Linking Technical Education to Business Growth: A Case Study on Building Technical Skills in India

Rakesh Basant
Pankaj Chandra

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Rakesh Basant
Pankaj Chandra

Indian Institute of Management
Vastrapur, Ahmedabad 380015

chandra@iimahd.ernet.in
rakesh@iimahd.ernet.in

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Abstract

Education has been recognized as the most important source of competitive advantage for a nation. It is the key determinant of firm level productivity which in turn drives business growth and profitability. Technical knowledge, in particular, is required both for industrial as well as service development. Technical institutions contribute to the growth of business and industry in a variety of ways. The most influential and direct impact is through their graduates who bring in new skills and perspectives to firms. Industries also seek advanced training on specific topics as well as consultancy from technical institutions. Often these institutions collaborate with academics to design and develop new technologies.

In this paper we have argued that technical education plays a crucial role in building these capabilities and consequently in the growth of industry. We use the case study of the Indian technical education system to explore the nature of this system, mechanisms used to govern it, linkages between the education regime and the industry, and the roles that different stakeholders play in ensuring that such a regime delivers sustained advantage to the society. We study the business growth in a few select sectors and the changing needs of technical skills therein. These sectors are agricultural implements, auto-components, chemicals, construction, garments and machine tools. We also illustrate the link between technological innovation and technical skills thereby pointing towards the trajectory of developing industrial competitiveness.

1.0 Introduction

Indian industrial experience, amongst the emerging economies, is an interesting case study on self reliance, development of technical manpower in diverse fields and subsequent industrial growth. That few emerging nations have been able to match this admixture is also true. The Indian experience also comes with its periods of heady growth, stagnation in the economy (despite a not-so-weak foundation) and finally resurgence in industrial development. We will argue in this paper that an important ingredient of the recent growth has been the extensive network of technical education programmes and related policies and consequently the strong base of technical manpower available in the country.

Business growth and technical education are linked through building and application of appropriate skills. Industry requires a range of skills and knowledge based interventions for it to become competitive and grow. While industry does have to upgrade skills of its employees periodically, the basic skill set and generic knowledge base is built in academic institutions. Trade schools prepare “industry personnel” who can start contributing to production upon hiring. Different industrial environments require different kinds of skills which may be provided by a specialized agency. The effectiveness of this agency-industry linkage defines, to a large extent, the impact of the technical education regime on industrial growth and dynamism.

In order to understand how firms grow, one has to understand the dynamic nature of competition in a changing environment. The Pharmaceutical industry in India till early 90s was primarily family run focusing on producing bulk drugs through a process innovation route (i.e., developing and patenting a new process for an existing product) in small sized plants and, predominantly, selling in the domestic and former Soviet bloc markets. This required strong analytical chemistry related skills, process and industrial chemistry knowledge for establishing small scale production units, and linkages with appropriate government and trading agencies to win orders in the Rupee-Rouble exchange. In 1990s it became apparent that patent regime in India will have to change to product patent. Also, its traditional market in the former Soviet bloc countries had changed dramatically. Firms in India started developing new plants that were bigger in size, were equipped with latest technology, were USFDA approved etc. They also formed linkages with firms outside India and brought in global shareholders. This allowed them to enter the global generic market with lower costs. They started to invest resources in developing new drug molecules, developed contract research capabilities for global drug producers, and entered drug testing business. The industry grew tremendously and in many directions. However, this required newer skills in chemical engineering, biology, clinical information science, pharmacology, pharmacokinetics, toxicology etc. which the industry sought from various institutions. In fact, lack of adequate manpower with life sciences training is the key reason for lower (despite an improvement over the last few decades) success in providing solutions to key medical problems in key markets. Another successful example is the setting up of fashion training institutes in the last decade with the growth in garment exports. More recently, with India becoming an important center for clinical trials as well as clinical trial data processing, there has been an emergence of diploma programmes that would train young graduates in Clinical Trial management and related processes. Changes in business require newer skill sets. This requires changes in the technical education regime and development of new programmes.

Technology and competition force firms to move in trajectories that might lead to de-skilling of certain types of workers while requiring development of other types of skills. Often firms develop new skills on the foundation of old ones. When the diesel engine cluster of Rajkot in Gujarat started to decline in late 1990s, firms diversified into new application domains of their old skills, i.e., casting, forging, machining; this formed the basis for the emergence of the machine tools cluster at the same location. While these firms capitalized on the above mentioned skills, they needed to source design skills and digital control technologies - capabilities that the firms did not possess. Consultants and graduates from technical educational institutions were hired to fill in this skill gap. The machine tool cluster of Rajkot has emerged as the third largest producer of machine tools in India.

Technical institutions contribute to the growth of business and industry in a variety of ways. The most influential and direct impact is through their graduates who bring in new skills and perspectives to firms. Industries also seek advanced training on specific topics as well as consultancy from technical institutions. Often these institutions collaborate with academics to design and develop new technologies. They also use specific testing facilities at these institutions. Of course, the extent and nature of benefits depend on the types and strength of these the linkage between industry and technical institutions.

Education has been recognized as the most important source of competitive advantage for a nation. It is the key determinant of firm level productivity which in turn drives business growth and profitability[1]. Technical knowledge, in particular, is required both for industrial as well as service development. Needless to mention, quality of this education is as crucial, if not more important, than quantity in order for firms to appropriate the benefits of technical education. It is impossible for firms to climb the value-add ladder and improve both the functionality and cost of a product or process without emphasizing quality of inputs (of which technically trained manpower is the most critical one). What is also obvious is that firms, in general, face a market failure in skill development – absence of adequate supply of training programmes, mismatch between industry needs and educational supply, lack of quality infrastructure in technical educational institutions, poor quality of teaching and updating of knowledge base in institutions, lack of investment by government and industry in developing skilled workforce, inability of industry to recognize the roles played by skilled personnel etc. are some of the reasons for this problem. This type of market failure leads to failure of firms to build capabilities and consequently their inability to sustain long term growth of their enterprise.

Before one starts to develop any intervention, one must understand the various ways in which technical education and skills mediate the process of business growth. Skills in people have the salient effect of improving ways in which work gets done as well as the choice of work that generates maximum returns fo the inputs deployed. It allows firms to do things which they would not be able to do otherwise, i.e., get orders of complex products or projects, deliver under difficult schedules and stretch the technical boundary to obtain solutions for difficult problems. It

[1] The Investment Climate Survey of India has revealed that higher levels of productivity (about 6 percent) and increase in wages (about 7 percent) were a direct result of higher educational levels acquired by the workforce in firms within a year (Source: "In Service Training in India: Evidence from the Indian Firm Level Investment Climate Survey", H. Tan, H. and Y. Savchenko, World Bank Working Paper, 2005 (as cited in "Skill Development in India: The Vocational Education and Training System" , Human Development Unit, South Asia Region, World Bank, January 2006).

also helps firms survive difficult times both in terms of resources as well as market conditions. Most interestingly, skilled manpower attracts other skilled people – many young people join, even at lower wages, firms that have good skill development programmes. However, building skills is a non-trivial process which requires investments as well as vision of both, enterprises as well as the government.

The purpose of this paper is to explore how an emerging economy like India addresses the issues that have been raised above with respect to technical education, skill building and the resultant business growth. In particular, the paper provides the following :

(a) an outline of the technical education regime in India and the changes therein over the years;

(b) some highlights of the extent and growth of business in certain sectors and the challenges that they face post-liberalization;

(c) some exploratory evidence of linkages between technical education and growth in business and the role played by skill building in this process in India.

This paper is organized as follows: Section 2 provides the contextual backdrop for our paper and highlights the recent changes in the Indian economy and the accompanying changes in the business environment. We also highlight the skill needs in this setting. Section 3 describes the state of Technical education in India, the management structures and the nature of technical education supply dynamics. Section 4 briefly describes the sectors that we have studied in this paper. It provides insights into the sectoral needs and the extent of growth as a result of various policy and managerial strategies. Section 5 discusses the linkages between technical education and business growth. It describes experiences of various companies and the role that skill building has played at different stages of their growth. Finally, conclusions are provided in the last section.

2.0 Indian Economy, Business Environment & Skill Needs

India's economy is firmly on the path to sustain an ever increasing growth over the coming decade. In the near future, the economy is expected to grow at a stable rate of 8 per cent and the growth rate might increase to 10-12 per cent in the medium term. Table 1 provides some key economic indicators for the Indian economy. Manufacturing and the services sectors have become a major driving force for the Indian economy. On the expenditure side, the economy was driven by broad-based domestic demand growth, while consumption growth was driven by good monsoons, which supported rural incomes. Liberalization measures have been successful in increasing foreign exchange reserves and making India one of the more attractive destinations of FDI, both in manufacturing and services sectors. Moreover, Indian firms have successfully penetrated external markets through commodity exports, manufactured products, and outward FDI. The domestic investment rates have also picked up in recent years.

Growth has been spread across variety of sectors. The export-oriented information technology (IT) and business process outsourcing (BPO) sectors continue to perform very well (although these sectors constitute only a small portion of total services output). Indian competitiveness in IT and BPO has been aided by substantial investment in telecommunications infrastructure and the phased liberalization of the communications sector. Apart from construction, the other significant contributor to the impressive growth of the GDP has been the strong performance by the manufacturing sector which accounts for about four fifths of industrial output. Textiles, basic metals & alloys, engineering & capital goods, and transport equipment were the fastest-growing product sectors in addition to consumer goods.

The economy will require carefully managed policy reforms and public budgeting, as it faces two main inter-related challenges in the next few years, to maintain and improve the growth rate of the economy. Gross fixed capital formation has to increase beyond an already healthy 26% of GDP and improvements in physical infrastructure will be crucial. Further, a structural transformation of the economy, together with a less distorted investment environment is required so as to stimulate productivity increases through the process of shifting resources from the less to the more efficient sectors. Successive governments have taken up infrastructure development as the key priority and have been working to address the related issues and bottlenecks.[2]

[2] For example, the Bharat Nirman program aims to enhance the quality and reach of rural infrastructure and help create productive farm and non-farm employment opportunities. The $27 billion National Urban Renewal Mission will reduce pressure on India's mega-cities, and create adequate infrastructure in other cities across the country.

Table 1: Summary of Indian Economy

	2005-06	Per cent Growth (over previous year)
GDP at factor cost at current prices: (Rs. Thousand crores) US$ million	3200.6 72316.3	12.5
At 1999-00 prices (Rs. Thousand crore) US$ million	2586.6 584542.3	8.1
Agriculture and allied sectors: (Rs. Thousand crore) (US$ million)	508.6 114937.8	2.3
Food grains production (Million tonnes)	209.3	2.3
Index of industrial production	215.4	7.8
Electricity generated (Billion kwh)	458.6	4.7
Wholesale price index	196.2 (on February 4, 2006)	4.1
Consumer price index for industrial workers	550 (December 2005)	5.6
Money supply (Rs. Thousand crore) (Outstanding at the end of financial year) (US$ million)	2551.9 (on January 20, 2006) 576700.5	16.4
Imports at current prices (US$ million)	108,803 (April-Jan 2005-06)	26.7
Exports at current prices (US$ million)	74,978 (April-Jan 2005-06)	18.9
Foreign currency assets (US$ million)	133,770 (by end January 2006)	8.2
Exchange rate (Re/US$)	44.25 (Average exchange rate for April-January 2005-06)	2.1
Per capita income (at 1999-2000 prices) Rs.	20,813	6
FDI (US$ million)	3348 (Up to Nov 2005)	49

Source: http://www.ibef.org/economy/economicindicators.aspx

Note: 1 crore = 10 million

However, the emerging skill needs for faster and diversified growth has not attracted enough policy attention. Given the dynamic economic situation, markets may fail to generate skills that are required to fulfill emerging needs of the transformation process of the Indian economy. The enactment of the Fiscal Responsibility and Budget Management Act at the national level, and the process of framing similar legislation at the state level will lower fiscal stress and, thus, allow funding for key social areas (such as health and education) to be increased. This may facilitate growth in government investments in education and skill building. One of the key sectors that would require skill formation is manufacturing where manufacturing practices and technologies need to change in order to make the sector more competitive and this would require re-tooling the existing workforce as well as infusion of new workers with new skills.

2.1 Skills and Competitiveness in the Manufacturing Sector

The GDP growth of 8.1% in 2005-06 was primarily driven by robust growth in manufacturing and services sectors. The Indian manufacturing sector has been moving up the value chain and a large number of multinational companies have established their manufacturing hubs in India. India’s importance as a low cost manufacturing base is getting further impetus from the favorable government policies. The government is planning to set up Special Economic Zones (SEZs) in all the states to boost exports and also offering benefits such as tax deductions and flexibilities in labor laws to players setting up shop in the SEZs.

Table 2 explains the three different business models for manufacturing sector in India highlighting the value proposition offered and the key success factors. The success of these strategies is dependent on the availability of requisite skills. The need for skills would expand exponentially as the manufacturing sector starts to grow more vigorously. For example, if a firm reaches the “design & manufacturing” stage it will build upon the skills required for the “manufacturing” model and then add to its portfolio strong product and process design/improvement skills – it may be recognized that a work force adept in low cost manufacturing does not necessarily possess skills needed to compete on new products and processes – plants will have to acquire these skills through training, consultants, hiring new employees, etc. Skill requirement is dynamic and the nature changes with the changing strategy of a firm.

Increased competition and global outlook increased the focus of Indian manufacturing firms on quality and companies are in the process of upgrading their technology base and diversifying their manufacturing range to serve the global market requirements. Manufacturing exports have risen at a rate of 30 percent CAGR against a sales growth of 15 percent. Indian manufacturing companies are enjoying gross profits and sales growth rates that are nearly twice that of global manufacturers.

