In the new age of automation and unprecedented technological advances, the nature of the job market in several economies is changing rapidly. Modern technology is changing the skills that

31 A few years ago, the Government of India attempted unsuccessfully to enact a legislation, 'Prohibition of Unfair Practices in Technical Educational Institutions, Medical Educational Institutions and Universities Bill 2010' to curb some of the familiar practices being followed by private institutions in India. See Tilak (2010a) for details. A few other legislations for reforming higher education also could not go through. See Tilak (2010b).

32 But surprisingly, in an interview to media, the Chairperson of AICTE, the apex body that regulates technical education in the India, Anil Sahasrabudhe said that currently it would be impossible to run an institute without compromising on quality when there are so many unfilled seats. Reported in *Indian Express* (2 February 2018). https://indianexpress.com/article/education/impossible-to-run-an-institute-without-compromising-on-quality-when-there-are-so-many-unfilled-seats-says-regulator-anil-sahasrabudhe-aicte-chairman-4978567/

employers seek, and therefore, the training imparted in the educational institutions needs to be revisited. In fact, today graduates are not sure about the use of knowledge and the skills they have obtained during their studies in dynamically changing labour markets. In the labour market, job-roles are being drastically modified, re-defined and changed altogether, and certain types of jobs are becoming redundant and new occupations with new roles are created. We are riding a new wave of uncertainty as the pace of innovation continues to accelerate and technology influences extensively the very basic characteristics of the labour market (WDR, 2019).

Engineering being a technical field that produces specific human capital is affected the most with the rapid technological progress. As a result, the nature and composition of skills that are required for an engineering graduate is going through a huge transformation. Globally, engineering education is experiencing an increasing pressure on graduate employability, particularly in the context of the changing environment in the labour market. The complexities found in the global engineering labour market have changed the discourse in the discipline. It is important to analyse what it means to be an engineer in the twenty-first century and how the skills and training imparted in institutions might better prepare engineers of the future (Winberg et al., 2020).

With fluctuating labour market conditions and unplanned growth of engineering education, mismatches have arisen between the supply of and demand for engineering manpower. The mismatch in India can be divided into two broad categories. Firstly, there is the skill deficit or skill gap, where a worker's skill is not up to the requirements of the job. Secondly, there is skill underutilisation (over-education or over-skilling), which arises when the level of education and skill exceed those required by the job. The latter causes 'bumping down' -- low skilled jobs being offered to high skilled workers. But a more familiar mismatch refers to the numbers of graduates produced and hired. Sengupta (2017) has estimated proportional mismatches with respect to educated manpower at all levels, using the data from several rounds of NSS. In 1993-94 and 2004-5, there were actually shortages in engineering manpower (degree level), but the quantum of shortages was very small. By 2011-12, the situation began to change, and there was a negative mismatch, the supply exceeding demand, but again by a very small proportion. We do not have such estimates for the period after 2011-12. But it is quite possible that the supply exceeds demand by increasingly larger proportions, as the available evidence on employment and unemployment trends to suggest.

The data from the National Sample Surveys shows that unemployment among the educated in India has been consistently rising over the years. Among the general graduates and above, the rate of unemployment has increased from 16.1 per cent in 1983 to 35.9 per cent in 2017-18. While the rate of unemployment is rising among the youth with almost any level of education, the rate of growth is the highest in case of those with technical education. It was 37.9 per cent in 2017-18, a sharp increase from 17.3 per cent in 1983 and 19.8 per cent in 1999-2000 (Khare and Arora, 2021).

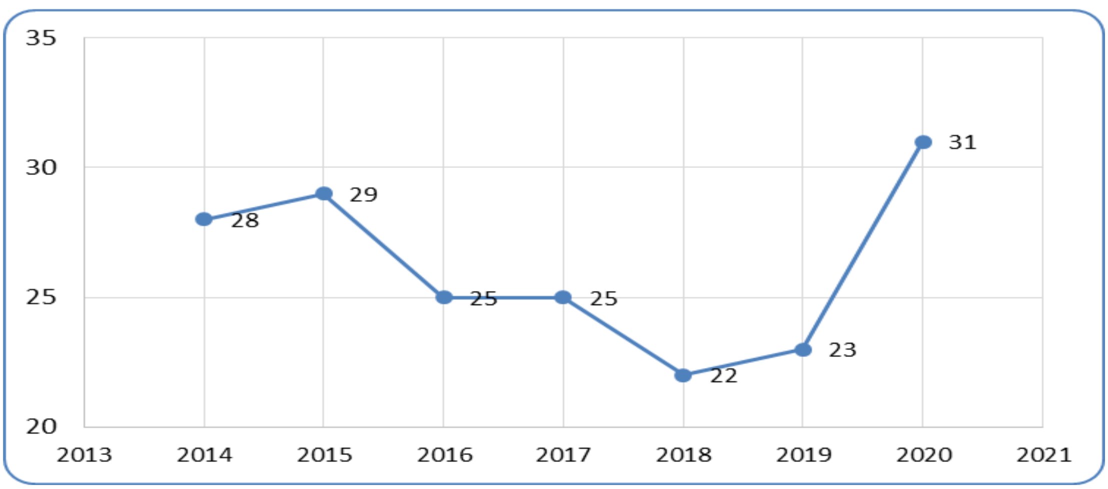
We do not have similar comparable data for engineering graduates. We have data on employability of graduates, hiring rates and placement records available from institutions of engineering education, which are analysed here.

Employment and Employability of Engineer Graduates

The rate of hiring of engineers has declined from 28 per cent in 2014 to 22 per cent in 2018, as shown in Figure 29. After a small increase in the following year to 23 per cent, it rose by 8 points to 31 per cent in 2020. According to this, nearly 70 per cent of engineers are unemployed in 2020; the figure was nearly 80 per cent in 2018.

Data on placement records also do not indicate any better situation. In 2017-18, out of the total number of engineering graduates of 7.93 lakhs, only 45 per cent were selected for employment in campus placement processes in AICTE-approved institutions. Of course, the corresponding rate is much higher in IITs, NITs and IIITs, where it was reported to be 77 per cent in 2018-19 (Nigam, 2020).[33]

Figure 29. *Fluctuating Rate of Hiring of Engineers in India (%)*



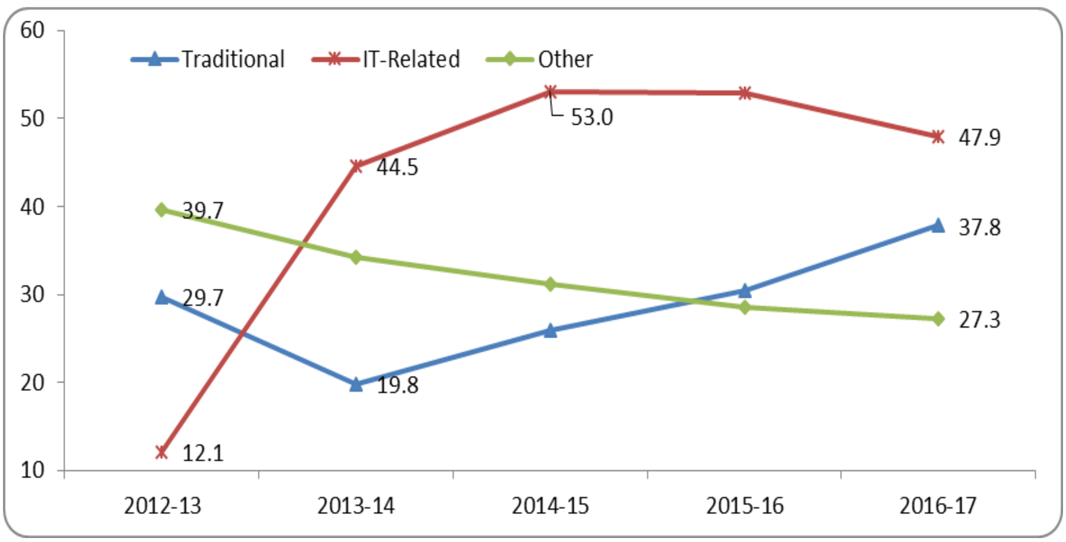
Source: Statista Research Department
https://www.statista.com/statistics/1043283/india-hiring-rate-engineers

It may be necessary to analyse the placement records by looking at the sub-stream of engineering, as different streams performed differently. AICTE data on

33 Out of the total number of graduates 23,928, as many as 17,946 secured employment in campus recruitment process.

placements enables us to do this.[34] Technological obsolescence in the labour market seems to have suddenly resulted a declining demand for graduates in electronics and IT-related engineering. The number of placements as a proportion of enrollments of engineering graduates trained in electronics and the IT-fields has gone down from 53 per cent in 2014-15 to 47.9 per cent in 2016-17. With the IT boom in the preceding period, this figure went up by more than four times from 12 per cent in 2012-13 to 53 per cent in 2014-15. Employment conditions for graduates in traditional areas of engineering improved from 19.8 per cent in 2013-14 to 37.8 per cent in 2016-17, as graduates in the modern (IT-related) areas and other areas suffered (*Figure 30*).

Figure 30. *Number of Placements as a Percentage of Enrollment in Engineering Education, by Major Categories of Streams*



Source: AICTE database

How does one explain the high rate of unemployment among the engineer graduates in India? In several cases engineering graduates in India are employed in non-engineering occupations that offers them a substantially lower salary. As the U R Rao Committee (AICTE, 2003, 162) stated, "The rising unemployment of scientists and engineers in the country is primarily due to (i) poor quality of our graduates coming out of our technical institutions (ii) lack of entrepreneurship, partly due to the limited availability of venture capital but mostly due to the inability of our students to venture and (iii) poor growth in the industrial sector."

34 It is important to note that data on placements provided by AICTE or the individual institutions do not normally include data on those who secure employment later, after leaving the college.

First, the issues of employment and unemployment of engineering graduates are coupled with the slowdown in the overall employment visible in the India economy. The unemployment rate in India has increased significantly over the last decade: 6.1 per cent in 2017-18 (PLFS, 2019), while graduate unemployment is 16.3 per cent in 2019 (Statista Research Department 2020). In an interview to the *Indian Express* (December 13, 2017), NITI Aayog Vice Chairperson Rajiv Kumar sees the decline in the demand for engineering graduates in the labour market as a sectoral shift that might be happening in the Indian economy -- a shift from traditional factory manufacturing jobs to emerging sectors like e-commerce. Secondly and more importantly, there are also problems with the type and nature of graduates who pass out and the engineering education they receive.

