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Vision of Engineering Education System with Balance Economic Growth of India

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Abstract— **This paper focuses on the journey of engineering education to flourish the India's economic growth. To know the role of engineering education towards the contribution of nation's economic growth, the meaning of true engineering education must be understood. The engineering student's life includes three phases in his/her education journey; i) education, ii) employment and iii) society welfare. At the world level, engineering education is the most preferred career option. At present India produces 15 lakh engineers for 1 trillion economies whereas United State (US) produces 1 lakh engineers for 16 trillion economies. The difference is the engineers of US is skill oriented from day one while India's engineers are not industry ready due to lack of skill and required 6 month or 1 year training after the course completion. So, the quantity and quality of engineers produced by India is not adequate to keep the pace with the world. In the new world technologies changes very fast so as engineering education from 1.0 to 4.0 and now education 5.0 more focuses on rehumanizing approaches with machine and technologies. The paper also emphasis different era of industry, society, education revolution with respect to engineering education to compete with globalized world.**

***Keywords*— engineering education, economic growth employment, society welfare, rehumanizing approaches, education 1.0 to 4.0, education 5.0.**

I. INTRODUCTION

NGINEERING has helped to advance the technology for Esolving societal problems and economy of the nation. The modern engineering combining sciences, technology and research for the overall development of society. Since the beginning, engineering reshapes the society and culture through various modification in living standard through engineering techniques, architectures and so on. Revolutionary example of engineering in the history are pyramids of Egypt, irrigation system of Indus civilization, river dams in China and establishment of commerce route in Asia, Europe and Africa by Britain. As per history, British era started the engineering education in India and mainly focused on civil structures and after independence the engineering education is mostly influenced by American Educational System. In India, engineering education is including different levels such as diploma, degree, post-graduate, post doctorate and research in specialized fields. Today's graduate of engineering requires not only technological skill and problem-solving skills, but must also be required with soft skills like collaborative, communication and presentation skills along with business ethics and inter-personal relationships. The responsibility of engineering colleges is also increase to impart soft skills in addition to the technological knowledge. The engineering student's life has three phases in his/her education journey; i) education, ii) employment and iii) society welfare. The first stage of students is education; the education is not a just a degree or completion of curriculum/courses, the real education should shape your character, capacity and caliber to ensure that all activities conduct by you with dignity and equanimity for the society development irrespective of the daunting challenges [1]. The second phase of students is employment to fulfill the needs. Employment is not an end of education; the real education empowers and enlightenment of an individual. The employment decides the level of services provided to the nation it is only the link between basic needs of personal and society. All the innovation and invention can be seen all around us to make our life easy at all level. Today, technology opens the new doors in all the fields such as agriculture, health, transportation, communication, construction etc. it is very hard to see the life without technological innovation and it must continue to do so in the times ahead. These days we are living in the era of the globalization and for that world is having different

challenges and issues. Currently technologies have capability to change the world such as Cloud computing, Data science (DS), Augmented & Virtual reality (AR & VR), Artificial intelligence (AI), Machine learning (ML) Mechatronics, Petroleum Engineering, Oil and Gas informatics, Business analytics and optimization, Automotive design engineering, Infrastructure development, Biomedical etc. Data, which is collected by internet of things (IoT) that will be transformed into a new type of intelligence through artificial intelligence and will reach every corner of society where all people's lives will be more comfortable and sustainable as people are provided with only the products and services in the amounts and at the time needed [2].

II. Developments and Revolutions

Any nation's economy is the impression of Society, Education, Engineering and Industries. Broadly, the economic growth is depending on how social, educational and industrial revolutions supports to grow in the society's wealth as shown in the figure 1.

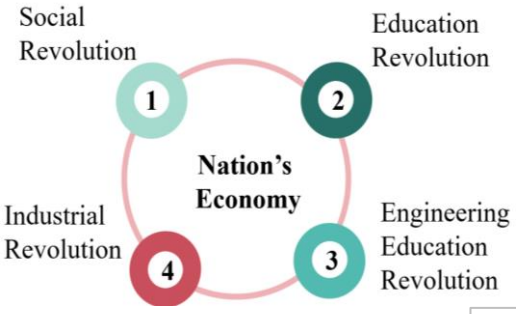

Fig. 1. Nation's economic growth parameter

Employment is one of the major factor of countries economy whereas gross domestic product (GDP) is the measure of total economic performance. Figure 2 and 3. shows the sector wise employment rate and GDP of India respectively.