Table 2: Business, Value Propositions and Skill Needs in Manufacturing

Models	Manufacture	Design and Manufacture	Design, Manufacture and Brand
Value Proposition	• Lowest cost producer for existing design	• Ability to convert specification into design • Help design better products for OEM	• Deep understanding of end-customer needs; • Manufacture at required cost on consistent basis • Ability to design tailored products
Key Success Factors	• Low cost operations • World class manufacturing practices • High quality standards • Large volume operations • Improve existing processes	• Ability to manage OEM relationships • Lean and efficient supply chain • Ability to manage global organization • Develop new processes	• High customer responsiveness • Ability to manage global organization • Short time-to-market • Deliver at short lead times • Develop new products & processes
Skills Required	• Ability to manage OEM relationships • Skills to read instructions & basic engineering operations • Statistical Quality Control • Continuous improvement skills	• Design capabilities • Experimentation Skills • Scheduling variety & setup reduction	• Research and design skills • Marketing skills • Process improvements – new products with improved processes

Source: Adapted from http://www.ibef.org/artdisplay.aspx?cat_id=83&art_id=4839

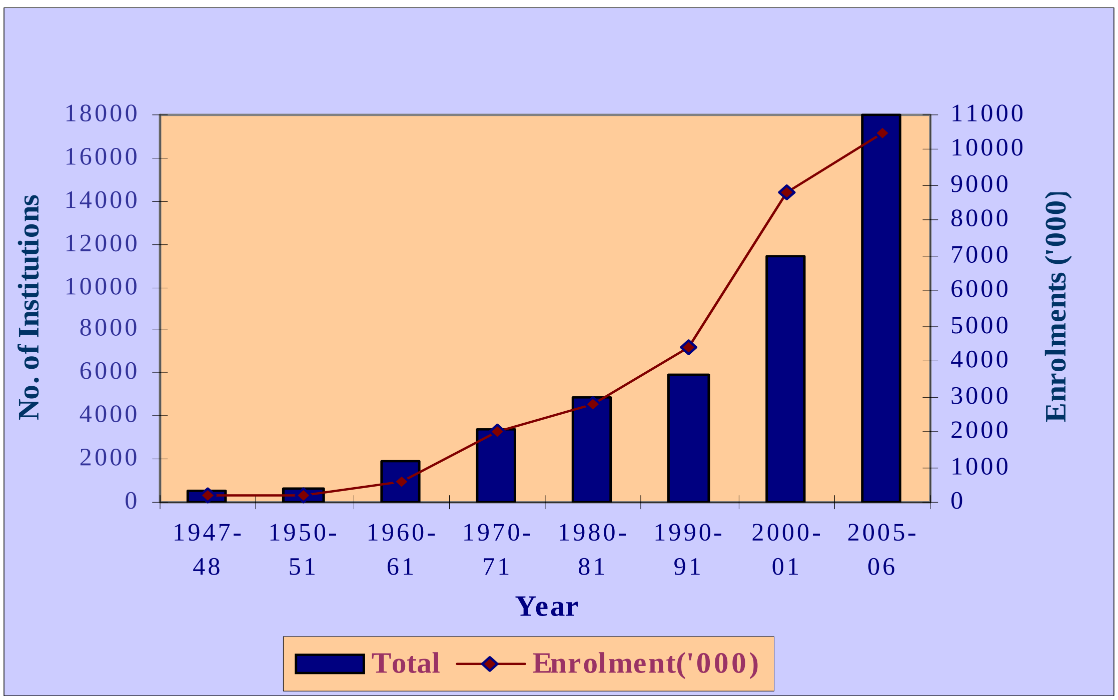
India's greatest advantage is that it can provide quality services at competitive prices as a result of which it is likely to witness substantial growth in exports and outsourcing market. India's advantage of high designing & engineering capability (i.e., very strong engineering skills - metal processing capabilities, machining capabilities, forging, casting, and other mechanical capabilities including designing) with low labor cost makes it the preferred destination for outsourcing.

Overall, manufacturing is expected to grow tremendously even in large volume operations (e.g., Nokia's new facility in Chennai which is expected to produce 1 million mobile phones per month). But sooner rather than later this growth might hit a skill constraint. Chandra (2005) estimates a severe shortfall in the textile industry, for instance. It is therefore critical to assess the systems of skill formation that are available in the country and the emerging skill needs. Two interesting initiatives need to be mentioned. The establishment of the National Manufacturing Competitiveness Council and the National Knowledge Commission have led to focusing of skill development issues in the country.

3.0 Technical Education in India –An Overview

One of the key successes of independent India has been its focus on preparing technical manpower for developing Indian industry. Industrialization was seen as key to development of the nation and technical education as the essential ingredient to sustain its health. Institutions of higher education have grown in numbers along with enrolment therein (Figure 1). Technical education has also expanded significantly in independent India (see Table 3). In this section, we present its current status and describe mechanisms that govern it (in this paper we will focus on engineering related education).

Figure 1: Number of Institutions Engaged in Higher Education and Enrolment Estimates[3]



[3] "Higher Education India: Challenges & Strategies for Reforms," S.K. Shrivastava, Presented at the Washington Symposium, NAFSA, Association of International Educators, March 28, 2006. Source:http//www.indiastat.com/India/showdata.asp?secid=22123&ptid=207092

Table 3: Progress of Educational Institutions in Selected Professional Courses in India

Year	Engineering		Medical	Dental
	Degree	Diploma		
1951	53	89	28	4
1961	111	209	60	11
1971	134	301	95	15
1981	171	363	109	16
1986	248	680	122	29
1987	272	763	125	36
1988	273	779	128	40
1989	321	879	128	43
1990	322	896	128	49
1991	351	910	128	54
1992	354	911	128	57
1993	370	988	146	63
1994	422	1029	146	67
1997	607	1135	201	100
1998	NA	NA	223	110
1999	NA	NA	147	NA
2000	776	1215	190	NA
2001	880	1225	190	145
2002	1347	1228	205	NA

Source: http://www.indiastat.com/india/ShowDataSec.asp?secid=371765&ptid=369157

3.1 Government Expenditure and Supply of Technical Institutions

During the period after independence[4] many radical changes in the socio-economic environment of India have taken place. Frontiers of knowledge have been expanding along with the infusion of modern skills and methods through technological development. To exploit these developments, a well-organized structure and a wide network of technical institutions offering

[4] The need for creation of centers of technical training was felt even during the pre-independence era. It arose out of the need to develop technical skills and educate the superintendents and supervisors for construction and maintenance of public buildings, roads, canals, and ports. Technical Education was also necessary for the training of artisans and craftsmen in the use of equipments and instruments used in various survey departments and the army. The lower grade technicians and artisans were hired locally for these jobs and most of them were illiterate and inefficient. This led to the establishment of various industrial training schools and other engineering establishments for imparting elementary education on reading, writing, arithmetic, geometry, and mechanics.

different types of programmes have been introduced in the country[5]: craftsman courses, technician (diploma) courses, graduate and post- graduate degree courses, etc., catering to the various levels of knowledge, skills and competences required by the economy.

In the year 2003-04 the government expenditure on technical education (both state and center) constituted about 4 per cent of the total expenditure on education and about 0.13 per cent of the GNP. The government expenditure on technical education as a proportion of GNP has been stable during the liberalization period (1991-2004) at around 0.12 to 0.15 per cent of the GNP. Expenditure undertaken by state governments on technical education varies a great deal across Indian States (Panel A in Appendix I). As proportion of the total expenditure on education, it ranges between zero (Arunachal Pradesh) and 10.9 per cent (Goa). The average is about 2.5 per cent.

Panel B in Appendix I provides data on the number of Industrial Training Institutes and Centers (ITI and ITC) in each state and the capacity of these institutions. One of the reasons why government expenditure on technical education may have not grown rapidly may be due to the privatization of technical education in the country. A large number of engineering institutions run by private entities are recognized by the government thereby increasing the supply of technical education. Panel C in Appendix I shows that most southern states (especially Tamil Nadu, Andhra Pradesh and Karnataka) and Maharashtra are far ahead of other states in the number of engineering seats that are available - inter-regional differences in the supply of engineering seats are high.

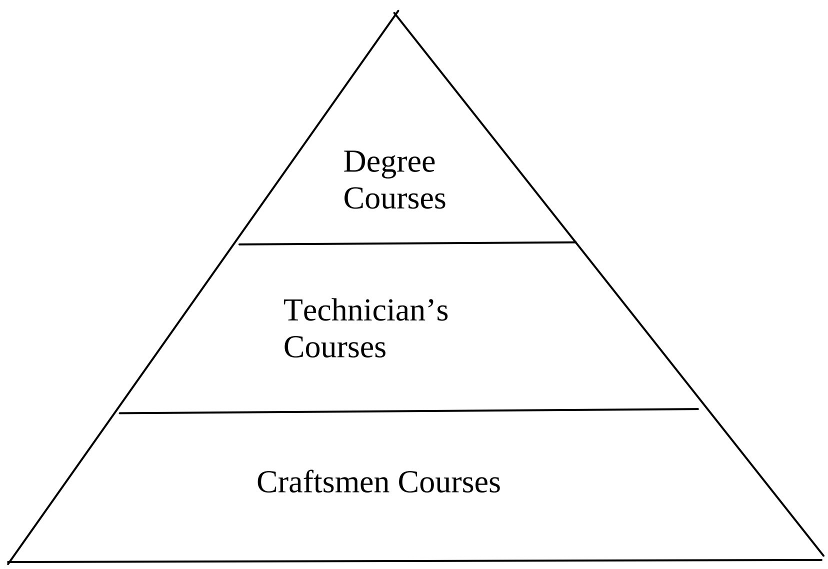
3.2 Nature of Technical Courses[6]

Broadly technical education in India can be classified in three categories as shown in Figure 2. At the early education level are the **Craftsmen Courses** that prepare manpower through vocational education. This education is imparted through the ***Industrial Training Institutes*** (or ITIs) to prepare skilled workers. The next level of technical education, termed as **Technician's**

[5] http://education.nic.in/tecedu.asp (website for Ministry of Human Resource Development (MHRD))
[6] The following section draws upon the World Bank report retrieved from www.ilo.org/public/english/region/ampro/cinterfor/news/gasskov.pdf

Courses, are delivered through *Polytechnic Institutes*, which offer diploma courses to produce middle level technicians along with adequate theoretical skills. At the top end of this pyramid are the **Degree Courses** in technology which are offered by the *Engineering Colleges.* These colleges conduct undergraduate and postgraduate degree courses in engineering and technology. Table 4 provides some details of the various courses in these three levels of institutions. Appendix I gives State-wise information on the number of ITI/ITC and Degree granting institutions in India.

Figure 2: Various Categories of Technical Education in India



The different types of educational programmes offered within each category are discussed below.

3.2.1 Craftsmen Courses

Two types of craftsmen courses are available in India – vocational training courses and the craft instructor's training course.

Table 4: Technical Education Institutions and their Courses in India

Education Levels	Number of Institutions	Enrollment	Courses Offered	Regulatory Structure	Degree/Certification
Industrial Training Institute	4650	678000	43 (Engineering trades) & 24 (Non-engineering trades)	Ministry of Labor, Directorate General of Employment & Training, National Council for Vocational Training (NCVT)	Diploma in the relevant trades
Polytechnic Engineering Education	1173	428143	197 (Diploma Trades) and 57 (Post Diploma Trades)	Ministry of Human Resource & Development, Department of Technical Education, UGC, AICTE	Diploma & Post-Diploma in relevant trades
Engineering & Higher Technical Education	1195	356268	Engineering Trades (Electronics, Mechanical, Civil etc)	Ministry of Human Resource & Development, Department of Technical Education, UGC, AICTE	Bachelor in Engineering/Technology, Master in Engineering/Technology, PhD

Sources: http://education.nic.in/tecedu.asp (MHRD website), http://meaindia.nic.in/indiapublication/higherandtechnicaleducation.htm)

3.2.1.1 Vocational Training

Training (ranging from 1 to 2 years) is imparted in 43 engineering and 24 non-engineering trades to people within the age group of 15 to 25 years but with low level of early education. For this purpose, government run Industrial Training Institutes (ITI), privately owned Industrial Training Centres (ITCs) and self-financed institutes have been established across various parts of the country. Interestingly, the number of ITCs that are run by private entities significantly higher than the number of ITI in all the southern states (Tamil Nadu, Andhra Pradesh, Kerala and Karnantaka) and Orissa (Panel A in Appendix I). Those trained enter the industrial workforce as entry level operators or technician-entrepreneurs. Examples of these trades include painting, welding, garment manufacturing, carpentry, etc.

The principal training schemes offered by the ITIs are the Craftsmen Training Scheme (CTS) and the Apprenticeship Training Scheme (ATS) that provide pre-employment industrial training. CTS is a long term institutional (usually 1 to 2 years) training program while ATS is a combination of institutional and practical training. Graduates are awarded the National Craft Certificate. Practical training constitutes almost 60 to 70 percent of the vocational training curriculum.

ITIs are completely funded by the state government for infrastructure development including purchase of machinery and other capital expenditure. However, some institutions that are designated as Centres of Excellence (CoE) receive 75% of the support from the central government. The institutes do not have the power to set the fee structure or provide any grants/scholarships.

3.2.1.2 Craft Instructor Training

Central Training Institutes have been established to conduct regular, refresher and retraining programmes for the Craft Instructors in various engineering and non-engineering trades. As a result, several Advanced Training Institutes have been established across major cities. The duration of this programme is 1 year and it provides training on advanced skills and practical experience on modern and specialized machines and equipments.

3.2.2 Technician's Courses

Polytechnic Institutes offer Diploma level courses for the training of middle level man power. Entering students needs to have a class 10^{th} pass certificate. Diploma graduates from polytechnics are expected to take up supervisory positions in a given field. The courses are normally of three years duration and the training is imparted in various disciplines of engineering and technology as well as in a few non- technological fields. Recently a few Women Polytechnics have also been established to cater to the specific needs of women who might be reluctant to take advantage of the facilities generally available in the regular polytechnics. Students who do well become eligible for admission to a degree level undergraduate engineering programme. Examples of these diploma courses include air-conditioning & refrigeration engineering, aircraft maintenance, automobile engineering, applied electronics, dairy technology, travel & tourism, commercial art etc.

3.2.3 Degree Level Courses

3.2.3.1 Undergraduate Courses

Centrally governed engineering colleges like the Indian Institute of technologies (IITs), National Institutes of Technology (NITs) and state-owned and privately-run colleges provide technical education for training professional engineers and technologists, leading to the award of Bachelor Degree in Engineering/Technology (often they are stand alone institution while others are part of a University). Education is imparted in almost all the engineering disciplines and the duration of the programme is four years. Panel B in Appendix I gives the details of the state-wise distribution of engineering colleges and their annual intake. Examples of field include mechanical engineering, electronics engineering, chemical engineering, mining engineering etc.

3.2.3.2 Post-Graduate Courses

Selected institutions like IITs, IISc Bangalore, NITs or university institutes like Banaras Hindu Unibersity (BHU) etc. offer various post graduate courses in engineering and technology to provide education to those who want to achieve higher level academic specialization and also for under taking research and development activities. These courses lead to the Master's Degree (and doctoral degrees) in the concerned discipline and are of two years duration. Many of these institutions offer part time courses for people who are working in industry. Duration of such courses is typically three years.[7]

The network of engineering institutes in India includes the following institutions:

Indian Institutes of Technology- These are the premier institutes for engineering and technical education in India and offer various programs including the facilities for Research and Doctoral work. They admit students through a highly competitive entrance examination.