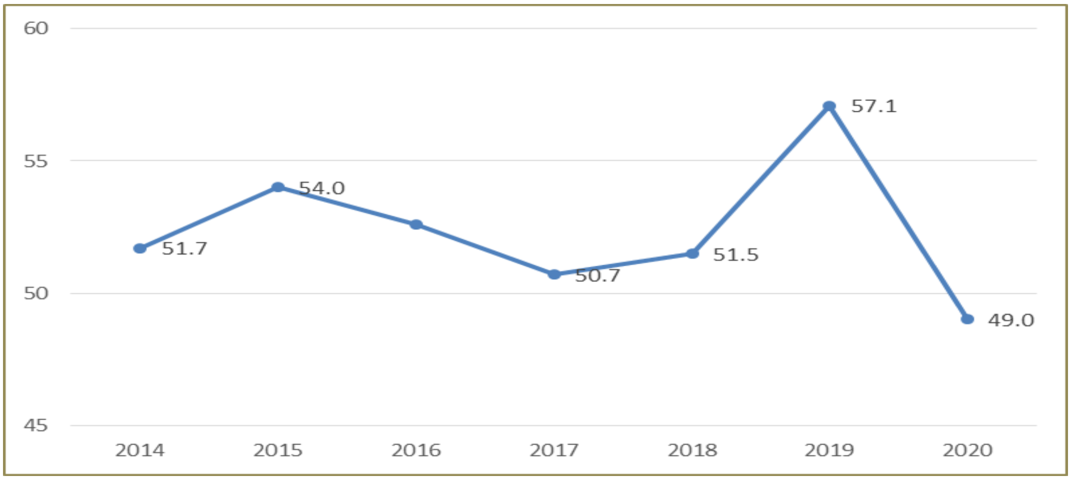
Due to weak labour market signals, many graduates still go for engineering education, and end up in unemployment – open or disguised. Graduates who are managing to get jobs are either mal-employed or employed on very low wages. As it is often argued, the prevailing labour market indications --- low employability of engineering graduates coupled with an abysmal record of job placement reflect the poor quality of engineering education in the country. Looking at the quality of graduates being produced by a large number of colleges in India, experts (e.g. MHRD, 2003) have described them as 'IT coolies' or 'techno coolies' or 'cyber coolies'. The quality attributes in terms of inter alia, skills and knowledge, with which the graduates come out of the colleges determine the employability of graduates.

Many employers in the labour market do not find engineering graduates are worth employing. A few high-paying firms of high repute are able to recruit the few high quality graduates produced by the best institutions, and generally like what they get, but a large number of medium and small firms are generally dissatisfied with the quality of the pool of graduates available to them. According to NASSCOM & McKinsey (2005), only 25 per cent of the engineering graduates are employable in India. Likewise, the latest Annual Employability Survey 2019 (Aspiring Minds, 2019) states that 80 per cent of Indian engineers are not fit for any job in a knowledge economy.

According to the India Skills Report (Wheebox, 2020), the employability of engineer graduates has remained static around 50 per cent with marginal fluctuations between 2014 and 2018. In fact, there has been no change in the employability prospects of Indian engineering graduates in the past nine years! Then suddenly it improved to 57 per cent in 2019, after which there was a steep fall to below 50 per cent (Figure 31). These fluctuating trends should indeed be a matter of serious concern, as they make any forecasting and planning difficult.

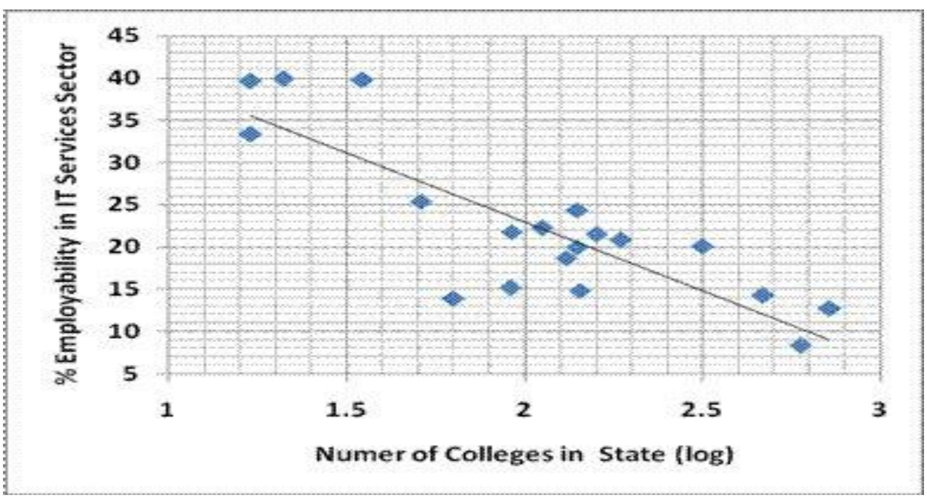
Aspiring Minds Team (2019) made an interesting analysis that shows that employability of graduates (in IT services) is low in those states where there are too many colleges like Tamil Nadu, Andhra Pradesh and Maharashtra and Karnataka, and it is reasonably high in those states which have fewer colleges like Delhi, Bihar, Jharkhand and Uttarakhand.

Figure 31. *Employability of Engineer Graduates (BE/BTech.) in India*



Source: Based on Aspiring Minds (2019)

Figure 32. *Employability and the Engineering Colleges in States*



Source: Aspiring Minds Team (2019). (Reproduced with permission)

Note that the former group of states also has a larger number of IT companies than the others. In fact, Aspiring Minds Team (2019) found a clear inverse relationship between the number of engineering colleges in a state and the employability of graduates, as shown in Figure 32. A large number of colleges in the states where employability is low are also private colleges. This makes it clear that expansion has taken place at the cost of quality measured in terms of employment, and private colleges have not cared much for quality.

What steps should be taken for improving the poor employability of engineering graduates in India? Apart from economy and structural factors, it emerges that the quality of engineering education one receives is an important factor that explains employment/unemployment and wages in the competitive labour market. Several studies and reports provide compelling reasons why undergraduate engineering education is in need of change to respond to the complex challenges in the labour market (Badran, 2007; Sahin, 2010; Adams et al., 2011; Winberg et al., 2020). For instance, literature on employability of engineering graduates emphasises curricular and pedagogical arrangements to prepare graduates for work and also to address several other risks and uncertainties they are going to face in the changing labour market. Therefore, higher education institutions must keep pace with rapidly evolving technology, to enable individuals to be future ready and reduce their rate of obsolescence (Ernst & Young, 2017).

The nature of engineering skills that a graduate needs to get employment in labour market is going through a big change in India. In addition to the foundational skills gained from mathematics, physics and engineering sciences, graduates should also learn key professional skills such as communication, collaboration, team-work, project management, professional ethics, and broader environmental and societal issues. In fact, graduate engineers are expected to have (a) soft or core employability skills, which cover generic attitudinal and affective skills, such as reliability and team-work, (b) communication skills, such as written and verbal communication skills in English, and (c) and professional skills, which generally cover cognitive skills related to the engineering professions, such as the ability to apply engineering knowledge, as well as design and conduct experiments and related data analyse and interpretation.[35] But as Blom and Saeki (2011) found in case of soft skills, such as reliability and self-motivation, there are huge skill-gaps. Employers in India see to be more interested in this type of skills. They rated professional skills the lowest on average among the three factor skills. This may be partly because employers think that engineering related skills can be partly acquired during in-house training even after graduation while core employability skills would require longer timeframe to be acquired. The National Employability Report further finds that only a handful of engineering graduates possess next generation technical skills that give them better employment prospects while a majority seems to have difficulty finding suitable employment. Only 2.5 per cent of Indian engineers possess the skills in artificial intelligence (that is, machine learning and data science), important skills required in

35 Many engineering institutions concentrate on only the professional engineering skills. The NBA identified the following as the attributes of engineer graduates: engineering knowledge, problem analysis, design and development, conduct investigation of complex problems, modern tool usage, engineer and society, environment & sustainability, ethics, individual and team work, communications, project management & finance, and life-long learning.

the changing labour market, 1.5 per cent to 4.5 per cent of engineers possess the necessary skills in data engineering, and while only 2.8 per cent to 5.3 per cent are qualified in wireless technologies that industry requires (Aspiring Minds, 2019). According to the Aspiring Minds (2019), only 40 per cent of engineering students in India get opportunities for internships and only 36 per cent undertake projects outside their assigned coursework. Even today, the engineering discipline in India is very theoretical, and students learn primarily through the lecture method. Similarly, the report also highlights that engineering students in India have very little industry exposure as they are trapped in a college bubble all the time. Only 47 per cent of students attend industry talks, and more importantly, 60 per cent of the faculty do not discuss how engineering concepts apply to industry. Most talks that students attend are intra-departmental, rather than seminars, workshops, conferences or webinars that typically feature outside experts and scholars who present complementary or alternative perspectives.

Providing on-the-job training to engineering graduates is seen as being costly and risky for many employers, and therefore, not a viable option. In fact industries generally do not seem to be willing to spend much on the training of their employees. They keep subtle pressure on the academics to produce ready-made employees. One forgets that educational institutions are better suited to provide training of mind rather for the job market which is continuously changing which even the best of industry experts cannot forecast (Ananthasayana, 2009). It is also argued that after getting a good professional on-the-job training, employees bargain for higher wages which if not conceded means they might leave the company to join another. Also, providing adequate training for the job market needs a threshold level of learning normally absorbed at the undergraduate stage which is missing among a majority of the engineering graduates. Therefore, it is important to see whether ta 4-year course in engineering after a senior secondary education actually adds any valuable employable skills in the graduates. Students need to be better equipped with employability-enhancement skills such as critical thinking, problem-solving, teamwork, decision-making and adaptability among others.

Engineering institutions should aim to develop twenty-first century skills (beyond core academic subjects) among young graduates. Engineering institutions should lead in preparing professionals in cutting-edge areas such as artificial intelligence, 3-D machining, big data analysis, machine learning, robotic process automation, cloud computing, data engineering, and data science that will create a huge wave of transformation across industries in the coming decade. But, even today the curricula and pedagogies in a majority of engineering institutions focus on imparting traditional technical knowledge, ignoring the new skills that are in demand in the changing labour market situations; thus the engineers fail to possess hard skills in a soft context.