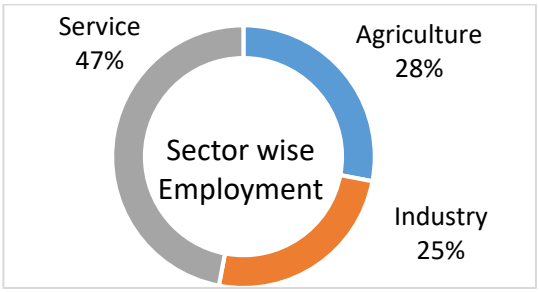

Fig. 2. Sector wise Employment rate

From the economic point of view the following points are the reflection of current situation in India:

1. Highest Population in the world: around 1.37 billion.
2. The Indian middle class is highest in the world.
3. Mixed Economy: 5th Largest Economy in the world (**GDP 3,176.30B)**
4. Outsourcing jobs: > 51 % at global level.
5. Service Export: IT sector > 45 % at Indian level.
6. IT sector has 7 % Share in India's GDP.
7. Half of the worker relay on Agriculture

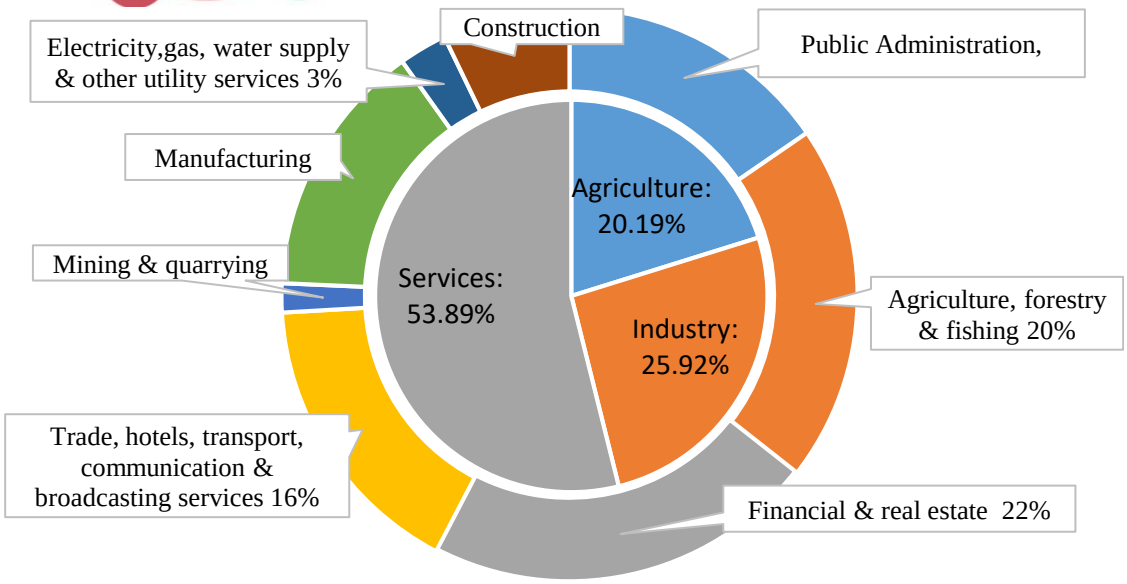

Fig. 3. Sector wise GDP [source: https://icsiindia.in/service-industry]

A. *Social Revolution:*

Society will exist as long as man will exists, the societal journey from hunting to society to smart society shows the global growth of mindset. Society represents the

relationship with one another and build-up the complex structure and association through interaction from which individual learns habits, skills, belief and growing mindset etc. The main agency of societies are; 1) Family, 2) Religion 3) Peer Group and Friends 4) Educational Institutions 5) Profession and Employment 6) Country and State. The various society challenges can be fulfilled by incorporating different education to keep all mentioned agencies together. The basic aim of engineering education should be focused on innovations by considering the society challenges. The continuous revolution of society as shown in figure 4

Fig. 4. Society revolution

B. Industry Revolution:

The industrial revolution is started from 18th century from agrarian and handicraft economy to manufacturing economy. This changing process in the field of industry is known as economic transformation. During industry revolutions some of the society like China and India did not begin their industrial revolutions until the 20th century, whereas others like US, Europe, began undergoing "second" industrial revolutions by the late 19th century. Today is the world of competition in various fields and industrial revolution give development in the field of technological, socio-economic, and cultural. The various stages of industry revolutions as shown in figure 5.

Fig. 5. Industry Revolution

C. Education revolution:

Education system is continuously growing from 1.0 to 4.0 and the journey of education 1.0 to 4.0 give a lot for the wellbeing of the society. Education 1.0 is complete teacher cantered-system and technology is completely forbidden in the class so the teacher has complete authority and students are completely passive. As the education system grows from 1.0 to 2.0, the communication and collaboration are also starting to grow. The system is completely exam and knowledge-based system in which knowledge is checked by exam and memory. In Education 3.0, student centric approaches were given importance and the teacher is transformed into a coordinator/facilitator, advisor, learner and practice guide. Now new flip classroom teaching methods were in the picture instead of traditional classrooms and students were researching. In the era of this education 3.0, lesson plans are now called learning plans, more dialogue and use of technology. In education 4.0, outcome/action-based system were focused and learning is done at home or at outside due to digitalization. Due to the technology being free and/or easily available Interactive flipped classrooms are applied with the use of VR. Learning plans are now creativity plans and co-creation and innovation is the center. As the technologies are growing very fast, continuous training and development of new knowledge and skill is required for teachers and institutions. Now education 5.0 is a digital transformation driven by the use of advanced technologies and placing learners and teachers at the center of the real-world teaching learning process to enable them to govern their own academic growth. Education 5.0 promotes research-based education system in which many barriers and series of innumerable challenges are jumped over in a race from education 1.0 to education 4.0. To reshape and match the existing education system with new and advanced digital technologies requires continuous growth. Education 5.0 aims to value creation, research skill, problem solving and combined all stakeholders, teachers, institutes and industry professionals to implement all advanced technologies. Learning and development is a continuous process and now technologies make learning anytime and anywhere.