Indian Institute of Science, Bangalore- IISc Bangalore is the oldest and leading post-graduate and research centre in Science and Engineering in India. It also offers a small undergraduate engineering programme.

National Institutes of Technology (NITs) – These institutions have been established in various States as a joint and co- operative enterprise of the Central and the State Governments. Each NIT functions as an All-India level institution admitting students and recruiting faculty from all parts

[7] http://education.nic.in/tecedu.asp(website for MHRD)

of the country. In addition to the under-graduate courses these Colleges also offer Post-graduate courses in various fields.

State Colleges, University Departments and Private Institutions – Besides the IITs and NITs there is also a wide network of state owned and privately-run engineering colleges which offer courses at degree and post-graduate level. Stand alone state owned as well as private universities are affiliated to a University. Many States have setup a State Technical University which is the degree granting (and affiliating) university for such institutions. In addition, State and private (Deemed) universities also have faculties of engineering & technology, that offer degree courses in a variety of fields. Some of the better known institutions in this category are BHU, BITS, University of Delhi, Jadavpur University etc.

Apart from various programmes described above, The government of India in its endeavour to provide the right stimulus for the growth of the industry – particularly with the objective of helping the small scale industry, has established nine tool rooms and training centres at Aurangabad, Ahmedabad, Bhubaneshwar, Guwahati, Hyderabad, Indore, Jamshedpur, Kolkata and Ludhiana. These tool rooms are equipped with the latest technology, are highly proficient in mould and die making technology, and promote precision & quality in the development and manufacture of sophisticated moulds, dies and tools. Appendix II provides details of the functioning of the Indo-German Tool Room in Ahmedabad. Given the application orientation of the too room programme and the potential to expose new & old workers to new machines, an extension of similar facilities throughout the country seems desirable. One, however, needs to evaluate various options for providing similar training with more industry participation (more on this later).

3.3 Regulatory and Governance Structures

In India, education is governed both by the Central as well as State governments. Technical education is governed by the Ministry of Human Resource Development (MHRD) and the Ministry of Labour at the Center and by the Departments/Directorates of Technical Education at the State level. The University Grants Commission and about 13 professional councils participate actively in the provision and regulation of technical education in the country.

Regulatory bodies are under the direct control of the government. Apart from other functions, they are responsible for the setting up and implementation of minimum standards for various degrees and diplomas. The academic titles are approved by the Central government. In all there are about 131 universities that affiliate 17,625 colleges for technical education.

Figure 3 : Key Regulatory Agencies reporting to the Ministry of Human Resources and Development

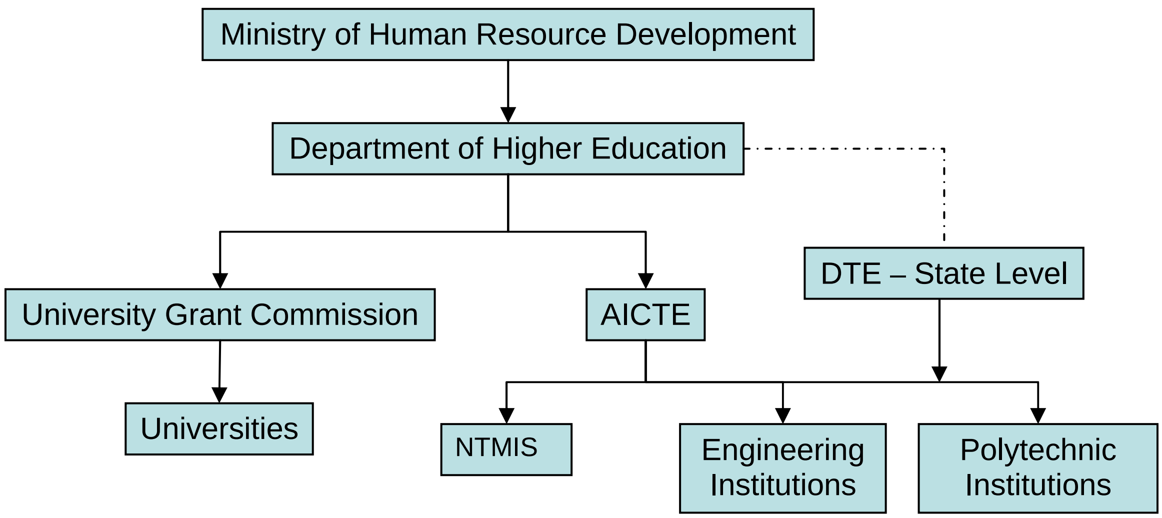
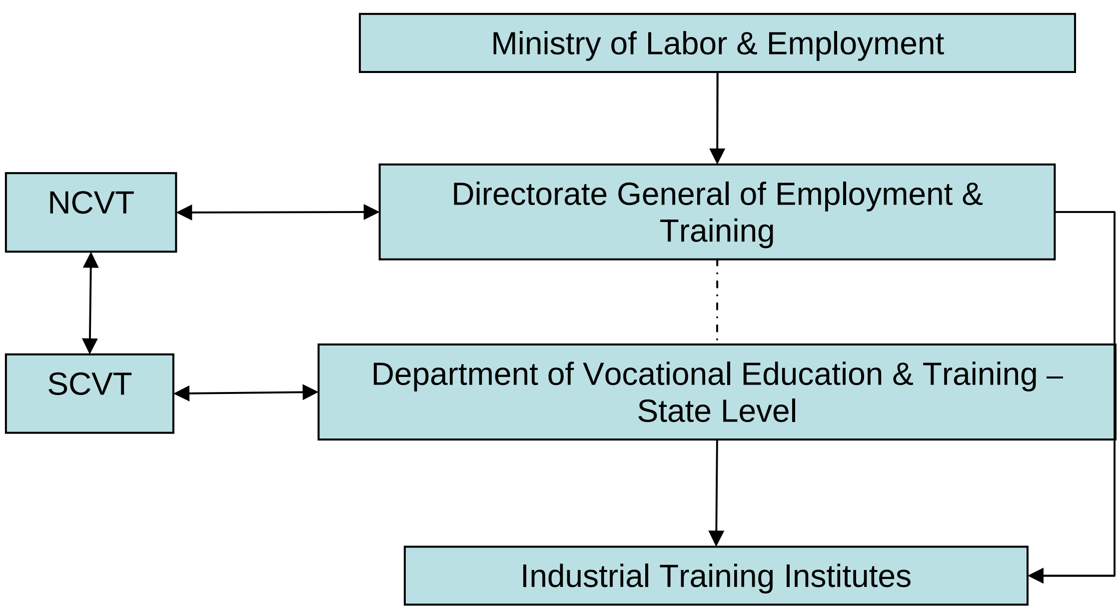


Figure 4: Key Regulatory Agencies reporting to the Ministry of Labour & Employment



Figures 3 and 4 show the key agencies involved in the administration of technical education in India under the two ministries. We describe below the roles of some important governing agencies which regulate technical education in India.

3.3.1 Regulation of Universities

Education in Universities is governed by a key government agency called the **University Grants Commission (UGC).** The UGC has the unique distinction of being the only grant-giving agency in the country which has been vested with two responsibilities: providing funds and coordination, determination and maintenance of standards in institutions of higher education. On the basis of developments in India and elsewhere, the Commission also advises the state and Union and state governments on measures to improve higher education.[8] All Universities that are supported by the Central Government are governed by the UGC which also sets norms and provides some support to State Universities.

3.3.2 Regulation of Engineering Education

Apart from the UGC which oversees engineering colleges that are part of universities, engineering education is managed at the Center by the All India Council of Technical Education (AICTE) and at the state level by the Directorates or Departments of Technical Education (DTE).

AICTE, under the Department of Secondary and Higher Education in the Ministry of Human Resource Development, is a Central agency whose role is to provide direction to technical education in the country by enforcing quality standards in technical education, grant permission

[8] The UGC's mandate includes: (i) Promoting and coordinating university education.; (ii) Determining and maintaining standards of teaching, examination and research in universities; (iii) Framing regulations on minimum standards of education; (iv) Monitoring developments in the field of collegiate and university education; disbursing grants to the universities and colleges; (v) Serving as a vital link between the Union and state governments and institutions of higher learning; and (vi) Advising the Central and State governments on the measures necessary for improvement of university education. (Source:http://www.ammas.com/topics/Education/a115530.html)

for establishment of new institutions, establish the degree equivalence, accredit institutions through the National Board of Accreditation and provide funds to areas deemed to be important. At the state level, **Department of Technical Education (DTE)** is responsible for guiding and supporting Post Graduate, Graduate & Diploma level institutions in Engineering & Technology, Architecture, Pharmacy and Management.

Manpower planning requires detailed data on the supply and demand for skills. **National Technical Manpower Information System (NTMIS)** is a "computerized manpower information system. Government of India generates and maintains an up-to-date data bank for providing reliable information on engineering graduates and diploma holders. NTMIS is expected to identify emerging technical skill needs and ascertain demand-supply gaps so that appropriate action may be taken.[9]"

3.3.3 Regulation of Industrial Training Certificate Education

The State Governments and Union Territories administer the Industrial Training Institutes and exercise financial control. The **Directorate General of Employment & Training (DGE&T)** within the Ministry of Labour & Employment is the National coordinating organization for designing and funding programmes relating to vocational training including Women's Vocational Training and Employment Services. A countrywide network of Employment Exchanges provide employment services. "Major functions of the DGE&T include framing of overall policies, norms and standards relating to vocational training, taking steps to expand, diversify and enhance craftsmen training, organize specialized training in specific institutes, decide on the scope of training for apprentices under the Apprentices Act and organize vocational training programmes for specific groups like the disabled, women, Schedule Caste, Schedule Tribes etc[10]".

Another important agency that governs vocational education is the **National Council for Vocational Training (NCVT)**. It is an advisory body at the Centre (within the Ministry of

[9] The information is based on :http://www.ntmis.org/ntmis.htm

[10] http://dget.nic.in/

Labour) whose role is to establish standards for achieving proficiency, design curricula, and manage the training of craftsmen. NCVT conducts the "All India Trade Tests" for award National Trade Certificates, inspects and recognizes institutions for Certificate courses, assists in setting up these institutions and provides recommendations to governments with respect to funding of these institutions[11]" Its counterpart at the state level is the State Council for Vocational Education (SCVT).

In order to oversee the functioning of the ITIs on a day to day basis, the government has an **Institute Management Committee (IMC)** for each of the ITIs. It includes Central and State government nominees as as well as representatives of industry associations. IMCs help generate revenue through various means such as projects and financial contribution from industry including donation of equipment. They also select trainees & contract faculty, develop curriculum, identify emerging training areas, facilitate faculty training, and oversee testing & certification processes etc.

In summary, India has a three tier system of producing technical professionals in engineering. The first tier comprises students who opt for a crafts course at an ITI in technical disciplines after Class 8/10. They typically setup their own business and work therein or join an industry as operators on the shop floor. They receive a Certificate of the trade from the ITIs. The second tier comprises students to have completed Class 10/12 and opt to enter a Polytechnic for training in a special engineering or non-engineering trade. These students graduate with a diploma. They join industry as junior engineers and supervisors. The third tier (or the highest level) is the degree granting engineering institutes where students enter after Class 12 and work towards an undergraduate degree. There is some scope for mobility between the various tiers but it is very restricted. The challenge that the technical education system faces is threefold – to continuously upgrade the quality of the infrastructure and introduce newer trades based on new requirements, to be able to recruit and retain good quality teaching staff, and to reach out to an increasing number of eligible candidates. The centralized governance can be restrictive in terms of flexibility to bring changes in curriculum, selection and training processes. In addition, the

[11] http://dget.nic.in/schemes/cts/nvts.pdf

institutions are dependent on the government for equipment up-gradation which is infrequent. In the next section we discuss the challenges faced by some industrial sectors and their need for technical skills.

4.0 A Brief Description of Sectors Under Study

The last section discussed the overall regulatory structure that governs the provision of technical education in India. In this section we will provide a brief description of business growth in a few select sectors and the changing needs of skills therein. These sectors are agricultural implements, auto-components, chemicals, construction, garments and machine tools. Table 5 provides some basic information on these sectors. All these sectors are reasonably large and have experienced reasonable growth.

Table 5: Some Characteristics of Sectors Under Study (2005-2006)

Sector	Contribution to GDP	No. of firms	Growth rate over previous year	Exports	No. of employees	Regional Concentration
Agricultural Implements	NA	NA	NA	375 crores*	NA	All across the country
Auto-Components	36500 crores	500	25%	6400 crores	500000	Gujarat, Maharashtra, Delhi
Chemical	130000 crores	6000	12%	15400 crores	NA	Western India (Gujarat & Maharashtra)
Construction	247000 crores	28000	8%	NA	3.2 crores	All across the country
Garments	88340 crores	30000	10%	26500 crores	0.35 crores	Ludhiana, Tirupur, Delhi, Bangalore, Mumbai and Chennai regions
Machine Tools	10000 crores	450	50%	49 crores	65000	Maharashtra, Gujarat, Punjab, Tamil Nadu and some parts of East India

* Year 2002-2003
* NA: Not Available

This section has been prepared from various sources including interviews with industry associations[12].

As we can see, each one of these sectors is geographically spread out and has seen significant growth rates. Some of them employ high number of employees and contribute quite significantly to the Indian GDP. We will now describe these sectors briefly. Its purpose is to understand the context in which we will explore the linkages between technical education and business growth these sectors.

4.1 Agriculture Implements Sector

Agriculture has been at the heart of the Indian economy for centuries. Although it contributes 21 per cent of the total GDP, around 60 per cent of the population of the country depends on it. The Indian Agriculture Industry is on the brink of a revolution that will modernize the entire food chain. The total agriculture production in India is likely to double in the next ten years.