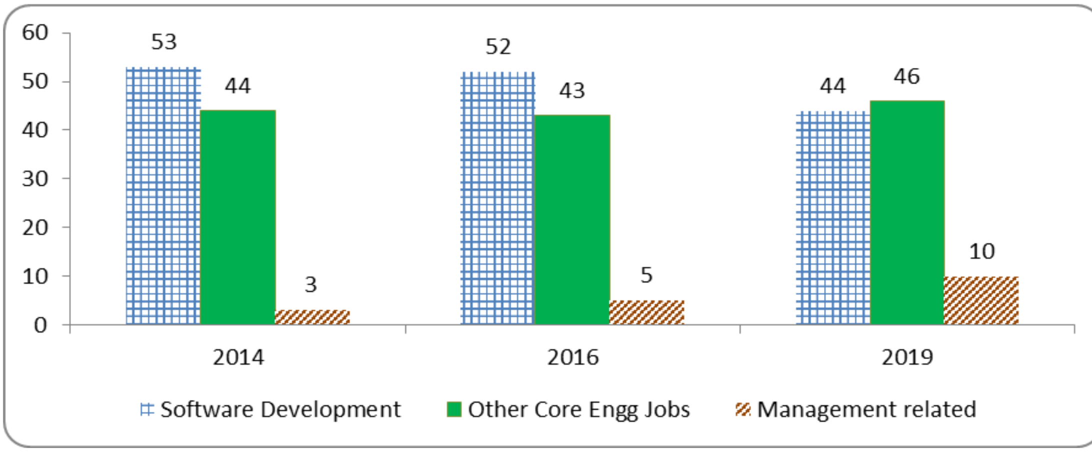
Additionally, an emphasis needs to be given to strengthen the interdependent relationship between engineering knowledge and professional skills among engineering graduates to improve their employability. It is argued that, in the changing labour market situations, apart from having a good conceptual understanding of basic science and mathematics, engineering students also need to develop generic skills, such as creative and critical thinking, problem-solving abilities, decision-making and so on (Badran, 2007; VIF, 2019). The new engineers need to know how to work in teams given the importance of social skills in the workplace (Sahin, 2010). Also, in the changing labour market situations, there is a need for engineers to acquire soft skills like cooperative working, communication and presentation skills, business ethics, inter-personal relationships, and skills to handle contemporary societal changes (Adams et al., 2011; Jha, 2005). Accruing these skills (in addition to gaining technical knowledge) would prepare graduates better to compete in the new world economy and in finding gainful employment in the labour market.

As has been constantly argued, there is a need for strategic policy interventions to strengthen the industry-academia interactions to improve linkages between engineering education and labour market in India. However, the latest AICTE-CII survey (CII, 2018) has revealed that 78 per cent of the total institutes have some linkages with industry, while 22 per cent have no linkages at all. Only about 7.4 per cent of the engineering institutions (710 out of 9,581) have received some funds from industry for setting up a department, cell or a laboratory. Out of the 710 institutions that have received funds, about 419 (60 per cent of the total) have received up to ₹ five lakh, while only 46 institutes have received ₹ one crore and above. Strong linkages with industry might not only help in mobilising more financial resources, but also human resources in the form of experienced industrialists, and more importantly help in modernising the curriculum and content of engineering education. This may help in better planning of the growth of engineering education in the country. To minimise the gap between the demand for and supply of engineering graduates, India should develop the mechanism that can better anticipate demand for different skills and vocation in the labour market and give that feedback to the technical education sector. This may be difficult in a fast changing dynamic environment. But some important signals can as well be drawn from such an exercise. With the policy inputs, engineering education should prepare youths to participate in the future labour market, where they will work together to address global challenges using their technical expertise and social skills. The aspirations of a twenty-first century engineering education require new thinking and new ways of doing, and those require engineering graduates to get advanced knowledge and skills in technical and professional areas. With globalisation, the technical education in India faces twin challenges, it has to be extremely useful for the domestic economy and at the same time made internationally relevant (Subramanian, 2015, p. 118).

Graduates' Preferences and Aspirations

Now let us briefly review the changing labour market aspirations of the graduates produced from the higher education system. The students' preferences and aspirations for and from different jobs also play an important role in explaining the phenomenon of unemployment. These are also not static; they are also rapidly getting altered over the years. Aspiring Minds (National Employability Reports for engineers 2014, 2016 and 2019) has surveyed students' preferences towards the kind of job roles, classified as software development, core engineering jobs (such as mechanical, electrical, electronic or civil engineer) and management related jobs. Interestingly, a majority of engineering graduates seem to have a strong preference either for software jobs or core engineering jobs, which is found to be true in all three points of time with small variations (Figure 33).

Figure 33. *Job-role Preferences of Engineering Graduates in India*



Source: National Employability Report - Engineers 2014, 2016 and 2019

It is noteworthy to mention that despite of the mushrooming job opportunities in managerial roles like technical sales, marketing and content development, engineers do not seem to prefer these jobs as yet, even though quite a few of them end up there. It is widely viewed that engineering graduates take up non-engineering jobs in the labour market as they, with a few exceptions, simply don't get suitable jobs in engineering. Their skills are not good enough for good jobs in engineering sector.[36]

The reports by Aspiring Minds have also detailed the graduates' job aspirations by their branch of study, gender, tier of college they have studied in (ranks of the colleges based on the employability of their students[37]) and by tier of city. There are visible variations between them. For instance, graduates with a computer/IT background are mostly interested in software jobs, while students with core engineering branches prefer equally software and core engineering jobs.

36 In the same context, it may be noted that very few engineer graduates take up jobs in research & development sector, again as they do not possess necessary skills for such jobs (Borah et al., 2019).

37 All colleges included in the Aspiring Minds' survey were ranked based on the employability of their students. Those in the top 33 per centile were considered as tier 1 colleges, those in mid-33 per centile range were considered as tier 2 colleges while those in the bottom 33 per centile set were taken as tier 3 colleges.

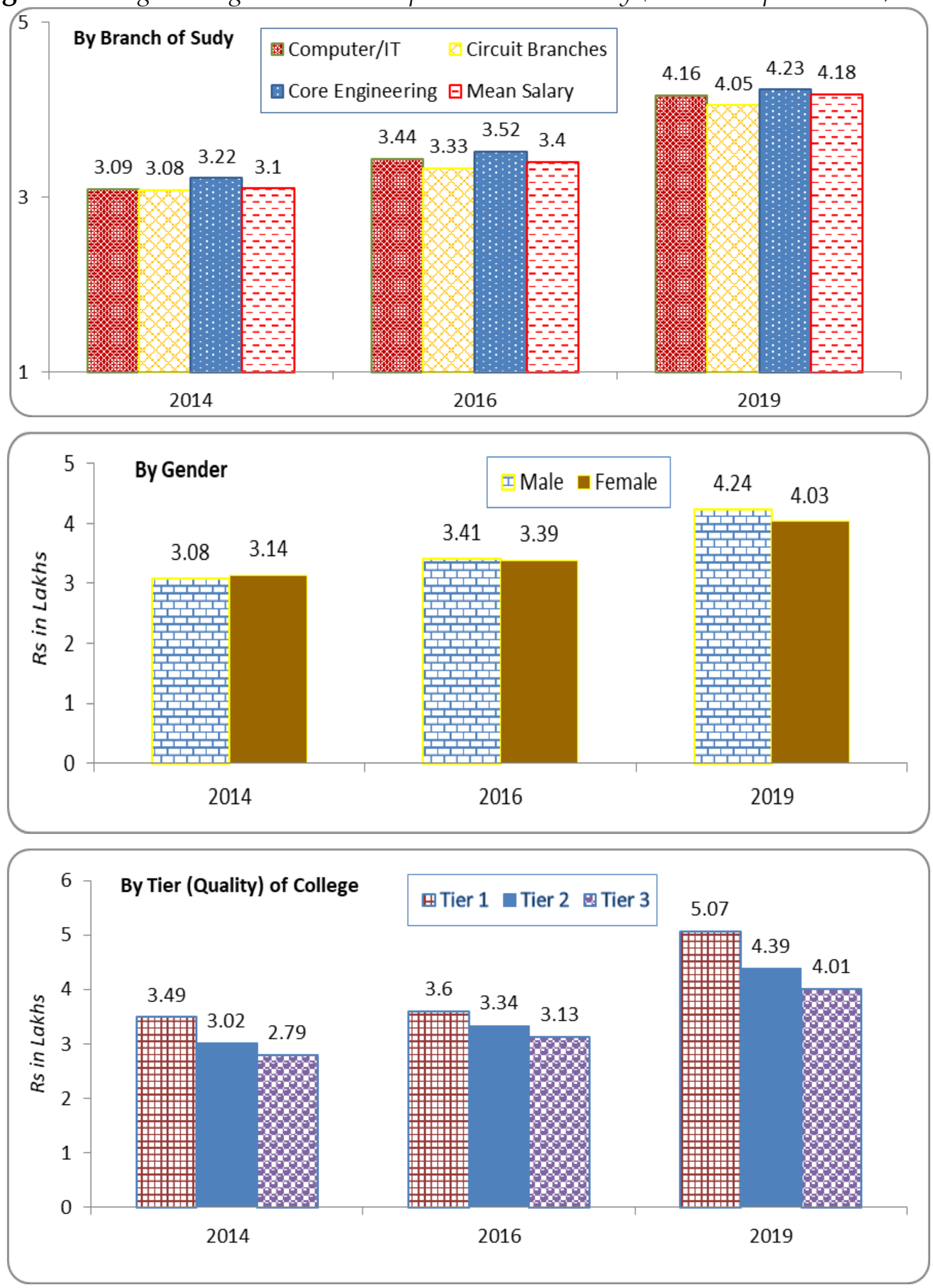
Surprisingly, for management related roles, students from tier 1 colleges (colleges with higher rates of employability of students) show a maximum inclination. Similarly, women in large numbers aspire to work in managerial positions, as compared to men.

Obviously, students while choosing to go for engineering education, consider labour market returns. Engineering being a privileged profession associated with high salaries, fresh graduates normally expect good salaries. The National Employability Reports for Engineers (Aspiring Minds) for the last three years have collected information of expectations of engineering graduates regarding their salaries in the job market. There are variations in the expected salary predicated by branch of study, by the quality of college and by gender (Figure 34). Graduates of mechanical engineering and civil engineering aspire for higher salaries, followed by computer science and IT-related branches) and then circuit branches (electronics engineering, electrical engineering, and instrumentation engineering). However, this is not in line with general perceptions, according to which graduates in computer/IT-related subjects of engineering command the highest pay due to their increasing demand in the labour market. Probably because of a recent fall in demand for IT graduates in the labour market, they tend to limit their monetary aspirations.

The salary expectations also vary according to the level of college one has attended and by gender. As expected, graduates from tier 1 colleges (proxy of better quality) aspire for much higher salaries in comparison to tier 2 and tier 3 college graduates. While the difference between the mean aspired salary of engineers from tier 1 colleges and tier 2 colleges is ₹ 68,000, the difference between those from tier 1 and tier 3 is ₹ 1.1 lakhs in 2019. Students from poor quality engineering colleges do not get a placement in large companies, also in some cases, major employers in the job market do not even participate in the placement exercises of these institutions. Therefore, graduates from these colleges limit their salary aspirations likewise and do not even aspire for high pay.

On an average, women seem to aspire for a slightly lower level of salaries than male engineering graduates in 2016 and 2019, while in 2014, the salary expectations among women were higher than the expectations of men. It is also observed that women students often access tier 2 or 3 colleges, and accordingly they get offers with low salaries. On average, the salary expectations of engineering graduates are not high: around ₹ 4 lakhs per annum. The variations in aspired salaries between colleges, or between branches of study or by gender are small in a given year. They were around ₹ 3 lakhs in 2014, which increased to about ₹ 4 lakhs in 2019. Only in 2019 do we find marginally higher differences between students of three tiers of colleges. In 2019, graduates from tier 1 colleges expected high salaries (₹ 5.1 lakh); this is the maximum figure we find in Figure 34, and in the same year, those from tier 3 colleges expected ₹4 lakhs as their salary on average. Perhaps by 2019, the quality differences in the graduates (identified by colleges) are being clearly noticed by employers.

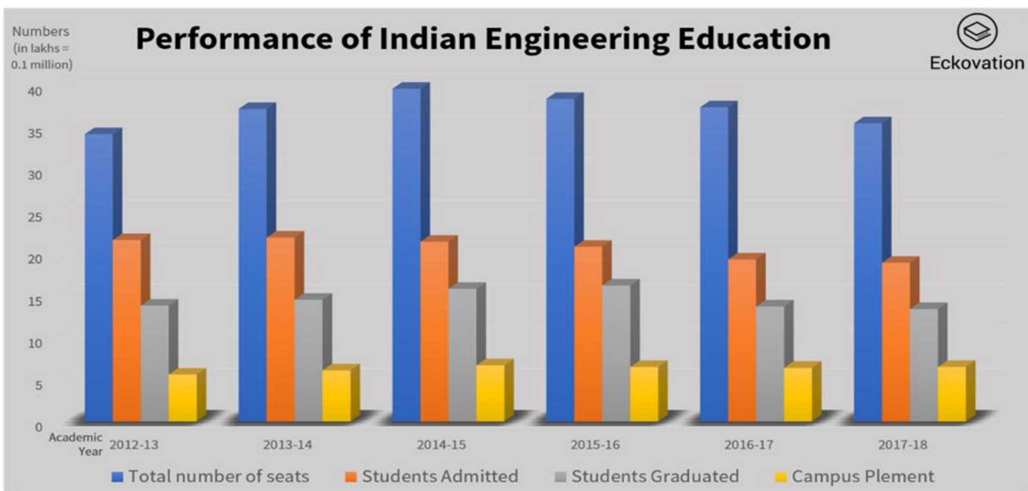
Figure 34. *Engineering Graduates' Expectations on Salary (₹ in lakhs per annum)*



Source: Aspiring Minds' *National Employability Report-Engineers 2014, 2016* and *2019*

The choices of students in choosing engineering studies and the sub-stream there in, and their labour market aspirations critically depend upon labour market information. Hence regular manpower surveys and labour market surveys are needed that provide detailed information, which will be helpful not only to students/graduates, but also public authorities in planning engineering education for future. Such information will also be immensely useful for institutional planning. Though manpower planning per se, is no more found to be meaningful, manpower analyses and labour market analyses that were a part of manpower planning, would be extremely useful (Tilak, 1995), particularly for specialised human capital categories like engineering manpower. Noting the absence of a satisfactory system of manpower planning, the AICTE (2015) recommended bringing out an annual report on demand and supply of technical manpower in India.

Figure 35. *Performance of the Engineering Education System in India*



Source: https://engineering.eckovation.com/engineering-education-performance-report-engineering-colleges-india/ (Reproduced with permission)

The overall performance of engineering education in the country can be summed up in the form of a diagram (Figure 35). Only about half the available student places get filled in; of those who take admission two-thirds to three-fourths graduate; and among those who graduate not even half get employment. The problems lie at every stage – from policy and planning of opening engineering institutions, their functioning, and the process of delivery of education, to the utilisation of graduate manpower. The system requires a multi- pronged major reform.

8. Concluding Observations and Policy Implications

India has registered a very impressive growth in its higher education during the post-independence period, and more impressively during the last three-four decades. Within higher education, there is a distinct pecking order, at the top of which are engineering and medicine. Engineering education has experienced an enormous expansion, beyond experts' anticipations. There are several paradoxes and contradictions in the growth, posing different kinds of challenges to the educational administrators, policy makers and rather the entire society. Based essentially on secondary data, an attempt has been made to understand the changing face of engineering education in India during the last fifty years. Five major dimensions are discussed in the study: (i) changing trends and patterns of the growth of engineering education, (ii) inequalities in growth in engineering education, (iii) quality of engineering education, (iv) financing of engineering education by the government and households, and (v) changing labour market conditions that influence the demand for engineering education. The diagnostic analysis leads us to highlight the following: (a) The expansion of engineering education in the country is very fast, and may not sustainable. Particularly there are too many engineering institutions in the private sector. (b) There are serious problems with respect to access to engineering education in terms of social groups, geography (region/state), gender and economic conditions of households. (c) The system suffers from a very severe degree of staggering paucity of well-qualified teachers. (d) The quality of engineering education has been very unsatisfactory. This will pull down the contribution of engineering education to economic growth. (e) Public funding for engineering education has been very inadequate, necessitating increase in the burden on households, and thereby raising issues of affordability of the low and lower middle strata of the society. (f) Labour market information system on engineering manpower and its utilisation, both are very limited, resulting in imbalances reflected in gluts and shortages.

India has experienced a massive expansion of engineering education during the last half a century, which many experts regard as unsustainable. The explosion in numbers is propelled by the private sector. We find that engineering education, along with rest of higher education in India, is heavily privatised, with about 90 per cent of the sector being in private hands. The private sector that is involved in engineering education today, operates essentially on a commercial basis, and less on a philanthropic basis; it is also financially not supported as much by the state.[38] The

38 The faculty in these institutions can, however, access research funds and special project funds from public sources; and students of private institutions can benefit from schemes such as scholarships, and fee-reimbursements offered by the state and to subsidised loans, apart from subsidies in transport. The fee reimbursement scheme in Andhra Pradesh is essentially for private self-financing institutions (Mathew, 2018a). In Tamil Nadu special scholarships are paid by the government directly to the self-financing colleges on behalf of Adidravida, tribal and converted Christian students (Mathew, 2018d).

dominance of the private sector in engineering education has resulted in several kinds of problems. The private sector has displaced the public sector almost completely. The recent data on several aspects of engineering education show that it has created various kinds of distortions. The private sector invested only in those places where it was rewarding. This has led to a high degree of regional inequalities. The southern and western regions of India have experienced a very high growth of engineering institutions and enrollment as compared to the northern and eastern regions. The participation of the private sector also widened inequalities by caste in access to engineering education. Inequality by gender has narrowed over the years. The increasing presence of the private sector in engineering and other technical and professional education studies has also led to disciplinary distortions, as the private providers are largely offering market-friendly and job-oriented programmes in those streams of engineering that help them expand enrollments, generate revenues through student fees, improve financial status and most importantly, increasing their profit margin. With their over-representation in decision making bodies in public universities, they also influenced heavily public policies referring specifically to even public institutions and distorted them to their advantage.

The large scale expansion has not been accompanied by sustained quality, let alone improved quality; in fact, it is plausible to argue that the expansion has taken place at the cost of quality of education. The quality-quantity trade-off has become clear; and democratic pressures, coupled with economic constraints have made the latter preferable to the former. It appears that the union government had concentrated on quality improvement, by focusing , in the pursuit of excellence, on a few high quality institutions like the Indian Institutes of Technology, leaving quantitative expansion to the states, which, given their fiscal constraints have left the task to the private sector, which cared little for quality. But it is important to realise, as the AICTE (2003, p.162) observed, "The future of the country depends on the quality of technical education we impart in our institutions and the type of practical training we provide to enable the future generation of engineers to become competent innovators, designers and product manufacturers."

With the massive expansion of poor quality engineering education, the employability of graduates has been greatly questioned in the labour market. Several surveys have come out with the fact that only about one-fourth of the graduates are actually employable as the rest do not possess the required skills that the labour market needs. It is argued that the majority of the engineering graduates in India receive low quality training in non-elite institutions while very few get high quality training in elite institutions. Also, little is understood about the contours of the changing labour market in the country and its influence on the demand for and supply of engineering education. The labour market is currently witnessing the new age of automation and is also being driven by unprecedented technological advances that requires a new set of skills among the engineering graduates. How far are the engineering institutions in India fulfilling such needs? Our understanding of the issues is: there is not much emphasis on the curricular and pedagogical arrangements to prepare graduates well for work in the changing contexts. The poor academia-industry interlinkage is another grey area in the engineering education sector in India. Additionally, most engineering colleges in the country (including many government institutions) are facing an acute faculty crunch, not to talk of the lack of physical infrastructure and laboratories to impart quality education and training. Lastly, all these issues discussed in the paper are strongly linked with the financing of engineering education in India. Recent data shows wavering and even declining trends in public expenditure and increasing trends in household expenditures on engineering and technical education over the years. But the increase in the latter cannot compensate for the shrinkage of the former. An increasing involvement of the for-profit private sector in engineering education has placed a clear emphasis on household investment. However, with the decline in enrollments in recent years, the earnings of the private engineering colleges are shrinking, compelling institutions to compromise further with quality by recruiting fewer numbers of qualified teachers, not providing minimum physical infrastructure, laboratories and other facilities, fuelled by a failure to provide adequate industry and corporate exposure. At this juncture, the role of the government is critical to reform/renew the engineering education in India. In addition to investing more on this, the government should also look at the possibility of rethinking on the role of the private sector in technical education and to re-establish the dominant role of the state.