Farm Mechanization has been one of the vital programmes of the government with the aim of optimally utilizing the available sources of farm power. Government has laid stress on the promotion and popularization of improved agricultural implements, both power operated and animal drawn. Financial assistance has been extended to farmers as well as to various registered

[12] http://www.indiainbusiness.nic.in/india-profile/automobile.htm, Indian Auto Components Industry – Status Report, 2005 . Retrieved from http://acmainfo.com/, http://www.indiainfoline.com/nevi/auwh.html, http://www.crisil.com/india-budget-analysis-2005/industry/post-auto_anc.html#key, Cygnus Research Report – " Indian Construction and Infrastructure Industry", Nov 2004 . Retrieved from www.site.securities.com on April 20, 2006, CRISINFAC "Construction Annual Review " – Feb 2006. Retrieved from http://www.iimahd.ernet.in/library/coidata.htm#CRISINFAC on April 21, 2006, Various News paper articles – www.timesofindia.com, www.businessstandard.com, http://www.imtma.in/, http://www.crisil.com/india-budget-analysis-2005/industry/post-auto_anc.html#key, *www. ibef.org, http://agricoop.nic.in/dac9899a.pdf, http://agricoop.nic.in/bud9900a.pdf, Cygnus Monthly Industry Monitor, http://site.securities.com/ci/ip.html?pc=IN&indu=115, http://www.worldbank.org/html/dec/Publications/Workpapers/wps2000series/wps2012/wps2012.pdf, http://apparel.indiamart.com/lib/garments/indian07251998.html,http://www.aepcindia.com/portal/printer_friendly/ prnapp_park.htm, http://www.pdexcil.org/news/tufs/tbook/g1.htm*

agricultural cooperative societies in order to increase ownership of tractors and matching implements. The Farm Machinery Training & Testing Institutes, established by the Government, have been playing a vital role in promoting agricultural mechanization and the training needs of machine operators, farmers and officers. The industry is entitled to a 150 per cent deduction in expenditure on in-house research and development.

The following, however, are the constraints facing the agricultural implements and machinery market in India:

- Varied requirement of equipment for each agro climatic zone
- Small and fragmented land holding
- Low investment capacity of the farmers and weak financing mechanisms
- Inadequate irrigation facilities
- Low know how of modern farming practices amongst farmers
- Inadequate availability of power
- Limited efforts towards farm mechanization
- Repairs & maintenance facilities in Rural India.

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Tractors have maximum utility in the agricultural sector. The tractor industry is segmented on the basis of the power of the tractor engine that is measured in terms of horsepower (HP). About 13 producers including 4 MNCsare involved in the manufacturing and sale of tractors in India. India is the largest market for tractors and firms like Mahindra and Mahindra are now exporting a substantial number of tractors to developed markets of US and Europe. The value of exports of tractors and agricultural machinery reached $75.45 million by the year 2002-03 out of which, the share of agricultural machinery was 65.3 per cent. Importing countries include Bangladesh, Nepal, Sri Lanka, US, UK, EU countries, Japan, South Korea, China, Hong Kong, Malaysia, Pakistan and Thailand.

This sector has not seen systematic design intervention and does not attract engineering graduates except in large Indian and foreign firms. This sector also includes manual production and low cost, low quality production of implements. The sector has not seen change in production practices over years. Currently, due to poor finances, not so easy access to credit, poor infrastructure including power has made it difficult to implement farm mechanization on a large scale. With the increase in the availability of low cost finance, better wealth creation of farmers in certain regions coupled with improvements in the infrastructure, the usage of tractors, farm implements and machinery is expected to go up. Consequently, the need for skilled technical manpower is poised to grow.

4.2 Automotive Components Sector

Indian Auto Component Industry, with a turnover of approximately Rs. 36,300 crores (2004-05) is into manufacturing of all the key components required for vehicle manufacturing – engine parts, equipments, suspension and braking parts, electrical parts, body & chassis and other components. The size of the auto component industry has grown from US$ 2.4 billion in 1997 to US$ 8.7 billion in 2004-05 (including export of US$ 1.4 bn). During the year 2003-04, the sector recorded a growth of 25.06%.

The industry structure is as follows:

- Big national players with an annual turnover of 50 to 500 mnUS$ (about 40 companies)
- Medium scale players with an annual turnover of 5 to 50 mn US$ (220 companies)
- Small scale players with an annual turnover of 1 to 5 mn US$ (about 230 companies)

Indian auto-component industry has seen major growth with the arrival of global vehicle manufacturers from Japan, Korea, US & Europe. These customers transferred the best technological methods and practices and initiated a drive among the Indian auto-component manufacturers to focus on Quality and Efficiency. India is emerging as one of the key auto components centers in Asia and is expected to play a significant role in the global automotive supply chain in the near future.

In addition to the above, several other factors are affecting the growth of the industry, e.g., reduction in the peak customs duty on components & raw materials (like Al, Cu and Pb) will benefit companies that import sub-components for manufacturing their final product**.** The extension of the 150 per cent tax benefit for in-house R&D will also benefit auto ancillary companies undertaking research and development and would help in the development of the sector. The free trade agreement with Singapore and the impending agreement with Thailand is expected to increase the technology flows in the industry.

Indian companies have been able to carve a niche in the OEM market by adopting a focused approach towards quality improvement and by keeping the costs low. In addition, a growing domestic market has attracted OEM's to India. According to a Auto Component Manufacturers Association (ACMA)-McKinsey study[13], India can achieve a 3-4 per cent share of the potential sourcing market (estimated by them at US$ 700 billion) by 2015 given India's strengths, especially its competitiveness in manufacturing labor intensive, skill-intensive parts (specially mechanical parts) and parts involving technology aggregates among others. It is, however, a laggard in terms of auto-electronics. Another trend has been acquisition of global auto-component firms by Indian companies. All of this will lead to a higher demand on the skilled workforce of the sector.

4.3 Chemicals Sector

The Indian chemical industry has seen phenomenal growth in the past 50 years and is a key sector of the economy. Ranked 12th by volume in the world for production of chemicals, the chemical industry in India contributes about 3% to the economy's GDP, roughly about $30 billion. The Indian chemical sector is highly dispersed and fragmented, comprising more than 6,000 companies, including a handful of multinationals. Western India (the States of Gujarat and Maharashtra) accounts for 45-50% of total Indian chemical industry. Most of the large players operate in the bulk chemicals segment, while both large and small players are present in Fine and Specialty chemicals. Chemical industry is highly heterogeneous with following major sub-sectors: Petrochemicals, Inorganic Chemicals, Organic Chemicals, Fine and specialties, Bulk Drugs, Agrochemicals, Paints and Dyes.

Fiscal concessions granted to small producers in mid-eighties led to the establishment of large number of units in the Small Scale Industry (SSI) sector. Currently, the Indian Chemical Industry

[13] "Vision 2015 for the Indian Automotive Components Industry," ACMA-Mckinsey Report, New Delhi, 2005.

is in the midst of restructuring and consolidation. With an emphasis on product innovation, brand building and environmental friendliness, it is increasingly moving towards greater customer-orientation. Despite being one of the oldest sectors, the Indian chemical industry is characterized by a low per capita consumption (at 5kg per annum against 40kg in western countries). The main growth drivers for the industry are economies of scale and backward integration.

The knowledge and talent level of professionals in the Indian chemical industries are now recognized which is evident from the desire of several multi national organizations to develop a hub for research and development and seek outsourcing of product development work from India. With an anticipated market value of $50 billion by the end of 2009. India will continue to have one of the fastest-growing chemicals markets in Asia-Pacific.

4.4 Construction Sector

Construction is the second largest economic activity in India after agriculture and accounts for nearly 11% of the GDP and around 50% of the Gross Fixed Capital Formation. The sector employs more than 3.2 crore people. The turnover of the industry is Rs 2470 bn. With government’s increased focus on infrastructure development, construction activity picked up pace in 2002-03. On the real estate construction front, too, the sector continues to perform well after returning to stability in 2001. The construction industry can be broadly classified as following:

- Real estate construction (residential and commercial construction)
- Infrastructure (roads, power and urban infrastructure) and
- Industrial construction (steel plants, textiles plant and refining pipeline/refineries).

The industry is highly fragmented with over 3 million construction entities (of which only 28,000 are registered) including real estate and housing contractors. This is because of the low fixed capital requirements to start a construction business. However, there is less fragmentation in the industrial/infrastructure industry than in housing sub-sector because of the higher technical expertise required in the industrial construction. Among the construction companies L&T is the market leader with a turn over of Rs 36,910 million for the quarter ending in December 2005.

With recent emphasis on infrastructure development, it is expected that construction sector will lead the national economy on to a higher growth trajectory. Over the next 3 years, construction investments are expected to grow at a CAGR of 8 per cent to Rs 8,300 billion, propelled by growth in investment in all the three segments of the construction sector. This segment, however, has not modernized both in terms of skills as well as tools of production within the country.

4.5 Garments Sector

Textiles (including garments) represent a leading sector of the Indian economy in terms of value of production, exports, employment and contribution to the exchequer. Indian textile industry constitutes 20 per cent of industrial production, 30 per cent of export revenue and 18 per cent of employment in industrial sector (with an employment of close to 4 million workers). The apparel sector comprises the production of garments and certain other sewn end-use products like accessories. The readymade garment industry constitutes about 6% to the gross domestic product (GDP) and accounts for 46% per cent of India's total textile exports. Intense competition, shifting customer loyalties, improvement in customer cycle times, aggressive marketing and the presence of global players are some of the salient features that have resulted in the change of industry outlook recently. Companies are re-aligning their activities towards meeting specific customer needs, radically changing business models and exploring new ways of collaboration between buyers and sellers

The strengths of Indian garment (as well as textile as a whole) industry are:

- Self sufficiency in cotton
- Presence across whole value chain, i.e. from fiber to garment.
- Good designing skills and fashion capabilities
- Greater flexibility
- Low cost skilled labour

The Indian garment industry is based on a system of decentralized production and exports have been niche-based focusing on low volume and high variety of outputs, within the broad area of fashion clothing. Small scale fabricators dominate garment manufacturing. India has approximately 30,000 readymade garment manufacturing units and more than three million people are working in the industry. Ludhiana, Tirupur, Delhi, Bangalore, Mumbai and Chennai are dynamic clusters of production each having its own strengths and niches.

While US is India's most lucrative market, exports to the EU have risen by 20% in the recent times. Growing order books coupled with stiff competition from China are pushing Indian garment exporters to pursue niche strategy. Companies are creating divisions to execute smaller orders or outsourcing to job workers, who cater only to small orders.

The Indian government is turning its attention to removing the bottlenecks that hinder its growth. A centrally sponsored scheme titled "Apparel Parks for Exports Scheme" has been launched. The scheme is intended to impart focused thrust to setting up of apparel manufacturing units of international standards in order to increase its share in the global market. Textile Policy 2006 of the Government of India[14] aims to achieve the exports of US$50 billion by 2010. This goal of achievement seems to be highly ambitious and a tough challenge, with the shortage of the skilled labour in the industry to meet the growing demand. With the advancement of technology in the industry and also raising exports and booming competition over the last few years' shortage of technically skilled labour is going to be major impediment for India to achieve the target[15].

4.6 Machine Tools Sector

The Indian machine tool industry has a turnover of approximately Rs 1000 crores at it grew at the rate of around 50% in 2005-2006. The industry manufactures a complete range of metal-cutting and metal-forming machine tools which include the conventional machine tools as well

[14] www.texmin.nic.in
[15] "The Textile and Apparel Industry," Pankaj Chandra, Forthcoming in the Handbook of Indian Economy, ed. K. Basu, Oxford University Press, New Delhi.

as CNC machines. Some other variants offered by Indian companies are – special purpose machine, robotics, handling systems and TPM-friendly machines.

Machine tool industry comprises about 450 manufacturers with 150 units in the organized sector. Ten major companies of this industry contribute to almost 70 per cent of production and over three-quarters of total machine tool production comes from ISO certified companies. The industry has an installed capacity of over Rs. 10,000 million and employs a workforce totaling 65,000 skilled and unskilled personnel.

The machine tool industry in India has the following advantages over other countries -

- Low cost manufacturing solutions for both domestic and export market
- Strong focus on Quality - over 75 per cent of the total production of the industry comes from ISO certified and CE accredited manufacturers.
- Engineering expertise on design, CAD, documentation, testing and evaluation.
- Existence of clusters (e.g., Bangalore Machine Tools cluster or the ones at Pune or Rajkot) for developing world-class manufacturing solutions.

The industry has grown over the last 4 to 5 years due to growth in the demand for metalworking machine tools from the automotive sector, the auto ancillary industry, defense, railways, job shops and small-scale industry units. Favorable government policies like Phased Manufacturing Policy in 1980 and the Industrial Policy of 1991 abolishing industrial licensing and allowing foreign direct investment forced the industry to induct new technologies, produce new products and focus on a much higher level of quality in their operations. Product Innovation and emergence of new machine tools have been one of the significant developments in machine tool industry, i.e., from manual to hydraulic machines and now the CNC and linear models. The industry has also gained, especially in the CNC category, from the presence of a strong software sector.

Indian-made machine tools are currently exported to over 50 countries. Lathes, presses, electro-discharge machines, and machining centers forms the bulk of export orders for Indian manufacturers. These machines are preferred in the export markets due to their cost-competitiveness and focus on quality. Several clusters exist for machine tool manufacturing. They include Bangalore, Pune, Rajkot, National Capital Region, Batala, etc. With the growth in user industries, this sector is poised to grow significantly.

4.7 Some Implications

Three patterns emerge from the description of these sectors: (a) the impending growth in sectors require trained manpower; (b) growth will require investment in new technology and consequently newer skills; and (c) improvements in infrastructure will lead to enhanced focus on productivity improvement within firms. Consequently, the role of technical training becomes critical (more on this in the next section).

The growth across these sectors of interest reveal a need for preparing technical workforce whose skills match with the emerging responsibilities. Table 6 lists for different sectors the roles that technical manpower will need to play and the skills that may be required for these roles. This table is based on interviews with managers in these sectors as well as representatives of respective industry associations. It shows what is expected of technical manpower at different education levels . The figures in Appendix IV describe the generic production processes for each sector and point to the different type of skill requirements.

Skills will play a crucial role in how these sectors are able to take advantage of increased opportunities and deployment of technology. Analysis of data from 55th Round of National Sample Survey (NSS) shows that certain sectors employ more graduates or higher secondary educated workers than others (e.g., metal fabrication, electrical industry, chemicals etc. These sectors also have a higher share of technical graduates that are employed though it is obvious that Indian firms have long way to go. Interestingly, these are also the sectors that are doing well and show high potential to growth (see tables in Appendix III).

In the next section we explore further this linkage between technical education and economic growth especially the processes that firms employ in building technological capabilities.

5.0 Linkages between Technical Education and Business Growth

Firms in developing countries face tremendous market and capabilities failures especially those that are unable to become part of global supply chains. It may be noted that firms that manage to reduce these kind of failures are also able to become part of these global supply chains. SMEs, in particular, face the dilemma of investing in skills ahead of market linkages or demand or growth in business while the latter may occur due to the former. In this section we explore how skills and talent have helped in the development of business in the sectors under study.