Over all, as discussed in the paper, engineering education in the country has undergone a sea change over the last three decades, particularly with an increasing presence of the private sector. The nature of changes in Indian higher education is very much nuanced and amassed over time but is also multi-woven with policy paradigms at the global and national levels in the macro politico-economic and education sectors. An expansion of the private sector has benefitted greedy private investors in education; expansion of technical – engineering in particular, has helped the information & technology sector in India and not less importantly internationally; the 'new middle class' and upper classes began to view expansion of higher education offering new opportunities to them in India and abroad and significant private benefits from all this; the imperfect markets, including imperfect education markets emerged and flourished; and overall expansion has benefitted the state politically and economically. The economic reform policies, which were originally instigated by the World Bank and western players are being widely welcomed. The nexus between politicians, bureaucracy, businessmen, involving party and caste, and not the least the new middle class (and upper classes) worked well with the tacit support of the state through its explicit policies and even absence of policies. In fact, several state governments openly promoted the idea of self-financed engineering institutions by openly welcoming private players through policy deregulation. As Fernandes (2006) described, the democratic politics in the era of economic reforms is highly influenced by the new middle class and these other factors. Many of these changes are not unique to India, many developing countries seem to undergo similar experiences. These issues are important; but the focus of the present study is somewhat so narrowly confined as not to include these aspects and rather confine to some specific aspects, that we analysed.

The study suggests that there is a need for a major restructuring of the engineering education sector, specifically with a better understanding of emerging market dynamics. Leaving the market to operate freely in engineering education (as has continued for the last three decades) may lead to a great distortion in the sector which has started with the devaluation of the engineering degree. Therefore, there is an urgent need to focus and discuss the changes that the engineering education sector has experienced (and continued to be experiencing) in the recent years. These may include: understanding the changing aspirations of parents for engineering education, revisiting the role of the private sector, searching for new strategies to cope up with the declining demand, and above all, an effective intervention of the state to regulate and restructure the engineering education sector to address the recent changes. The massive expansion of engineering education emphasises the need to ensure that the system and institutions are effectively and efficiently governed and managed to meet the needs of industry and society. We are conscious that this study has left out many important issues like faculty recruitment policy, students' choice for institutions and study programmes, a nuanced understanding of the students experiences in and outside the classroom that have serious policy implications. Lack of data is one of the important reasons for not addressing several of these concerns and, therefore we argue for building a strong comprehensive database that covers historical as well as current data on a large set of dimensions of engineering education that would contribute to quality research, informed and effective policy making and planning of technical higher education in the country. This certainly calls for some urgent action.

Besides setting up an institutional structure that would build such a robust and comprehensive database, the study highlights a few important policy implications. First, there is a need to effectively regulate the growth of engineering education in the country. Permissions and approvals to open new institutions -— public or private, and to offer new programmes need to be based on reliable and transparent and scientific data on the need for such institutions, and programmes, rather than being influenced by political and economic considerations. Leaving this to market forces results in different kinds of imbalances and chaos as we have already seen. As the AICTE (2018) committee has recommended, no new college may be allowed to be started. Permissions may be deferred for opening of new colleges for a few years. In the meanwhile, the government may have to take up on a large scale weeding out the substandard institution, and consolidation of the engineering education system, adopting closures and mergers of institutions. It is not only those where enrollments are less than intake that they need to be closed, but also in case of the institutions in those states, where the intake is higher than national average, as argued by the U R Rao committee (AICTE, 2003). As it is mandatory that all institutions and all the programmes they offer need to be subject to a national assessment, the mechanisms of assessment and accreditation need to be made robust, scientific and transparent, leaving no chance for manipulation. Several loopholes in granting permissions to open, and in assessment and accreditation of the institutions, apart from shortfall in accreditation, are highlighted often in the media. The process of approval by the AICTE for opening new institutions or new degree programmes is based on a set of criteria including the credibility of the management, teachers, assurance of compliance to AICTE norms and standards, approval by the state government, and market relevance of the curriculum, etc. In addition, there is a further process of accreditation by the NBA, which is regarded as having higher standards, relating to capability of the institution, teachers, and the programmes to adhere to strict quality criteria. But these mechanisms have been proven to be insufficient and ineffective, as many institutions are often reported to be flouting these criteria and still functioning.[39] Several loopholes in granting permissions to open, and in assessment and accreditation of the institutions are highlighted often in the media, stressing the need for very effective regulatory mechanisms and quality assurance systems.

Second, a clear focus has to be laid on improving the quality and standards in higher education. Besides consolidating existing institutions, and regulating the future growth, special attention has to be given to the recruitment of quality faculty and the provision of a good learning environment that includes good infrastructure consisting of libraries, classrooms, laboratories and modern equipment, which will be conducive for good teaching and learning and also for research. The Technical Education Quality Improvement Project (TEQIP) project (www.teqip.in), launched by the government of India with the assistance of the World Bank in 2003 as a 10-12 year project, for improving the quality of engineering institutions partly addresses some of the quality concerns in government and government-aided private institutions, and in phase II and III in addition, the self-financing private institutions. But is felt that "due to shortage of academic and non-academic staff and other factors, the scheme has not been able to achieve its targets as desired" (Patel 2016). Educational institutions — either public or private, cannot be left with such high rates of vacancies as we have found. The overall research environment needs massive improvement in majority of the institutions. The need for major curricular reforms needs no emphasis. The curricula may have to include knowledge and skills in the core domain, but it also deeds to add many other individual traits and social, cultural, and human values. The aim in all this should be not just to improve the employability of the graduates, but also to produce holistic personalities who will be able to serve society better. Vertical linkages between high quality institutions like IITs on the one end and the under graduate institutions on the other end, as envisaged under TEQIP, and horizontal linkages between several institutions of the same level may go a long way in enhancing the standards of education in the system as a whole. Otherwise, we may continue to have a few pockets of excellence amidst a myriad of institutions characterised by mediocracy.

Third, private investors find investment in setting up engineering and technical education institutions yielding high and quick returns, as the existing fee regulatory mechanisms are weak, and there is scope for making money out of fee reimbursement systems floated by some state governments. These mechanisms

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39 In fact, if accreditation mechanism is made robust, it is likely that this will promote employment of Indian graduates significantly particularly in foreign countries, as expected when India signed Washington Accord in 2014.

which are actually meant to help students, seem to help the private management more. Both need to be examined and made efficient in such a way that they do not become sources of profit making. In one of the reports, it was found that in some states a good number of institutions generate fees in such a way that more than 50 per cent excess revenues are generated. Philanthropy needs to be insisted as an essential major component of the activities of private investors in education.

Fourth, higher education, including technical education has to be necessarily inclusive in nature. Major initiatives are necessary to ensure that no academically deserving student is prevented from entering engineering institutions, for lack of economic resources. Along with general subsidies, specific public subsidies targetted to help the disadvantaged sections have to be strengthened in the form of scholarships and other financial assistance. The limitations, in fact, the ill-effects of the cost recovery measures like student fee and loans need to be taken note of in making public policies on financing higher education.

Finally, there is a need for special attention to be focussed on private institutions. As many of the ills in engineering education are associated with private institutions, we need a strong and effective regulatory mechanism that oversees almost every activity of the institution, without at the same time becoming hindrance to its proper development. In this context, the proposal of the National Policy on Education (2020) to have a common uniform approach for the regulation of public and private institutions may be counterproductive, or the proposal to have a 'little but tight' regulation may not work. Given the size of the private sector in technical education, and given various other features that distinguish the private institutions from public institutions, a clear robust system of regulation of private institutions is necessary.

In independent India, there have been several commissions and committees that examined the problems of technical education, engineering education in particular in recent years, and made valuable recommendations, some of which have been acted upon, and many not. Non-reflection of the policy recommendations of the commissions, committees, expert groups and task forces in the actions of the government and the institutions and continuation of the deficiencies have been the familiar features of the education scene in the country. Most recently, the Government of India (2020) proposed a new National Education Policy which promises a set of sweeping reforms, successful implementation of which might transform the whole education sector, including specifically technical and more specifically engineering education. The policy purposes, inter alia, developing holistic and multi-disciplinary higher education institutions, where by all mono discipline institutions like engineering colleges, technical universities, and IITs, will be transformed into multidisciplinary institutions offering more subjects outside the core discipline, like arts, liberal arts, humanities, and social sciences, emphasising core content values as well as human traits like human values. These institutions will also provide under graduate, graduate and research programmes, focusing on all the three functions of higher education, namely, teaching, research, and community engagement. They may also offer integrated programmes covering under graduate and graduate studies. Some of these proposals may promote studies interests in studies at master's level and research programmes, which would result in better knowledge production and dissemination, besides increasing the supply qualified faculty.

The policy also promises the granting of graded autonomy by developing a stage-wise mechanism to all institutions, in such a way that finally all institutions will be independent with no affiliation to any university. Besides setting up a National Research Foundation to promote research in all areas, the policy proposes revamping of regulatory structure. All institutions will be governed and regulated by a board of governors at the institutional level, and by a Higher Education Council of India at the national level. The AICTE will become a professional standard setting body. While some of these proposed reforms aim at improving the overall quality of education substantially, they seem to be inadequate to address one particular problem that we have highlighted, namely the growth of commercially oriented self-financing colleges. Though the policy promises to curb all tendencies towards commercialisation of education, it is not clear how that will it be done. It also promises, as already noted, 'little but tight regulation.' Given the experience, one may be sceptical on how reduction in regulation will improve the system, curb a multitude of malpractices associated with private institutions, and even some public institutions, and how many institutions will be able to be governed better by internally constituted boards of governors with much reduced state control. The promised 'little but tight' regulation may actually allow further mushrooming growth of such commercially oriented poor quality institutions, leading to a further aggravation of problems.

While we feel that this paper gives a critical analytical descriptive account on the status and prospects of engineering education in India in a comprehensive way that will perhaps help to bring a new understanding on a variety of complex issues in engineering education contributing to richer discussions in academic as well as policy fora, we do note that there is much scope for further research. Our findings offer clear directions for further research. First, our analysis focusses on the issues and challenges of engineering education at the national level, and we see great value in similar studies at the state/regional levels. This would help to address some region/state specific issues in engineering education which are not covered in this study. For instance, why the patterns in the growth of engineering education in southern states differ from northern states? How the changing demand for engineering education in the country varies across states? Is it linked with the state-specific policies on engineering and technical education? Second, this study discusses the issues in engineering education exclusively at the under-graduate level only. We have not examined issues relating to post-graduation and PhD levels of education in the field of engineering, except making a few occasional references, which needs a separate study. Third, as this study is limited to engineering education only, similar attempts should be made covering other disciplines of higher and professional/technical education in India. What is happening to arts, humanities and social sciences is also important to analyse. This would also help to provide a comparative picture of engineering education with other disciplines of study in higher education. Fourth, in the changing nature of labour market, it is important to take stock of the production of professional graduates in different disciplines and comparing that with their demand in the job market. Manpower analyses are important, as they throw light on a variety of dimensions that will have implications for educational planning as well as economic planning, including for market interventions. Such analyses would help in reducing mismatches, even though manpower planning per se lost its charm over the years in the rapidly changing world. Lastly, further research is required on the cost recovery measures such as student fee and student loans (both of which have become very popular methods), adopted by the state to fund costly disciplines such as engineering education and their effects on the growth of higher education, and their implications for labour market and the society at large.