Technical education programmes aim at the development of skills in a society. Investment in technical education programme leads to long term building of technological capabilities in product, process and practice domains. Technical education programmes train their students on design and development of new products or improvements of existing products, on machinery and equipments that define the process of production, as well as on shop floor practices (e.g., quality control, production planning etc.) that are aimed at improving the efficiency and effectiveness of production systems. It is this need for technological innovation that often drives the requirement for technical skills. Technical education programmes reduce the need for development of basic skill building programmes by each manufacturing firm thereby designing an effective way of preparing industrial workers. More importantly, it also provides for a mechanism for bringing in new skills and perspectives in the organization.

A survey of 17 firms was conducted in April 2006 to understand the demand side requirements of various skills. The respondents were owners/senior employees of SMEs who were attending an advanced general management programme at IIMA. These owners/executives came from various parts of India and represented diverse industrial sectors. In addition, we interviewed several managers in Rajkot and Ahmedabad, visited various firms (cases on a few of them are included in this section), and discussed skill requirements with various industry associations. We also interviewed heads of private and public technical education centers, head of the Directorate of Technical Education and Manpower Planning in Gujarat and the head of the National Technical Manpower and Information Systems, New Delhi.

Table 6: Skill Requirements at Various Levels in Different Sectors of Industry

Sector	Roles & Responsibilities of Technically qualified employees		Skills Required among technically qualified employees	
	ITI	Polytechnic & Engineering	ITI	Polytechnic & Engineering
Machine Tools	Production and Testing	Product Development, Quality Assurance, Designing	Casting , Forging, Fitting, Machining etc	Designing, Working knowledge of production methods & maintenance, People management skills
Chemicals	Maintenance	Research and Product Development, Redesigning processes, Chemical Analysis, Synthesis, Maintenance, Process Control	Maintenance skills Chemistry Instrumentation	Working knowledge of chemistry and various chemical reactions/processes, Chemical engineering, Instrumentation, people management skills
Auto-Components	Production, Testing	Designing, Product Development, Quality Assurance, Supervision	Casting , Forging, Fitting, Machining etc	Designing, Working knowledge of production methods & maintenance, People management skills
Garments	NA	Designing, Process Improvement, Quality Control	Cutting, Stitching	Designing skills, Working knowledge of production methods & maintenance, People management skills, Merchandizing
Agri-Implements	Production, Testing,	Product Development, Supervision, Testing & Quality Control	Casting , Forging, Fitting, Machining etc	Designing, Working knowledge of production methods & maintenance, People management skills
Construction	Field Work and Supervision	Supervision, Designing, Site Accounting, Procurement	Surveying, Structural engineering	Architectural Designing, Project management, Geology, Structural engineering, People/Process Management Skills

5.1 Links between Technological Innovation and Technical Skills

Availability of technically skilled workers facilitates innovation in products, processes and practices. We now discuss the finding of our indicative survey on evidences of linkages between technical education and innovation and consequently business growth. More important, we highlight some of the important processes that firms deploy to build these skills through our survey findings and short case studies developed for most of the sectors under study. Details of these case study firms is given in Appendix V.

The findings of a preliminary survey of seventeen firms are not statistically conclusive, yet they provide a process based explanation of linkages between technical education (via building of skills) and growth in business (via application of the skills). Figures 5 and 6 provide some information on the size of the firms sampled – they are mostly SMEs.

Figure 5: Distribution of Sample Firms by Sales

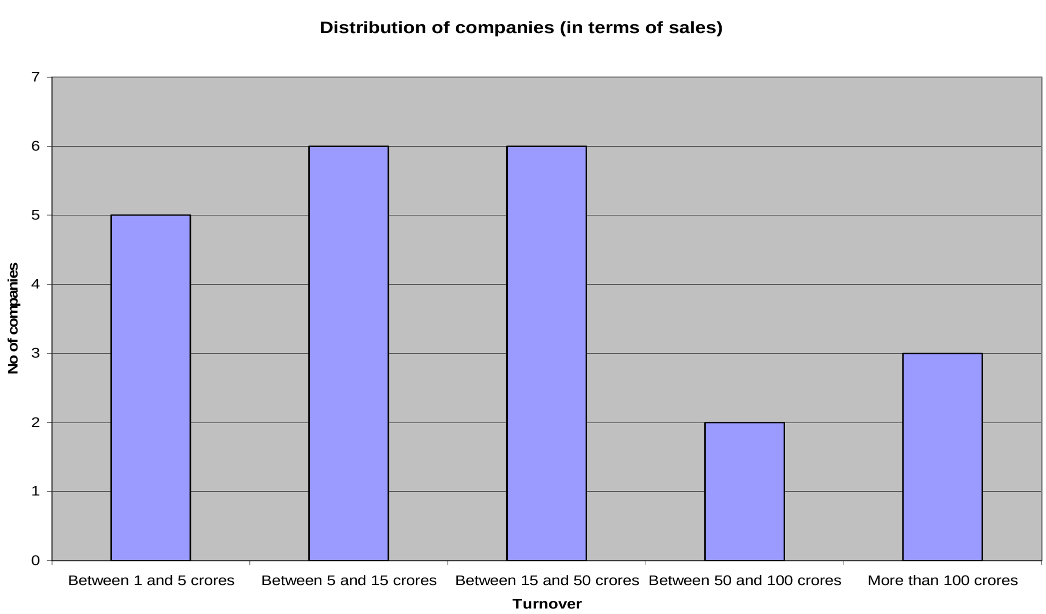
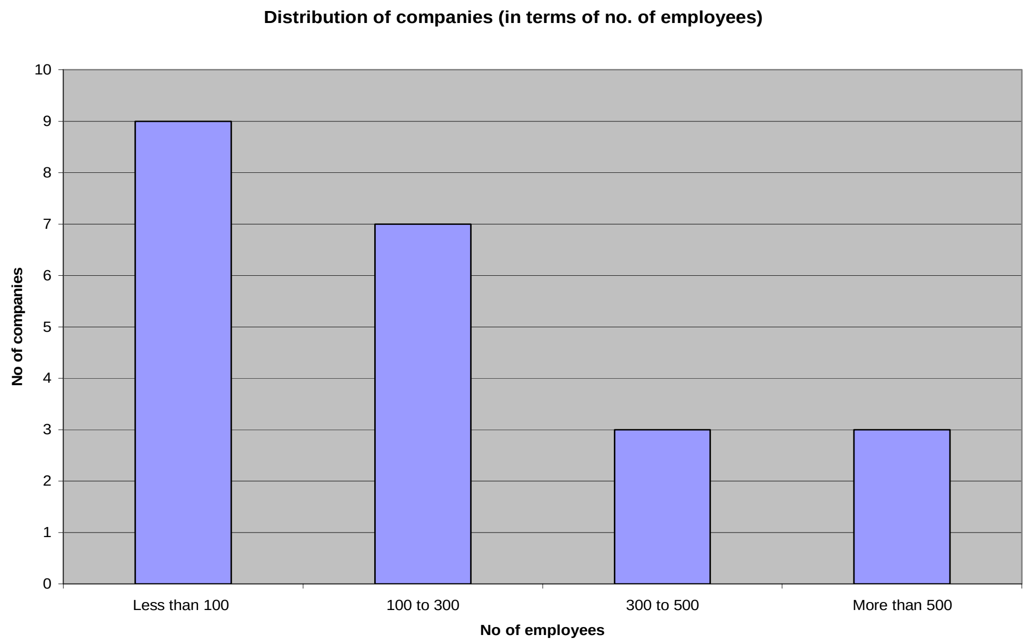


Figure 6: Distribution of sample firms by number of employees



We compute an index that we call the "innovation index" which is a measure of technological sophistication of firms. It gives us an indication of whether the firms are innovating, i.e., improving the product, process and practice related capabilities on their shop floors (though it does not indicate the extent of improvements). These in turn are related to the competitiveness of the manufacturing facility. Innovation index is a composite score of three questions that we asked the firms – whether there was an increase in the complexity of the products that the firm is producing, whether the shop floor has seen process improvements over the years, and whether the plant has adopted practices (like quality assurance, inventory control, TQM etc.). A "yes" response on any one of these questions is given a score of 1 while a "no" response gets a score of 0. So a firm, can get a maximum score of 3 and a minimum score of 0. Each of the three capabilities, product, process, and practice is weighted at 20%, 40% and 40% respectively keeping in mind the fact that SMEs mostly improve their capabilities through the practice and process routes. It can be seen from Figure 7 that as the percentage of technically skilled employees in a firm increases, the innovation index of that firm (or plant) also increases (the dotted line in Figure 7 is the best fit line). The implication is that it is through the skills of its employees that allows a firm to climb the product technology ladder (i.e., produce more complex products) or enhance its productivity by improving the processes and practices on shop floors.

We also see case based evidence of the above and the processes used by firms to build capabilities. These cases are presented in boxes below. The 3P (i.e., product, process and practice innovation) related cases also show the processes deployed by firms to strengthen their innovative capability by developing and deploying skills (see Box 1A-1C). **Hi-Life Machine Tools** or HMT (Box 1A) has successfully transited from producing hydraulic machines to CNC machines by hiring skilled workforce at each stage or bringing in appropriate skills via consultants. HMT also devotes 30 percent of its investment in training so that its workforce is able to use the technology available and innovate. It may also be noted that there are certain complementary investments (e.g., ERP system for HMT) that would be needed to take advantage of the increasing skills of the workforce – firms that do not make such investment in complementary technologies or in building practice related abilities, often, see stagnation in returns to investment in skills. Similarly, **Metro Chem** (Box 1B) has seen tremendous benefits in hiring manpower with advanced skills - chemists, chemical engineering graduates, PhD graduates and experienced people from the industry - they have helped the firm drive the research and product development efforts in their research laboratory. Experimentation in the laboratory has helped the firm reduce the problem of effluents by redesigning their processes and using by-products to produce other useful products.

BOX 1A: 3P Cases-Product Innovation at HMT

Hi-Life Machine Tools (HMT) was incorporated in 1974 as a small job-work manufacturing firm in engineering tools. Presently they are an ISO 9001 – 2000 company with an annual turnover of Rs 5 crores. They produce three varieties of grinding machines including the Special Purpose Machines (SPMs) and are the largest exporters of grinding machines from India.

Product Innovation and emergence of new machine tools has been the key development in the machine tool industry. HMT established itself in manual grinding machines. However, with the changing needs of the customers the company gradually started the production of Hydraulic Machines and now it produces CNC machine tools (due to better productivity, higher precision and increased reliability).

HMT identified the need for technical skills during each phase of the transition and acted on the same. They hired mechanical and electronics graduates from reputed engineering colleges as well as industry – for product development, Quality Assurance, Designing etc. They also sought help from professional agencies and external consultants in PCB design for the CNC machines. Currently, they have 105 employees which include 12 engineers and 25 ITI graduates. They realize the importance of technical education and maintain constant focus on the skill development and training of the employees. Most the new recruits from colleges are sent to professional agencies like Indo German Tool Room, Ahmedabad and Siemens Training Center, Mumbai for advanced training. About 30% of their investment goes into training of employees and another 30% into process improvements and technological up-gradations (e.g., implementation of an ERP package).

HMT endeavors to be a market leader by further product innovations (i.e., between 6 and 8 inch machines) through constant technological enhancements and by leveraging their technically qualified workforce. They wish to acquire the Linear Model for CNC Machine tool manufacturing which is considered to be the future of such machines.

BOX 1B: 3P Cases-Process Innovation at Metro Chem

Metro Chem started its operations in 1976 with the manufacturing of Chemicals & Dyestuff. They had setup 3 more units by the end of 1984 and started exporting in 1986. Currently they have a turnover of Rs 200 crores which include. Seventy percent of turnover comes from exports to 30 countries.

During 1980s the industry was grappling with the problem of poor quality of products (due to insolubles), high costs (due to wastage) and pollution (due to effluents). Metro Chem thus identified the need for building technological competency and set up its independent Research Lab (Chroma Laboratories) in 1989 to cater to the R&D needs of the company. Spray-Dryer technology based on membrane filtration was a breakthrough development in the sector which helped Metro Chem achieve better yields and improved control of the the quality of the products..

The company hired chemists, chemical engineering graduates, PhD graduates and experienced people from the industry to drive the research and product development efforts in their research lab. Research inputs from the laboratory have helped the company in many ways. They were able to reduce the problem of effluents by redesigning their processes and by using the by-products to produce other useful products. This helped in reducing the wastage and also the environmental hazards of the effluents. Metro Chem promoted trial & experimentation philosophy to troubleshoot the problems of quality. They developed many new products and solved many problems of synthesis through process improvements.

The company currently hires graduates from engineering colleges and Universities for different roles – Electrical/Mechanical Maintenance, Production Engineering, Synthesis work etc. The company perceives a significant difference between a technically trained person and an uneducated (but experienced) worker. They find that a lack of education acts as a barrier in achieving higher productivity and efficiency. The company understands the importance of technically skilled employees and maintains focus on their training needs through formal skill development programs and seminars. Sometimes they also seek technical help from external agencies and consultants from the National Chemical Laboratories and UDCT.

In the wake of growing competition from China and other domestic producers, the company foresees an increased role of R&D and technological competencies to provide a sustainable competitive advantage.

BOX 1C: 3P Cases-Improvements in Practices at Amul

Amul Industries started its operations in 1998 with the manufacturing of connecting rods for OEMs. Gradually the company started manufacturing crankshafts, auto-components and other components for the industrial market. Presently, the company with its three manufacturing units in Rajkot has a total turnover of Rs. 100 crores and is exporting to countries like Germany, US & Italy. Amul Industries also has a large domestic customer base (OEMs) including TATA Motors, Mahindra & Mahindra, and Ashok Leyland.

Most of the Indian OEMs had stringent requirements from their suppliers in terms of – Raw Material Control, Process Control, Quality Assurance, and Assurance on Deliveries. OEMs from abroad also emphasized process and raw material control along with their own specific Quality standards. The requirements from these firms have driven the technological up-gradation process at Amul Industries. The company installed a separate CNC manufacturing unit for connecting rods in Rajkot to cater to the high end needs of some of its customers. They also set up a modern state-of-the-art forging unit in Pune to ensure the quality of forged parts. The decision of setting up a forging unit in Pune was primarily driven by the availability of skilled workforce in that region. The company is ISO 9001 & QS 9000 certified and has adopted many best practices over the last few years, including Inventory management, Kanban system for deliveries and up gradation of Quality check norms.

These technological changes have driven the need for technically skilled people in the company. The company currently has a workforce of 600 employees out of which 200 are technically skilled. The employee strength has increased by more than 50% in the last three years and most of the people hired in this period were ITI / engineering graduates or experienced people. They have been maintaining a constant focus on skill enhancement of the employees through formal training sessions (on User control plans, SPC etc) or through on-the-job training under a skilled worker. They also recruit students on short-term projects and internships from Engineering colleges / ITI and provide them actual shop floor experience. These students are later hired by the company.