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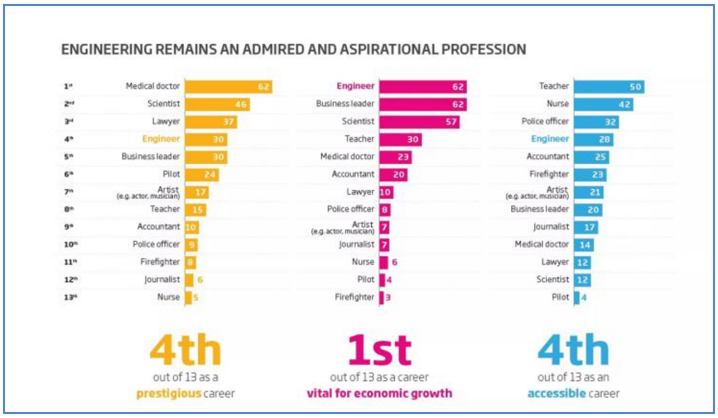
Appendix

Figures

Figure A1. *Global Perceptions on Engineering Career*



Source: QEPEF (2016). (Reproduced with permission)

Tables

Table A1. *Indicators on Science and Technology (2010-18)*

	Researchers R&D	Technicians	R&D Expenditure
	per 1 million Population		% GDP
India	253	73	0.65
Korea	7980	1311	4.81
Japan	5331	524	3.26
Germany	5212	2007	3.09
USA	4412		2.84
France	4715	1806	2.20
China	1307		2.19
Singapore	6803	377	1.94
Australia	4352		1.87
UK	4603	1305	1.72
Canada	4326	1268	1.57
Malaysia	2937	263	1.44
Brazil	888	978	1.26
Thailand	1350	297	1.00
Russian Federation	2784	438	0.99
South Africa	538	130	0.83
Mexico	315	140	0.31
Hong Kong	4026	316	

Source: World Development Indicators: Science and Technology http://wdi.worldbank.org/table/5.13

Table A2. *Growth of Engineering Institutions in India*

	Degree	Diploma	Total	% Distribution	
				Degree	Diploma
1951	53	89	142	37.3	62.7
1961	111	209	320	34.7	65.3
1971	134	301	435	30.8	69.2
1981	171	363	534	32.0	68.0
1991	351	910	1261	27.8	72.2
2000-01	680	1155	1835	37.1	62.9
2009-10	2894	1914	4808	60.2	39.8
2018-19	3124	3440	6564	47.6	52.4

Source: *Statistics of Higher & Technical Education* (various years).

Table A3. *AICTE Approved Institutions offering Engineering Education 2020 (Degree and above level)*

	Number
Central Universities	13
Deemed Universities -- Government	9
Deemed Universities -- Private	69
(State) Government Universities/Institutions	346
Government Aided Universities/Institutions	64
Private Aided Colleges	6
Unaided Colleges	2540
University Managed Institutions -- Government	77
University Managed Institutions -- Private	44
All	3168

Source: AICTE Dashboard

Table A4. *Enrollment as a Percentage of Intake in Engineering Education in States (2012-13 and 2018-19)*

State/Union Territory	2012-13			2018-19		
	Intake	Enrollment	% of Enrollment in Intake)	Intake	Enrollment	% of Enrollment in Intake)
Andhra Pradesh	1,77,805	93,004	52.31	156,166	88,451	56.64
Assam	4,275	3,190	74.62	5,085	2,605	51.23
Bihar	7,790	4,732	60.75	11,020	5,783	52.48
Chandigarh	915	856	93.55	1,645	1,479	89.91
Chhattisgarh	24,880	13,356	53.68	18,982	6,460	34.03
Delhi	7,532	7,252	96.28	9,098	6,972	76.63
Goa	1,260	1,214	96.35	1,320	1,103	83.56
Gujarat	54,349	45,998	84.63	61,556	28,213	45.83
Haryana	66,050	29,254	44.29	41,873	13,621	32.53
Himachal Pradesh	8,190	3,253	39.72	5,193	1,466	28.23
Jammu & Kashmir	2,485	2,086	83.94	3,945	2,478	62.81
Jharkhand	5,870	4,311	73.44	6,521	3,611	55.38
Karnataka	94,770	74,085	78.17	1,02,899	68,637	66.70
Kerala	55,850	40,664	72.81	55,845	27,227	48.76
Madhya Pradesh	99,671	66,865	67.09	78,913	38,012	48.17
Maharashtra	1,56,243	1,12,424	71.96	1,44,061	85,747	59.52
Odisha	44,478	22,937	51.57	40,445	17,391	43.00
Puducherry	6,720	4,682	69.67	7,920	3,087	38.98
Punjab	43,869	22,184	50.57	35,914	14,552	40.52
Rajasthan	62,340	34,756	55.75	45,793	15,429	33.69
Tamil Nadu	2,57,252	1,78,493	69.38	2,97,500	1,43,165	48.12
Telangana	1,73,285	86,746	50.06	1,18,693	69,708	58.73
Uttar Pradesh	1,45,912	81,553	55.89	1,03,945	46,686	44.91
Uttarakhand	14,385	6,834	47.51	10,515	4,333	41.21
West Bengal	34,053	25,625	75.25	36,713	19,906	54.22
All States & Union Territories	1,855	1,475	79.52	3,260	1,495	45.86
All India	15,52,084	9,67,829	62.36	14,04,820	7,17,617	51.08

Source: AICTE Database

Table A5. *Distribution of Engineering Institutions and Population (Age-Group 18-23), 2012-13 and 2018-19*

State	2012-13 Engg Instns.	%	Population (Lakhs)	%	2018-19 Engg. Instns.	%	Population (Lakhs)	%
Andhra Pradesh	357	10.590	57.62	4.10	305	9.763	54.42	3.83
Assam	14	0.415	36.47	2.59	19	0.608	37.45	2.64
Bihar	22	0.653	106.18	7.55	38	1.216	118.14	8.32
Chandigarh	3	0.089	1.52	0.11	4	0.128	1.96	0.14
Chhattisgarh	50	1.483	30.19	2.15	46	1.472	31.49	2.22
Delhi	18	0.534	21.48	1.53	17	0.544	23.28	1.64
Goa	5	0.148	1.59	0.11	5	0.160	1.81	0.13
Gujarat	110	3.263	71.33	5.08	126	4.033	72.32	5.09
Haryana	159	4.717	31.85	2.27	130	4.161	31.84	2.24
Himachal Pr.	21	0.623	7.72	0.55	17	0.544	7.18	0.51
Jammu & Kashmir	8	0.237	14.07	1.00	11	0.352	12.77	0.90
Jharkhand	14	0.415	36.34	2.59	20	0.640	38.70	2.72
Karnataka	192	5.696	73.32	5.22	193	6.178	69.13	4.87
Kerala	153	4.539	31.40	2.23	160	5.122	29.63	2.09
Madhya Pradesh	226	6.704	86.08	6.12	186	5.954	89.64	6.31
Maharashtra	369	10.946	134.40	9.56	363	11.620	132.32	9.31
Odisha	98	2.907	47.00	3.34	94	3.009	46.07	3.24
Puducherry	14	0.415	1.35	0.10	17	0.544	1.67	0.12
Punjab	103	3.055	33.78	2.40	97	3.105	31.21	2.20
Rajasthan	137	4.064	83.76	5.96	117	3.745	90.43	6.36
Tamil Nadu	513	15.218	76.48	5.44	533	17.061	69.63	4.90
Telangana	341	10.116	41.73	2.97	239	7.650	39.41	2.77
Uttar Pradesh	320	9.493	239.15	17.01	253	8.099	250.94	17.66
Uttrakhand	35	1.038	12.41	0.88	29	0.928	11.96	0.84
West Bengal	83	2.462	109.57	7.80	93	2.977	108.53	7.64
Other States and Union territories	6	0.178	18.77	1.34	12	0.384	18.85	1.33
All India	**3371**	100	1405.59	100	3124	100	1420.79	100

Source: AICTE Database

Table A6. Government and Private Institutions and Intake in engineering Education: *Distribution Across States (%) 2018-19*

	2012-13 (%)						2018-19 (%)					
	Institution			Intake			Institution			Intake		
	Government	Private	Total	Government	Private	Total	Government	Private	Total	Government	Private	Total
Andhra Pradesh	3.50	11.25	10.59	3.29	12.06	11.46	3.87	10.66	9.76	4.92	12.14	11.12
Assam	2.45	0.23	0.42	1.81	0.16	0.28	2.66	0.30	0.61	1.21	0.22	0.36
Bihar	2.80	0.45	0.65	2.80	0.33	0.50	4.84	0.66	1.22	2.51	0.50	0.78
Chandigarh	1.05	0.00	0.09	0.86	0.00	0.06	0.97	0.00	0.13	0.83	0.00	0.12
Chhattisgarh	2.10	1.43	1.48	1.92	1.58	1.60	1.69	1.44	1.47	0.97	1.41	1.35
Delhi	3.50	0.26	0.53	2.72	0.32	0.49	2.18	0.30	0.54	1.98	0.43	0.65
Goa	0.35	0.13	0.15	0.39	0.06	0.08	0.24	0.15	0.16	0.21	0.07	0.09
Gujarat	7.69	2.85	3.26	11.43	2.91	3.50	4.84	3.91	4.03	5.69	4.17	4.38
Haryana	2.80	4.89	4.72	2.27	4.40	4.26	4.36	4.13	4.16	3.11	2.96	2.98
Himachal Pr.	0.70	0.62	0.62	0.28	0.55	0.53	0.97	0.48	0.54	0.45	0.36	0.37
Jammu & Kashmir	1.40	0.13	0.24	0.87	0.11	0.16	1.45	0.18	0.35	0.90	0.18	0.28
Jharkhand	1.05	0.36	0.42	1.34	0.31	0.38	1.94	0.44	0.64	1.38	0.31	0.46
Karnataka	8.39	5.45	5.70	11.86	5.68	6.11	5.81	6.23	6.18	7.40	7.31	7.32
Kerala	14.69	3.60	4.54	13.13	2.89	3.60	11.14	4.21	5.12	7.60	3.38	3.98
Madhya Pradesh	5.59	6.81	6.70	6.09	6.45	6.42	3.63	6.31	5.95	3.17	6.02	5.62
Maharashtra	7.69	11.25	10.95	6.78	10.31	10.07	7.26	12.28	11.62	4.78	11.16	10.25
Odisha	2.80	2.92	2.91	2.43	2.90	2.87	2.42	3.10	3.01	3.44	2.79	2.88
Puducherry	0.70	0.39	0.42	0.65	0.42	0.43	0.73	0.52	0.54	0.63	0.55	0.56
Punjab	2.45	3.11	3.06	3.27	2.79	2.83	2.42	3.21	3.10	3.10	2.47	2.56
Rajasthan	4.90	3.99	4.06	5.22	3.93	4.02	4.60	3.61	3.75	3.97	3.14	3.26