The company has recently upgraded its manufacturing facilities and envisions a greater need for technical skills in the future (due to OEM requirements). They look forward to a greater intake of technically skilled people from the industry and educational institutes in the coming years.

AMUL Industries (BOX 1C), on the other hand, is a classical example of a firm that had to relocate its forging facilities from Rajkot to Pune because of paucity of appropriately skilled workforce in Rajkot. Business moves where they can find skilled people as they contribute more towards its growth through their knowledge. (In India, areas with large repository of skilled people, e.g., National Capital Region, Mumbai-Pune corridor, Bangalore, Chennai etc. have seen tremendous growth in the number of firms setting up businesses as well as economic development. It should not be a surprise that these areas also have large concentrations of technical institutions.) AMUL realizes the significance of technically skilled employees as the drivers of growth and competitiveness of the firm. They have been maintaining a constant focus on skill enhancement of the employees through formal training sessions (on User Control Plans, SPC etc) or through on-the-job training under a skilled worker. The company is ISO 9001 & QS 9000 certified and has adopted many best practices over the last few years, including Inventory management, Kanban system for deliveries and up gradation of Quality check norms – all of which have helped to make it a successful firm.

Interestingly, sample firms with higher innovation index also exhibit higher percent increase in sales (see Figure 8). Firms that are higher on the technology complexity ladder or that implement process and product improvement programmes see an increase in their sales turnover – such firms secure higher premium on their products and are able to develop and produce products at lower costs and through improved processes. As we saw earlier that firms that have a higher percent of their employees with technical skills are also higher on innovation index. Hence, a positive relationship appears to be existing between percent of skilled employees in a firm and an increase in sales turnover. It is not surprising that in almost all of our case studies we found firms increasing the number of hires with technical skills as well as an increasing focus on in-company training.

Firms hire technical manpower for a variety of reasons. As is apparent is the case of **Artex Apparel** (Box 2), market demand is perhaps the biggest driver of skill acquisition. Survival in a stagnating market or potential for growth in a changing scenario (e.g., the phasing out of MFA opened up new markets for Indian textile firms) drive business in the direction of skill upgradation – sometimes for helping firms manage their enterprise better and sometimes to meet

Figure 7: Innovation Index Versus Increase in Technically Skilled Employees (as % of total employees)

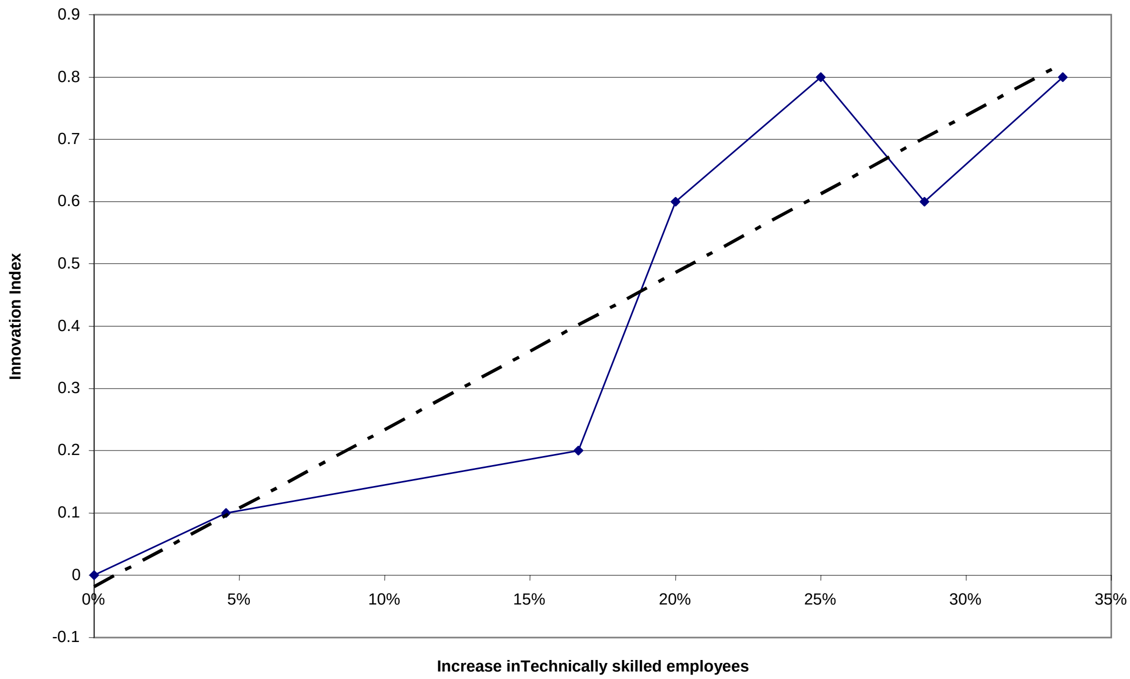
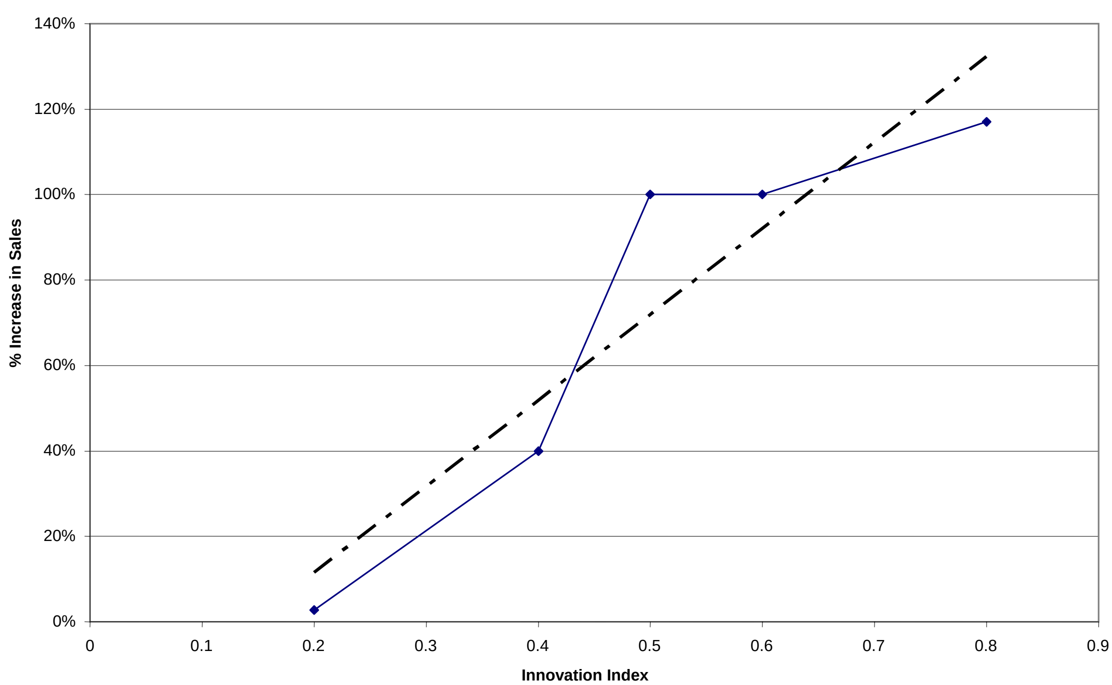


Figure 8: Percent Increase in Sales as Percent of Innovation Index



BOX 2: Artex Apparel

Artex Apparel, an ISO 9001:2000 certified, international garment manufacturing and exporting company was established in 1981 by a commerce graduate. The second partner, a textile trader, joined the company in 1989. With a vision to be the most trusted global brand for kids wear, Artex has been investing in advanced technology and has been expanding since then. The turnover of the company exceeds Rs 150 million (90% of which comes from exports). The company exports to large retailers in US, EU and Middle East. It also undertakes job work for some private labels in order to optimize the utilization of its capacity. Known for its quality products, it has received quality award for children wear from the Prime Minister of India.

The company manufactures garments in denim and cotton, chiefly for children. It also manufactures in small proportions bags, caps etc. It employs about 750 people including 6 designers from National Institute of Fashion Technology (NIFT), 4 garment technologists and a few textile engineers. However most of the labourers are literate but without any technical qualification.

The company started hiring the technically qualified people from year 2001 onwards, primarily due to the exponential growth the company was experiencing. Following were the major drivers for recruitment of the technically qualified people:

- To allow the entrepreneurs to focus on managing the business and address the strategic issues while leaving the day to day operations to skilled employees
- A strong belief that technically qualified people help to make better product with good designs using latest techniques
- A strong belief that garment technologists and textiles engineers could improve the processes and techniques of production

The company maintains that its specialized team is its biggest asset and that it has been able to achieve success due to investment in human capital. Further, due to the help of technically skilled employees, the company has been able to decentralize its operations having established separate divisions for administration, merchandising, designing, production, marketing, sourcing and other functions involved in the garment business.

Training is continuous and in house for new employees. It starts with simple jobs and then gradually increases in complexity in order to train them for various specialized jobs and machines. Most of the employees are capable of working on multiple machines requiring different skill sets. Recently, a consultant (a professor from NIFT) has been hired to monitor the progress of these trainees once every week and help them with the development of skills and competencies. The company also sends its designers to markets within the country as well as abroad in order to understand the trends and changes first hand. Company states that though these graduates do not have practical exposure and knowledge of t the industry, they have basic knowledge about their trade and have a good grasping power.

Students from NIFT, engineering colleges and some other institutes keep visiting the company for projects. Currently, the company does not hire from Industrial Training Institutes (ITIs) as their graduates do not have enough knowledge about garment manufacturing. However, with the garment courses being started by the ITIs, it is expected that soon they will recruit from the ITIs.

the technical requirements of the customer. Firms like Artex see the advantage of engaging with technical institutions for this purpose – a linkage that provides both better trained employees but also inputs on a variety of technical problems. Interestingly, most firms (especially small family owned enterprises) tend to appreciate the value of skilled workforce only after they attain a certain turnover. Very few startups, especially amongst the small manufacturing sector have a group of well trained employees to start with. The problem lies in various domains – lack of availability of risk capital to develop an innovative idea appropriately, small firms struggling to meet their livelihood while trying to grow and hence their reluctance to invest in technical manpower, and lack of interest amongst technically trained graduates to work for small firms etc.

Firms, especially in developing countries, face market failures as well as capabilities failures. Market failures are well appreciated in economic and management practice. Capability failures, on the other hand, are often more nuanced. They relate to the inability of firms to build distinctive capabilities through which they could compete in the market (especially global markets). These may relate to inability to design and manufacture competitive products or inability to stabilize or improve existing processes (via stretching or upgrade of equipment or developing better processes) or inability to implement managerial practices needed to manage plants effectively and improve productivity. Skills of employees and presence of skilled employees are essential for overcoming the capability failures of firms. One can also argue that firms that have higher and diverse skill sets are more likely to understand the drivers of market failure (i.e., through better information, better analysis of markets and customer needs, better linkages with potential customers and suppliers etc.) and hence reduce the occurrence of market failures for the firm.

Sample firms seem to be appreciating this linkage between capabilities/market failures and skills. They find several reasons for hiring skilled technical employees. Table 7 gives their response on advantages of hiring skilled manpower (they are in no specific order). As can be seen from these responses, these benefits are of the following nature:

(a) Hiring young talent that is job ready: helps in making the employee productive early on in a firm that allows it to earn returns on wages sooner;

(b) Talent that brings in New Skills: allows the firm to develop new products, improve new processes or implement newer productivity enhancing practices; it may help the firm to replace less effective practices with better ones; many firms deploy new skills for winning new customers/markets or newer products;

(c) Facilitate adoption of New Practices and Technologies: helps in implementing new technologies or practices that require advanced skills;

(d) Help Improve Productivity and other Parameters of Competition like Cost, Quality, Delivery, Customer Service, Innovation: enables firms to implement new shop floor improvement programmes as new skilled employees often bring such an experience

(e) Requirement of formal training is less: helps in reducing the cost of in-house training – this is very crucial when the firm is small;

Table 7: Advantages of Hiring Skilled Technical Employees

They learn faster and adapt better
Easier in adopting any new technology into your business
Easier to incorporate best management practices because of the background (they are used to working in organized manner)
Bring Innovation
Better Efficiency and Lower costs
Better productivity
Reduction in wastage/ down time
Better Customer Satisfaction
Improved productivity
raise quality standard
waste minimization
More productivity
Less training cost
less employee turnover
Better Productivity
Less wastage
High quality

As a big picture, what is obvious is that skilled workforce allows firms to service customers better (i.e., through improved cost, quality, delivery and flexibility performance) and also service better customers (i.e., those that provide bigger orders or those that demand higher quality products & services or those that seek high value added inputs and consequently pay premium). They allow firms to win orders from new customers and retain old ones. The case of Artex Apparel is instructive. It underscores the drivers for skill building and processes that firms deploy to acquire them.

As we saw earlier in Table 6, firms in different sectors perceive requirements of specific skills a bit differently. However, the managers surveyed feel that skilled manpower bring in certain generic skills that are important for running businesses effectively. Technically educated people at different levels of education carry differential strengths. Most firms cutting across industrial sectors find the following generic skills in technical graduates to be essential (based on our survey and interviews with firms and industry associations) for business growth and development:

- Learning ability
- Eagerness to learn and work
- Fundamentals of engineering
- Use of computers
- Product development abilities
- Communication skills & teamwork
- Knowledge of labour laws and industrial relations
- Knowledge of safe working practices

Table 8: Formal Education and Skill Rating by Sample Firms

	Learning ability	Eagerness	Fundamentals of Engineering	Use of Computers	Product Development Abilities	Communication and Team work	Knowledge of Labor law and Industrial relations	Safe working practices
Engineering and Polytechnic								
Average	3.4	3	2.86	2.94	2.44	2.87	2.27	2.53
Std Dev	0.83	0.5774	1.29	1.18	1.21	1.19	1.22	1.13
ITI Graduates								
Average	2.82	3.09	2.45	2.36	2.36	3.00	2.17	2.83
Std Dev	0.60	0.70	1.13	1.29	1.43	0.85	1.11	1.19

Note: Firms rate different programmes on various skill types on a scale of 1 to 4

In our survey of seventeen firms, we found that firms rated skills at varying levels for graduates from different category of technical education programmes. It can be seen from Table 8 that sample firms rate graduates from engineering & polytechnic programmes higher than the graduates of ITIs on their ability to learn, fundamentals of engineering, use of computers, product development abilities and knowledge of labour laws and industrial relations. This reflects a higher level of training and prior preparation amongst engineering graduates and the roles that they play in plants (supervisory, design and managerial) vis-à-vis the ITI graduates who are essentially trained as operators. In this context, the case of a machine tool manufacturer in Jamnagar (in Gujarat, India) is instructive. This one producer manufactures low end manual lathes for local market (i.e., sold to firms located within a radius of 100 kms). He designs his machines himself. Over the years, he has provided more flexibility to his machines (based on consumer demand) – machine that does drilling and metal cutting, machine that does drilling at various angles, metal removal and some boring etc. He sells these special machines to local producers who require low cost options. These machines, however, are "origami in metal" and suffer from poor precision, stability and have short life due to poor design and usage of low quality material. The producer-designer does not have any formal education and is now facing complaints on his "constantly failing" machines even in local market. He is obviously unable to find customers in large production centres. For the first time, the producer has hired a young polytechnic trained engineer to develop custom designs using a CAD package that he has recently purchased thereby deploying principles of good design in his newer machines. He is aspiring to train his son as an engineer as he now appreciates that with his style of designing and production, his firm will not survive the next decade as it will require more advanced skills to produce robust products. This transition on the skill trajectory has become the key factor for the growth of firms.