Tamil Nadu	6.29	16.05	15.22	7.16	17.27	16.57	13.56	17.59	17.06	29.65	19.78	21.18
Telangana	1.75	10.89	10.12	1.28	11.90	11.16	3.15	8.34	7.65	1.95	9.52	8.45
Uttar Pradesh	5.94	9.82	9.49	4.85	9.74	9.40	6.78	8.30	8.10	5.00	7.79	7.40
Uttarakhand	1.75	0.97	1.04	1.70	0.87	0.93	1.94	0.77	0.93	1.72	0.59	0.75
West Bengal	5.94	2.14	2.46	4.32	2.04	2.19	4.60	2.73	2.98	2.61	2.61	2.61
All States and Union Territories	1.75	0.03	0.18	1.29	0.03	0.12	1.94	0.15	0.38	0.82	0.13	0.23
All India	100	100	100	100	100	100	100	100	100	100	100	100

Source: AICTE Database

Table A7. *State-wise Share of Enrollment in the First Year of Engineering in 2018-19, by Social Category*

State and UTs	SC	ST	OBC	Open	Minorities	Total
Andhra Pradesh	12.27	2.15	36.36	45.03	4.19	100
Assam	7.98	15.82	23.19	43.53	9.48	100
Bihar	0.92	0.09	2.82	2.03	0.50	100
Chandigarh	15.89	3.45	1.76	78.90	0.00	100
Chhattisgarh	10.51	10.23	36.16	41.64	1.46	100
Delhi	9.45	1.23	9.71	61.63	5.79	100
Goa	0.82	6.17	19.76	53.13	20.13	100
Gujarat	4.85	5.28	22.68	63.91	3.28	100
Haryana	4.95	0.19	7.16	31.60	2.56	100
Himachal Pradesh	20.40	5.87	11.32	60.10	2.32	100
Jammu & Kashmir	2.54	4.12	5.00	62.31	26.03	100
Jharkhand	9.99	13.82	23.07	40.26	4.41	100
Karnataka	7.79	2.48	34.54	46.60	8.60	100
Kerala	4.01	0.46	35.17	32.96	27.38	100
Madhya Pradesh	3.83	1.95	12.46	19.04	2.37	100
Maharashtra	9.94	1.51	33.68	48.53	6.34	100
Odisha	19.49	12.04	14.20	52.11	2.16	100
Puducherry	0.24	0.01	2.03	0.55	0.17	100
Punjab	16.00	0.93	10.06	64.70	8.31	100
Rajasthan	9.58	6.09	22.69	56.54	5.11	100
Tamil Nadu	79.10	3.53	251.85	105.32	37.68	100
Telangana	9.84	5.15	40.74	35.81	8.46	100
Uttar Pradesh	17.42	0.63	28.46	46.60	6.89	100
Uttarakhand	0.34	0.07	0.63	2.60	0.09	100
West Bengal	8.45	1.08	9.47	75.45	5.55	100
All States and Union Territories	5.15	19.53	16.39	49.36	9.57	100
All India	11.72	2.68	35.12	43.08	7.40	100

Source: Based on AICTE Database

Table A8. *Regional Distribution of Institutions, Intake and Enrollment in Engineering Education, 2018-19 (%)*

	Institutions	Intake	Enrollment
Southern	46.32	52.61	55.78
Northern	10.24	8.93	7.92
Eastern	7.23	6.55	6.27
Western	11.78	10.35	12.10
Central	11.46	11.35	10.13
North West	12.58	10.21	7.80

Source: AICTE Database

Table A9. *Distribution of Enrollments in Higher Education across Various Branches, by Gender (2018-19)*

	Enrollment			Distribution by Gender (%)		
	Male	Female	Total	Male	Female	Total
Arts/Social Science	48,31,123	54,23,479	10,25,4602	32.93	38.95	35.86
Science	23,09,286	24,04,015	47,13,301	15.74	17.26	16.48
Commerce/Management	24,69,892	22,11,492	46,81,384	16.83	15.88	16.37
Engineering/Technology	27,39,712	11,12,476	38,52,188	18.67	7.99	13.47
Medicine	4,70,891	7,25,867	11,96,758	3.21	5.21	4.18
Others	18,50,327	20,48,191	38,98,518	12.61	14.71	13.63
Total	1,46,71,231	1,39,25,520	28,59,6751	100	100	100

Source: *All-India Survey of Higher Education 2018-19*

Table A10. *Growth in Enrollments in Engineering Education, by Major Categories of Disciplines*

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
All									
Traditional	34.57	40.89	42.23	45.43	48.31	49.63	48.63	47.17	44.48
IT-Related	52.68	46.12	46.34	43.97	41.15	39.86	40.23	41.73	44.12
Other	12.75	12.99	11.43	10.60	10.54	10.51	11.15	11.10	11.40
Total	100	100	100	100	100	100	100	100	100
Male									
Traditional	41.20	48.75	51.37	55.11	58.32	59.62	58.15	56.26	52.86
IT-Related	45.99	38.54	37.40	34.67	31.61	30.37	31.24	33.23	36.37
Other	12.82	12.71	11.22	10.21	10.07	10.01	10.61	10.50	10.76
Total	100	100	100	100	100	100	100	100	100
Female									
Traditional	18.48	21.20	19.61	21.01	22.68	23.85	24.57	24.47	23.84
IT-Related	68.95	65.13	68.46	67.42	65.59	64.35	62.93	62.94	63.20
Other	12.57	13.68	11.93	11.57	11.74	11.80	12.51	12.59	12.96
Total	100	100	100	100	100	100	100	100	100

Source: AICTE database

Table A11. *Trends in Enrollments in Major Disciplines in Higher Education in India*

	1975-76	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06	2010-11	2015-16	2016-17	2017-18	2018-19
Numbers in Lakhs												
Arts	11.57	11.86	15.49	18.89	27.41	35.57	51.38	67.48	113.57	115.31	125.62	126.60
Science	4.64	5.34	7.01	8.69	12.60	15.74	22.55	31.27	54.17	49.66	55.08	53.53
Commerce/ Management	4.15	5.54	7.82	9.70	14.10	16.55	19.86	29.05	46.37	48.91	57.15	57.85
Engineering & Technology	0.96	1.29	1.77	2.17	3.16	5.29	7.95	28.62	48.85	47.82	42.51	40.76
Medicine	1.05	1.10	1.23	1.50	2.20	2.61	3.48	6.53	11.18	11.83	12.52	13.64
Others	1.89	2.40	2.73	3.30	4.79	4.24	5.05	6.80	10.69	20.74	34.08	35.34
Total	24.26	27.52	36.05	44.25	64.26	80.01	110.28	169.75	284.85	294.27	326.96	327.72
Distribution (%)												
Arts	47.67	43.08	42.97	42.69	42.65	44.46	46.59	39.75	39.87	39.19	38.42	38.63
Science	19.12	19.40	19.44	19.64	19.61	19.67	20.45	18.42	19.02	16.88	16.84	16.33
Commerce/ Management	17.10	20.14	21.69	21.92	21.95	20.68	18.01	17.11	16.28	16.62	17.48	17.65
Engineering & Technology	3.96	4.68	4.90	4.90	4.91	6.62	7.21	16.86	17.15	16.25	13.00	12.44
Medicine	4.33	4.00	3.41	3.40	3.42	3.26	3.16	3.84	3.93	4.02	3.83	4.16
Others	7.81	8.71	7.58	7.45	7.46	5.30	4.58	4.01	3.75	7.05	10.42	10.78
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: *Selected Educational Statistics*, and *All-India Survey of Higher Education*; and UGC *Annual Reports*.

Table A12. *Number of Vacant Student Places in Engineering/Technology Institutions in India*

	Total Vacant Seats	% to Total intake (All Institutions)	% to Total Intake (Private Institutions)
2012-13	5,84,255	37.64	39.66
2013-14	6,89,908	42.21	44.33
2014-15	8,30,203	48.68	51.21
2015-16	7,76,527	47.60	50.06
2016-17	7,71,556	49.55	52.40
2017-18	7,26,108	49.18	51.95
2018-19	6,87,203	48.92	52.12

Source: *All-India Survey of Higher Education* (various years)

Table A13. *Enrollment as a Percentage of Intake in Major Categories of Disciplines*

	2012-13	2013-14	2014-15	2015-16	2016-17
Traditional	69.25	65.46	55.27	51.97	45.31
IT-Related	55.48	48.94	45.86	49.00	53.12
Other	72.37	69.38	63.40	62.47	59.68

Source: Based on AICTE database

Table A14. *Faculty Vacancies in IITs in India, 2019*

	Sanctioned Strength	Teachers in Position	No. Vacant	Vacancy %
IIT Bombay	1091	677	414	37.9
IIT Delhi	776	663	113	14.6
IIT Kanpur	743	438	305	41.0
IIT Kharagpur	1203	722	481	40.0
IIT Madras	1000	595	405	40.5
IIT Guwahati	630	410	220	34.9
IIT Roorkee	800	432	368	46.0
IIT Hyderabad	284	206	78	27.5
IIT Jodhpur	140	112	28	20.0
IIT BHU Benaras	215	146	69	32.1
IIT Gandhinagar	160	101	59	36.9
IIT Patna	182	117	65	35.7
IIT Indore	188	145	43	22.9
IIT Mandi	159	128	31	19.5
IIT (ISM) Dhanbad	781	304	477	61.1
IIT Tirupati	93	88	5	5.4
IIT Palakkad	93	81	12	12.9
IIT Jammu	93	57	36	38.7
IIT Bhilai	93	47	46	49.5
IIT Dharwad	93	43	50	53.8
IIT Goa	93	44	49	52.7
Total (23 IITs)	9718	6009	3709	38.2

Source: Kalra (2019) in *Indian Express*

Table A15. *Faculty in Engineering/Technology Institutions in India*

	Faculty	Student-Faculty Ratio
2012-13	2,15,385	15.5
2013-14	3,01,841	12.2
2014-15	3,89,711	11.1
2015-16	4,03,786	10.5
2016-17	4,06,980	10.2
2017-18	4,06,927	9.9
2018-19	3,38,193	11.4

Source: AICTE Database.