BOX 3:'CAPTAIN' Minitractor

Asha Exim Pvt. Ltd, established in 1995, has a manufacturing facility in Rajkot. The agro engineering products of the company are marketed under the brand "CAPTAIN" which stands for 'Commitment for Agro Engineering Products with Technique and Innovation' – a motto by which the two entrepreneurs have conducted their business. Belonging to a family of small farmers, they were aware of the hurdles and limitations of the small farmers and realized that only mechanization in farming can enable the farmers to progress faster.

This led to the two founders to design an all season, multi-purpose tractor. The entrepreneur who developed the tractor did not have any technical education. They hired the services of expert consultants to design the tractor according to the needs of the farmers. It took three years for the company to develop its tractor (1998-2001) and get a certification of worthiness from the Central Institute.

Sensing a need for in-house technical expertise in order to design and further develop the tractor and agri-implements, the company has hired technically qualified people over the last five years. The company now employs over 50 people including 1 design engineer, 3 Diplomas in Mechanical Engineering (DME), 25 diesel mechanics, and 10 Industrial Training Institute graduates. The design engineer is chiefly responsible for introducing changes in the design of the tractor and its allied implements, while the DME graduates are involved in the testing and quality control of the products. The ITI graduates and mechanics are involved in the assembly and manufacture of the tractors and it allied implements.

Because of the skilled workforce, the company has been able to make continuous changes in its products and introduce newer implements to complement the tractors. Due to the technically skilled manpower at its disposal, the company is currently working on a newer model of the tractor, with multiple power ranges, akin to the larger tractor. No external help has been sought for the development of the current model, indicating the maturity and the expertise of the company. The entrepreneurs cite the skills of its designers and DME employees as key to the development of the tractors and numerous implements it has produced over the years.

The company is a pioneer in the small tractor category in India. The company's claims that its tractors are fuel efficient and require less maintenance have been validated both by the government rating agencies and the farmers. Currently the company sells more than 350 tractors annually.

The example of Captain Mini Tractor is also quite similar as the machine tool designer of Jamnagar. However, it shows how the firm has been able to increase its production quantity and the quality of the product by inducting technical graduates in their workforce.

These cases show that the framework for lifetime learning includes training within technical education system and outside, i.e., within the boundary of the firm. Three key processes play an important role in strengthening this linkage between technical education and industrial development – a strong public-private partnership to develop a network of technical institutions, close interaction with industry to maintain the relevance of the training and to introduce new skill trades, and a cost-effective process to deliver life-long training. Firms benefit from public investment in technical education. Their ability to appropriate the benefits depends to a large extent on the strength of the processes mentioned above. However, development of sustained growth also requires investment in training within the firm.

6.0 Conclusions

Growth of business is dependent on building of distinctive capabilities in a variety of domains – products, processes and managerial practices. And capabilities are built on the foundation of good education, strong networks (many of which are formed amongst alumni of educational institutions), and intelligent policies. In this paper we have argued that technical education plays a crucial role in building these capabilities and consequently in the growth of industry. We use the case study of the Indian technical education system to explore the nature of the technical education system, mechanisms used to govern it, linkages between the education regime and the industry, and the roles that different stakeholders play in ensuring that such a regime delivers sustained advantage to the society.

A few crucial observations emerge from this case study: (a) the Indian experience in developing and regulating technical education has had an immense impact on the development of public and private enterprises in the country; (b) the key advantage of this regime has been the development of very diverse capabilities in manpower thereby helping India diversify its industrial base; (c) the system to regulate the technical education has to be less rigid, more entrepreneurial, more decentralized, one that provides upward mobility within training programmes – in here, the Indian system has been found wanting especially in later years of its establishment; (d) notwithstanding the earlier comment, Indian industry has developed chiefly on the backbone of its widely trained manpower base and despite numerous policy constraints over the years; and finally, close linkage between industry and academia has been beneficial to both the stakeholders. Industry has used a variety of mechanisms for engaging with the technical education regime.

More specifically, the IGTR model of training manpower is worth emulating across the country. Flexibility in choice of the same trade at different levels (say after class 8 as well as after class 10) will offer more opportunities to potential students. The experience of the Product Development and Testing Centres (PDTC) has been mixed – private management of such public centers would be helpful in enhancing the capabilities of tiny enterprises. The government may have to consider technical education as an infrastructure sector. In addition, firms and industry association may have to play a more pro-active role in the development of manpower if they are to grow in this competitive setting.

With liberalization, the challenges in the Indian economy have grown manifold as have opportunities. Firms realize that innovation and technology management are crucial for sustained growth – form some sectors this implies improvement in basic managerial practices to become part of the organized sector (e.g., construction or garments), for others it has meant integrating new technological processes and delivering new technology in their application industry (e.g., agricultural implements and machine tools), while for some it has meant working on the frontiers of knowledge and industrial change (e.g., chemicals and auto-components). All of the above require a large scale deployment of new skills, perspectives and managerial frameworks to allow them to compete in a global market. A large pool of technically trained manpower that is also adept in social processes to manage in local environments become a crucial necessity.

APPENDIX I: Data on Technical Education

Panel A: State-wise Budgeted Expenditure on Technical Education in India (2003-2004)

States/Uts	Technical Education		Total expense on Education
	Total	%age	
Andhra Pradesh	939847	2.09	44961127
Arunachal Pradesh	0	-	1466538
Assam	280943	0.96	29181222
Bihar	431459	1.23	35125349
Chhatisgarh	235833	2.08	11326978
Goa	197406	7.58	2604256
Gujarat	1137018	3.36	35368320
Haryana	543187	3.44	15803710
Himachal Pradesh	84251	0.86	9779259
Jammu & Kashmir	235312	2.63	8963823
Jharkhand	492129	4.02	12256568
Karnataka	853237	2.27	37524047
Kerala	1420714	5.00	28387861
Madhya Pradesh	1069810	4.2	25493032
Maharashtra	2372926	2.82	84267844
Manipur	30955 00	1.13	2728493
Meghalaya	159600	6.55	2438493
Mizoram	59258	3.42	1731996
Nagaland	111528	5.23	2132777
Orissa	191584	1.01	19055981
Punjab	262520	1.29	20423719
Rajasthan	390634	1.04	37688806
Sikkim	12900	0.97	1332550
Tamil Nadu	1256496	2.56	49142046
Tripura	38965	0.83	4567743
Uttaranchal	367151	3.37	10894530
Uttar Pradesh	1397491	2.24	62272969
West Bengal	745098	1.59	46901116
States	15368252	2.39	643921153
Andaman & Nicobar Islands	46400	5.01	925500
Chandigarh	167800	10.94	1533155
Dadra & Nagar Haveli	11300	6.17	183200
Daman & Diu	15400	8.62	178600
Delhi	624767	4 .89	12768361
Lakshadweep	0	-	189000
Pondicherry	140103	10.48	1336785
Union Territories (UT)	**1005770**	**5 .88**	**17114601**
India	**16374022**	**2.48**	**661035754**
Total Centre	**15449200**	**15.67**	**98611800**
Grand Total	**31323222**	**4.19**	**759647554**

Panel B: Number of ITIs and ITCs by States and Number of Seats (2002-03)

Name of States/UTs	Number of Govt. ITIs	Seating Capacity	Number of Pvt. ITCs	Seating Capacity	Total ITIs/ITCs	Total Capacity
Haryana	78	13189	24	1428	102	14617
Himachal Pradesh	48	4913	5	388	53	5301
Jammu & Kashmir	37	4124	0	0	37	4124
Punjab	106	13999	32	1852	138	15851
Rajasthan	89	8752	21	1420	110	10172
Uttar Pradesh	181	38228	100	9284	281	47512
Chandigarh	2	936	0	0	2	936
Delhi	14	8948	36	1572	50	10520
Uttaranchal	35	5112	15	1544	50	6656
Andhra Pradesh	90	23631	479	85386	569	109017
Karnataka	106	18636	401	27456	507	46092
Kerala	68	13912	465	43593	533	57505
Tamil Nadu	67	21276	604	60112	671	81388
Lakshdweep	1	96	0	0	1	96
Pondicherry	7	1256	7	424	14	1680
Arunachal Pradesh	2	368	0	0	2	368
Assam	24	4536	3	84	27	4620
Bihar	28	10256	13	2712	41	12968
Jharkhand	14	2564	13	1380	27	3944
Manipur	7	540	0	0	7	540
Meghalaya	5	622	2	304	7	926
Mizoram	1	294	0	0	1	294
Nagaland	3	404	0	0	3	404
Orissa	27	6320	129	11476	156	17796
Sikkim	1	140	0	0	1	140
Tripura	4	400	0	0	4	400
West Bengal	48	11564	13	740	61	12304
Anda. & Nico. Island	1	204	0	0	1	204
Goa	11	2492	4	420	15	2912
Gujarat	129	60396	98	12666	227	73062
Madhaya Pradesh	130	19186	20	1884	150	21070
Chattishgarh	73	8248	54	6072	127	14320
Maharashtra	347	64662	266	28924	613	93586
Dadra Nagar Haveli	1	228	0	0	1	228
Daman & Diu	2	388	0	0	2	388
Grand Total	1787	370820	2804	301121	4591	671941

Source: http://dget.nic.in/schemes/cts/NumberOfITIs.htm

Panel C: State/Region-wise Number of Approved Under Graduate Degree Engineering Institutes and Total Intake in India

Regions	States/Uts	2002-2003	
		Number	Intake
Central	Madhya Pradesh	45	12970
	Chhatisgarh	12	3385
	Gujarat	25	9559
	Total	**81**	**25914**
East	Mizoram	1	120
	Sikkim	1	420
	West Bengal	45	10709
	Tripura	1	160
	Meghalaya	1	135
	Arunachal Pradesh	1	210
	Andaman and Nicobar Islands	0	0
	Assam	3	720
	Manipur	1	150
	Nagaland	0	0
	Orissa	38	9505
	Jharkhand	7	1890
	Total	**99**	**24019**
North	Bihar	7	1575
	Uttar Pradesh	83	22491
	Uttaranchal	9	2290
	Total	**99**	**26356**
North-West	Chandigarh	3	580
	Haryana	33	9385
	Jammu and Kashmir	5	1245
	New Delhi	13	3540
	Punjab	33	8875
	Rajasthan	29	7807
	Himachal Pradesh	3	610
	Total	**119**	**32042**
South	Andhra Pradesh	215	64300
	Pondicherry	6	1950
	Tamil Nadu	250	79122
	Total	**471**	**145372**
South-West	Karnataka	111	40385
	Kerala	73	17858
	Total	**184**	**58243**
West	Maharashtra	151	47035
	Goa	3	740
	Daman & Diu, Dadra & Nagar Haveli	0	0
	Total	**154**	**47775**
	India	**1207**	**359721**

Source: http://www.indiastat.com/india/ShowDataSec.asp?secid=208511&ptid=207092

APPENDIX II : INDO-GERMAN TOOL ROOM, AHMEDABAD: A CASE STUDY

The Indo-German Tool Room, Ahmedabad (IGTR) was established by the Department of Small Industries, Government of India. Land and other infrastructure was provided by the Government of the State of Gujarat while the Government of Germany provided machinery and expert manpower who helped setup the operations of the centre and subsequently transferred the technology and expertise to their Indian counterparts.

Objectives

The objectives of the IGTR is to

- Provide training in Tool & Die Technology, CAD/CAM Solutions & CNC Technology
- Undertake design development and manufacturing of quality Press Tools, Moulds & Dies, Gauges, Jigs & Fixtures
- Provide consultancy for Product Development, Productivity & Quality Improvement

The centre has a "training center" to help achieve the first objective – it is committed to develop human resources to cater to the needs of metal, plastic and service industries in the area of tool technology and CAD/CAM/CAE. The "production center" at the institute aims to fulfill the second objective. It follows the dual German philosophy of ***"learning by doing and doing while learning"*** to enable trainees to become productive from day one on their jobs.

Courses

Training courses vary in duration from 6 months to 4 years with varying levels of entry qualifications as given below:

1. School drop outs - 6 month duration
2. 10th pass/certificate – 2 years training plus one year in production centre
3. Diploma – 4 year duration, graduates also eligible for BE admission
4. Post diploma – 1 year duration for CAD/CAM and tool design capability
5. Post graduate – specialization in tool design with 1 year plus 6 months internship

The institute plans to start a Master's and Doctoral level programmes in tool design after 2007 and its plans to seek a a deemed university status by 2009-10. For all its courses, the institute undertakes its own entrance exam followed by an interview in order to select the students.

Training Process

Other than having a training and a production centre within the same campus, it is a unique institute which is considered as a profit centre. In 2005-06, the institute earned enough revenue to cover about 87% of its costs. With 83 skilled expert instructors, the institute trained about 600 students in the last academic year. It is equipped with modern class rooms and a library. Additionally, it offers hostel accommodation, canteen services and sports facilities.

The training process primarily involves working in the workshop or production centre. About 80% of the training is devoted to practical experience while the remaining 20% comprises theoretical inputs, personality and communication development courses. The number of seats in any course depends on the machines available. The institute follows the strict norm of having one student per machine so as to give proper and complete training to its students.

Over the years the training has become more practical with students making presentations and one on one interaction with the trainers. Periodical assessment is done to evaluate the skills gained by the students as wells as on the behaviour of the trainee on the job.

Unique Experience

Since the students work in the production centre as a part of their training, the uniqueness lies in the fact that the industry is training the students by giving jobs to the production centre. It is based on the German model where industrial houses and companies train the employees and not the government. This leads to students being job ready and productive from day one, by working on the latest machines.

After training in the training centre they are placed in the production centre for on the job training for a period of about six months. Students are involved in all stages of customer engagement, from requirement gathering to the final product delivery, which forms a part of the curriculum.

Industry Interaction

The institute also runs an induction programme for new employees various firms in the area of CAD/CAM. In order to meet the increasing demand for CAD/CAM operators, the Institute has developed a special focus in that area. Currently the institute has more than 100 CAD/CAM workstations spread across 5 design laboratories.

Since the awareness of the institute is not as expected, it has recently started to promote itself through newspapers, school trips, sending people to various educational institutes and making presentations about the institute.

Curriculum and Autonomy

The curriculum was first designed in 1994 with professionals from industry, HR managers and IGTR faculty. It was based on the kind of positions/skills required by the industry. Every 3 years the curriculum is updated based on the current industry needs by a committee comprising of 2 professionals from industry, 2 from academia, 2 from IGTR and an HR manager from industry

The eligibility norms for the students are decided by AICTE, while the selection criteria for the faculty are decided by the recruitment committee of the institute. Further, the institute has the mandate to alter the content of the entrance exam based on the needs of the courses. It does not experiences any interference from government agencies in the day to day operations of the institute. It generates its own revenue to meet the expenses primarily from production and training activities. Annual expenditure of the institute is around Rs 35-40 million, most of which is generated internally. Every year IGTR invests around 2 crores in capital expenditure through a grant from the government.

Faculty Development

To keep up with the requirements of the industry, the institute identifies the training needs of the faculty every six months. It spends around 2% of its revenue on the up-gradation of skills of its faculty. Most of the technical training is conducted within the institute while outside expertise is sought for behavioural inputs. Entrepreneurship is promoted among the faculty by encouraging them to take up the projects on their own. Faculty visit the industry, spot the problems and then bring it to IGTR to solve them.

Placements

About 90% students of the institute get placed during the Feb-July season. The remaining students opt for self-employment or further studies. The pay scales of the graduates vary from Rs 2000 to 12000 per month based on the skill sets of the students.

APPENDIX III: ANALYSIS OF NSSO DATA

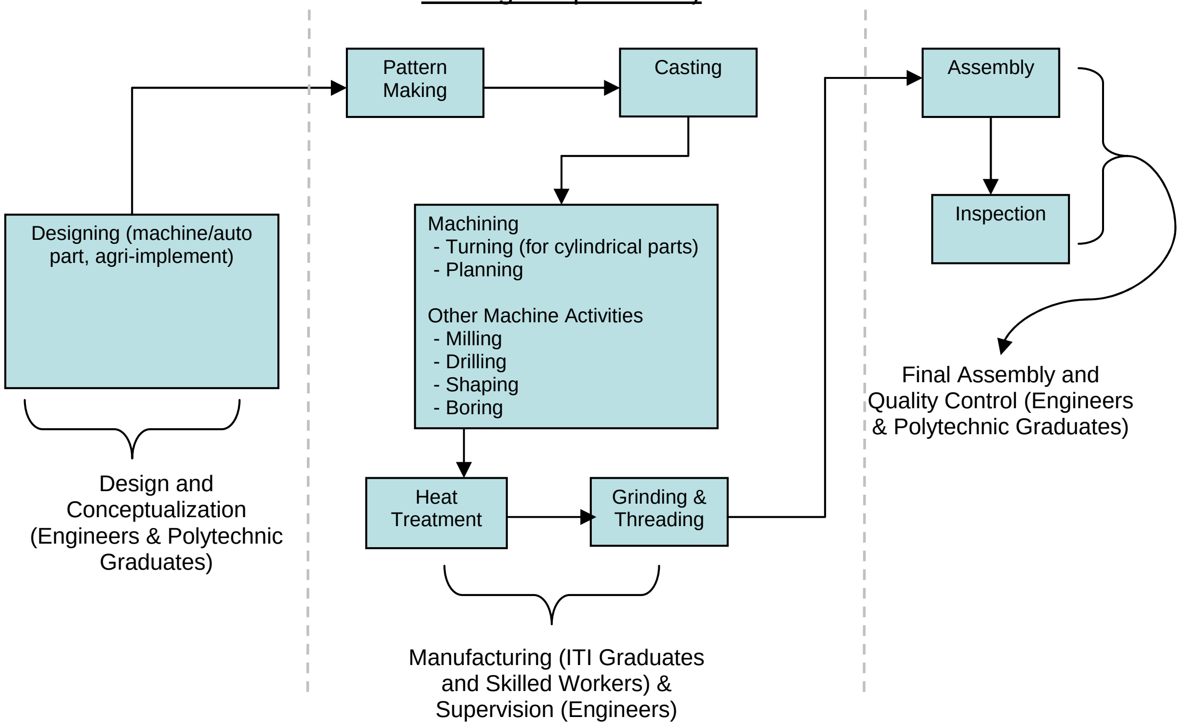
Panel A: Distribution of Workers in Different Industry Groups by Levels of Education, 1999-2000								
Industry Group	**Illiterate**	**Below Primary**	**Primary**	**Middle**	**Secondary**	**Hr. Secon**	**Graduate**	**Total**
Total	23.7	14.2	16.8	20.3	13.6	6.2	5.4	100.0
Food & Beverages	30.0	13.6	14.9	17.4	12.8	6.2	5.2	100.0
Spinning Weaving & finishing Textiles	27.7	16.6	18.3	18.7	11.1	4.9	2.8	100.0
Knitting, Crocheting etc.	11.2	17.6	26.0	17.1	19.2	3.3	5.7	100.0
Apparel excluding fur	13.2	12.7	19.8	30.1	17.4	3.6	3.2	100.0
Soaps & detergents	6.0	8.1	8.1	25.7	15.2	19.7	17.2	100.0
Other chemical products nec	24.9	11.8	15.9	18.0	15.0	9.1	5.2	100.0
Plastic products	8.9	14.9	17.3	10.2	26.8	10.5	11.4	100.0
Other fabrication – Metal	2.2	5.5	11.9	27.0	19.0	13.5	20.9	100.0
Domestic Appliances nec	3.7	17.8	13.8	33.0	11.4	13.0	7.5	100.0
Electric motors, generators	8.5	0.0	0.0	8.5	12.3	39.9	30.8	100.0
Electric lamps & lighting equipments	3.8	22.4	22.7	30.5	9.8	8.7	2.1	100.0
Medical, Surgical & orthopedic	17.7	13.6	17.2	22.3	16.7	5.8	6.6	100.0
Watches & Clocks	32.4	13.9	15.3	13.1	10.4	5.0	9.9	100.0
Coach work for Motor vehicles	25.4	22.9	20.0	11.9	6.3	3.3	10.3	100.0
Transport equipments	24.9	11.0	14.1	30.0	5.9	6.7	7.3	100.0
Manufacturing nec	76.7	1.3	0.0	20.5	1.5	0.0	0.0	100.0

Panel B: Distribution of Workers in Different Industries by Technical Education, 1999-2000						
Industry Group	**No Technical Education**	**Technical Degree**	**Diploma in Agriculture & Others**	**Diploma in Engineering & Medicine**	**Diploma Crafts**	**Total**
Total	97.2	0.3	0.9	1.2	0.3	100.0
Food & Beverages	97.8	0.2	0.9	0.9	0.2	100.0
Spinning Weaving & finishing Textiles	97.9	0.3	0.6	1.1	0.1	100.0
Knitting, Crocheting etc.	96.3	0.3	0.9	2.1	0.4	100.0
Apparel excluding fur	97.1	0.1	1.9	0.2	0.7	100.0
Soaps & detergents	95.8	0.1	0.6	3.1	0.4	100.0
Other chemical products nec	94.8	1.4	1.1	2.3	0.4	100.0
Plastic products	93.5	1.0	0.5	5.0	0.0	100.0
Other fabrication – Metal	81.1	1.9	3.4	13.6	0.0	100.0
Domestic Appliances nec	97.6	0.0	1.4	0.7	0.2	100.0
Electric motors, generators	85.4	4.4	5.9	4.4	0.0	100.0
Electric lamps & lighting equipments	94.4	1.0	0.0	4.6	0.0	100.0
Medical, Surgical & orthopedic	98.9	0.0	0.1	0.5	0.4	100.0
Watches & Clocks	96.8	0.4	1.6	1.2	0.0	100.0
Coach work for Motor vehicles	95.1	1.8	1.2	1.5	0.4	100.0
Transport equipments	97.3	0.0	2.7	0.0	0.0	100.0
Manufacturing nec	98.5	0.0	0.0	1.5	0.0	100.0

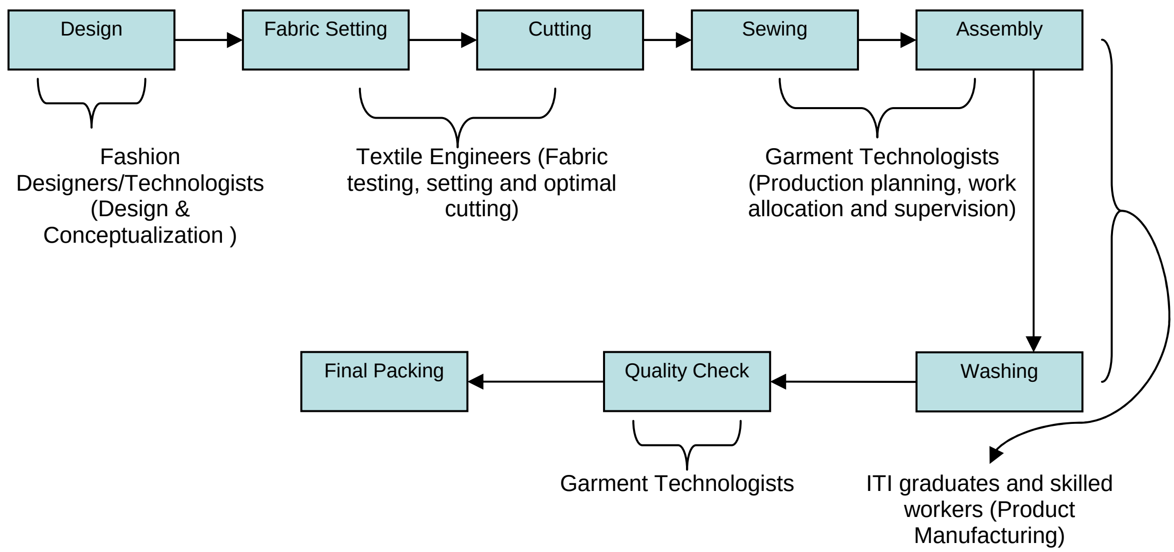
Source: NSSO, 55th Round Data

APPENDIX IV: PRODUCTION PROCESSES OF VARIOUS SECTORS AND ROLES OF GRADUATES

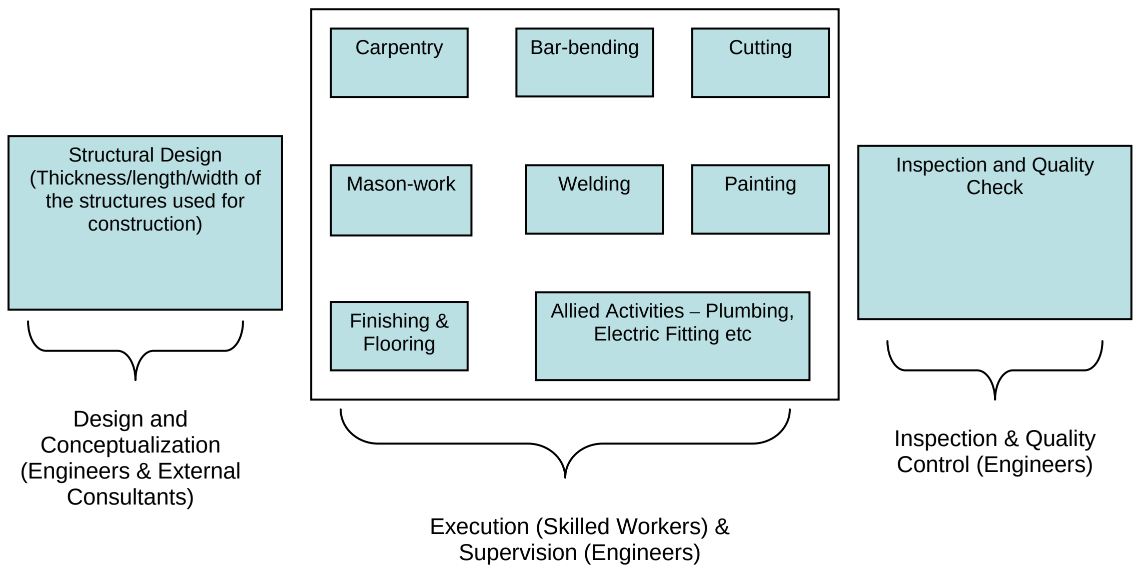
Manufacturing Process – Engineering Industry (Machine Tools, Auto-Components and Agri-Implements)



Manufacturing Process – Garment Manufacturing



Various Activities Involved in Construction Industry



APPENDIX V: DETAILS OF SECTORAL CASE STUDEIS

Sector (Firm)	Turnover (Rs cr)	No of Emp.	Year of Estd.	Products	Technically Qualified Workers				Other Workers (Skilled & Un-skilled)
					ITI		Polytechnic & Engineering		
					No	Qualification	No	Qualification	
Machine Tools (HiLife Machine Tool)	5	105	1974	Grinding Machines	25	Fitter,Turner, Machinist	12	Mechanical, Electrical & Electronics Engineering	65
Chemicals (Metrochem)	200	450	1976	Dyestuff	90	Fitter,Turner, Maintenance	60	Chemistry Graduates, Electrical,Mechanical, Production and Chemical Engineering	300
Auto-Components (Amul Industries)	100	600	1998	Connecting Rods	125	Fitter,Turner, Machinist	25	Mechanical, Production Engineering	450
Garments (Artex Apparels)	15	600	1981	Kids Wear	NA	NA	12	Fashion Technology, Garment Technology, Textile Technology	580
Agri-Implements (Asha Exim-Captain MiniTractor)	4	50	2001	Tractors & Allied Implements	35	Fitter, Diesel Mechanic	4	Mechanical Engineering	11
Construction (Gannon & Dunkerly-single site data)	5	65	NA	Buildings & Construction	10	Mason, Carpentry, Electrician, Plumbing	5	Civil Engineering	50