Table A16. *Rate of Growth Rate in the Number of PhDs awarded and Undergraduate Enrollment in Engineering and Technology in India (%)*

	PhDs Awarded	Under Graduate Enrollment
1975-76 To 1990-91	4.41	9.69
1991-92 To 2010-11	9.52	14.18
2011-12 To 2018-19	18.57	2.41
1975-76 To 2018-19	9.66	10.15

Source: *All-India Survey of Higher Education* (various years).

Table A17. *Number of PhDs awarded in Engineering/Technology and as a proportion of Total Undergraduate Outturn in India (%)*

Year	No. of PhDs relative to Under Graduate Outturn
2011-12	0.396
2012-13	0.333
2013-14	0.324
2014-15	0.531
2015-16	0.562
2016-17	0.376
2017-18	0.562
2018-19	0.861

Source: *All-India Survey of Higher Education* (various years)

Table A18. *Number of Doctorate Degrees Produced in Universities in India*

Year	No. of PhDs in Engg & Tech.	No. PhDs in Higher Education	% of Engg & Tech. PhDs in PhDs in All Subjects	Year	No. of PhDs in Engg & Tech.	No. PhDs in Higher Education	% of Engg &Tech. PhDs in PhDs in All Subjects
1950-51	10	180	5.56	1997-98	696	11107	6.27
1955-56	24	416	5.77	1998-99	682	11067	6.16
1960-61	16	796	2.01	1999-00	723	11296	6.4
1963-64	19	975	1.95	2000-01	778	11534	6.75
1973-74	95	3056	3.11	2001-02	734	11974	6.13
1980-81	139	6080	2.29	2002-03	833	15328	5.43
1981-82	190	6404	2.97	2003-04	882	17853	4.94
1982-83	160	6597	2.43	2004-05	968	17898	5.41
1983-84	192	6934	2.77	2005-06	1058	18730	5.65
1984-85	210	7139	2.94	2006-07	844	12773	6.61
1985-86	194	7346	2.64	2007-08	427	13237	10.78
1986-87	224	7219	3.1	2008-09	1245	13768	9.04
1987-88	225	7934	2.84	2009-10	1449	14477	10.01
1988-89	238	8238	2.89	2010-11	1682	16093	10.45
1989-90	252	8052	3.13	2011-12	2173	19861	10.94
1990-91	262	8016	3.27	2012-13	2119	20275	10.45
1991-92	299	8743	3.42	2013-14	2533	22849	11.09
1992-93	277	10136	2.73	2014-15	4340	27327	15.88
1993-94	329	9923	3.32	2015-16	4772	27671	17.25
1994-95	337	9851	3.42	2017	4907	34400	14.26
1995-96	374	10397	3.6	2018	7160	40813	17.54
1996-97	298	10408	2.86	Rate of growth*	5.97	3.19	

* Average annual rate of growth
Source: UGC *Annual Reports* (various years)

Table A19. *Expenditure on Technical Education as a share to Total Expenditure on Education and Percentage to GDP*

Year	% to Total Expenditure on Education	% of GDP	Year	% to Total Expenditure on Education	% of GDP
1990-91	2.90	0.15	2004-05	3.87	0.11
1991-92	4.33	0.14	2005-06	3.87	0.28
1992-93	4.35	0.14	2006-07	3.44	0.44
1993-94	4.37	0.13	2007-08	3.71	0.26
1994-95	4.09	0.13	2008-09	4.75	0.31
1995-96	3.99	0.12	2009-10	4.91	0.57
1996-97	3.95	0.12	2010-11	4.57	0.48
1997-98	4.05	0.12	2011-12	5.06	0.51
1998-99	4.01	0.13	2012-13	5.08	0.56
1999-2000	4.04	014	2013-14	5.06	0.58
2000-01	3.95	0.13	2014-15	5.07	0.70
2001-02	4.11	0.12	2015-16	4.86	064
2002-03	4.11	0.11	2016-17(RE)	5.21	0.75
2003-04	3.88	0.10	2017-18(BE)	5.78	0.77

RE: Revised estimates; BE: Budget estimate
Source: *Analysis of Budget Expenditure on Education* (various years)

Table A20. *Public Expenditure on Engineering Education as a Percentage of Total Expenditure on Technical Education (States and Union Territories)*

	%		%
1991-92	21.9	2005-06	20.9
1992-93	21.8	2006-07	20.2
1993-94	17.6	2007-08	19.1
1994-95	18.6	2008-09	18.8
1995-96	18.5	2009-10	15.3
1996-97	18.5	2010-11	15.6
1997-98	19.8	2011-12	15.0
1998-99	17.6	2012-13	15.9
1999-2000	17.4	2013-14	16.5
2000-01	19.4	2014-15	14.6
2001-02	20.5	2015-16	19.1
2002-03	20.1	2016-17(RE)	15.4
2003-04	19.3	2017-18(BE)	25.8
2004-05	20.1	Average	18.6

Source: *Analysis of Budget Expenditure on Education* (various years)

***Table* A21.** *Household Expenditure on Higher Education per Student, by Major Area of Study (₹ per annum)*

	2007-08	2017-18	Increase (%)
Humanities	5,596	11,161	99.45
Science	11,350	19,419	71.09
Commerce	8,420	18,478	119.45
Medical science	40,160	85,972	114.07
Engineering	43,654	70,575	61.67
Others	23,698	53,606	126.20
All	14,519	26,423	81.99

Source: Compiled by authors based on NSS 64th (2007-08) and 75th round (2017-18) data.

Table A22. *India: Estimated Stock of Engineers, 1971 to 2003*

Year	Degree Holders	Diploma Holders	Total
1971	1745	2304	4049
1981	3049	4258	7307
1986	3908	6014	9922
1990	4922	7978	12900
1991	5196	8593	13789
1992	5558	9111	14669
1993	5977	9701	15678
1994	6449	10260	16709
1995	6981	10978	17959
1996	7533	11731	19264
1997	8065	12422	20487
1998	8591	13123	21714
1999	9137	13795	22932
200	9695	14560	24255
2001	10244	15317	25561
2002	10783	16067	26850
2003	11832	17205	29037

Note: Stock is taken at the beginning of the year & in the working age group
Source: IAMR *Year Book*, 2007

Table A23. *Private and Social Rates of Return to Higher Education, by Gender, 2006 (per cent return per year of schooling at each level)*

Level of Education	*Earnings Forgone*	*Earnings Foregone + Tuition*	*Private + Public Costs (Social Rate of Return)*
Men			
Diploma (All)	19.0	13.7	12.0
Graduate (All)	19.5	14.1	12.3
Diploma (Technical)	21.0	11.0-13.2	8.7-10.0
Graduate (Engineer)	36.8	20.4-24.1	16.0-18.6
Women			
Diploma (All)	18.6	12.6	10.7
Graduate (All)	18.0	12.4	10.6
Diploma (Technical)	30.0	12.1--16.0	7.8 –10.2
Graduate (Engineer)	…		

Source: Carnoy et al (2010). Based on National Sample Survey, 2006.

Table A24: *Estimates of Mincerian Rates of Return, by Gender, 2006*

	Model I		Model II	
Variable	***Male***	***Female***	***Male***	***Female***
Age	0.07***	0.05***	0.07***	0.05***
	(0.00)	(0.00)	(0.00)	(0.00)
Age squared	-0.00***	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
General Education (Left out = higher secondary)				
Not literate	-0.96***	-1.24***	-0.95***	-1.24***
	(0.01)	(0.03)	(0.01)	(0.03)
Literate without formal schooling	-0.81***	-1.16***	-0.80***	-1.16***
(EGS/NFEC/AEC)	(0.05)	(0.13)	(0.05)	(0.13)
Literate without formal schooling				
(TLC)	-0.85***	-0.99***	-0.84***	-0.99***
	(0.06)	(0.12)	(0.06)	(0.12)
Literate without formal schooling	-0.71***	-0.61***	-0.70***	-0.61***
(Others)	(0.05)	(0.11)	(0.05)	(0.11)
Below Primary	-0.75***	-1.00***	-0.74***	-1.00***
	(0.02)	(0.04)	(0.02)	(0.04)
Primary	-0.61***	-0.99***	-0.60***	-0.98***
	(0.01)	(0.04)	(0.01)	(0.04)
Middle	-0.43***	-0.74***	-0.42***	-0.74***
	(0.01)	(0.04)	(0.01)	(0.04)
Secondary	-0.21***	-0.30***	-0.21***	-0.30***
	(0.01)	(0.04)	(0.01)	(0.04)
Diploma/certificate course	0.36***	0.48***	0.14***	0.36***
	(0.02)	(0.06)	(0.03)	(0.07)
Graduate	0.48***	0.52***	0.41***	0.46***
	(0.02)	(0.04)	(0.02)	(0.04)
Postgraduate and above	0.75***	0.66***	0.69***	0.61***
Technical Education (Left out = no technical education)				
Technical Degrees (all fields) &			0.34***	0.15***
Diploma or certificate (below			(0.03)	(0.05)
graduate level) in other technical				
fields				
Diploma or certificate (below				
graduate level) in			0.23***	0.11
Engineering/Technology			(0.03)	(0.09)

Diploma or certificate (below graduate level) in Medicine			0.27***	0.19**
			(0.08)	(0.09)
Diploma or certificate (graduate level) in other tech fields			0.18***	0.22***
			(0.05)	(0.07)
Diploma or certificate (graduate level) in Engineering/Technology			0.55***	0.12
			(0.04)	(0.11)
Diploma or certificate (graduate level) in Medicine			0.69***	0.76***
			(0.09)	(0.12)
Constant	5.08***	5.32***	5.07***	5.32***
	(0.03)	(0.06)	(0.03)	(0.06)
No. of Observations	49351	13266	49198	13244
R-squared	0.39	0.43	0.40	0.44

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Carnoy et al (2010). Based on National Sample Survey, 2006.

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This working paper unravels, with the help of data collected from multiple sources including official websites of the Government of India and other bodies such as All India Council for Technical Education and the National Sample Survey up to the most recent years, several specific aspects related to the growth of engineering education in India. This paper offers valuable insights into the current status and future prospects of engineering education, and reflects on the current public policies in this regard.

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