Fig. 6. Education Revolution

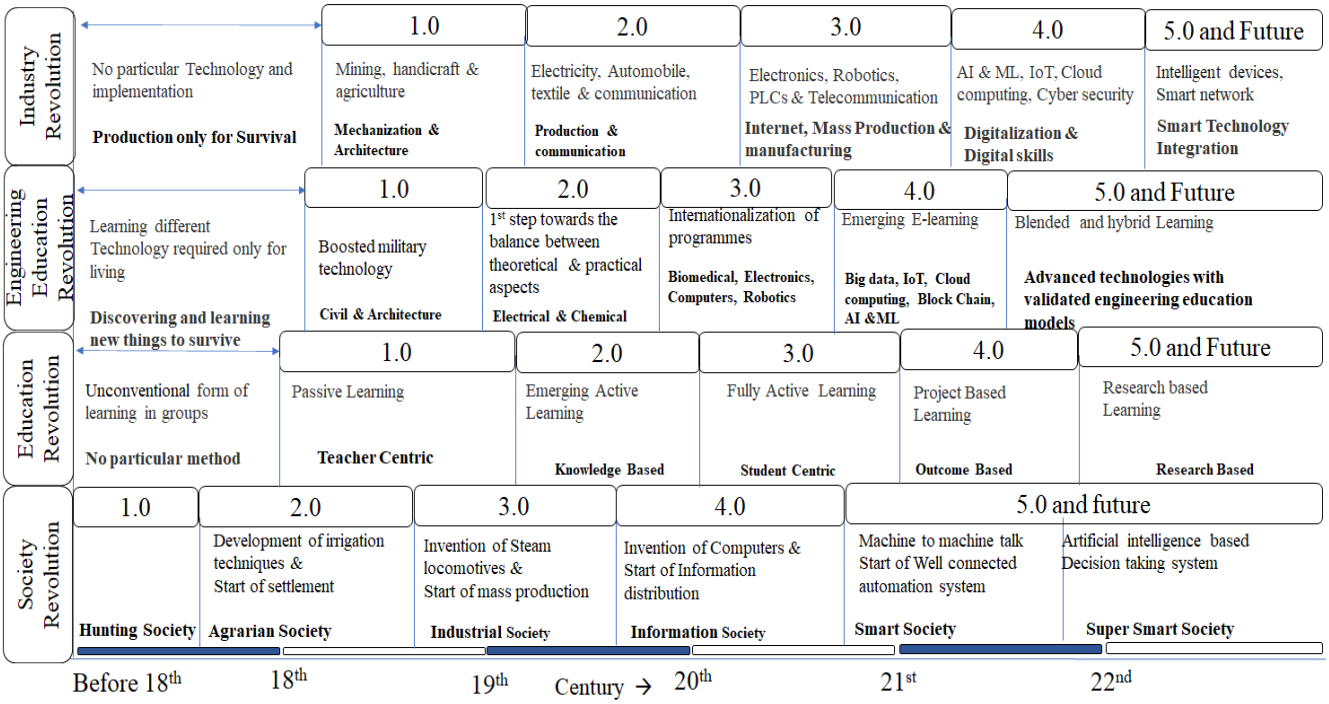

Fig. 7. Interdependence of various revolutions in the world

D. Engineering Education Revolution:

In India the journey of professional engineering education starts from the establishment of the engineering college at Roorkee (1847) and Poona Civil Engineering College at Pune (1854), Bengal Engineering College in Shibpur (1856), Banaras Hindu University (1916), Harcourt Butler Technological Institute, Kanpur (1920) were some of the earliest engineering colleges established and continue till the present day. In 1945, advanced technological education is established in higher technological institutes based on the Massachusetts Institute of Technology (MIT) in the four regions of India and establishment of Indian Institutes of Technology at Kharagpur (1959), Bombay (1958), Kanpur (1959), Madras (1960) and Delhi (1961) (Delhi was added on to the original four). The All India Council for Technical Education (AICTE) was set up in 1945, to oversee all technological education in India. The engineering education also saw many changes from 1.0 to 5.0 in terms of technologies and innovations. The engineering education revolution from 1.0 related to the civil and architecture development and the era of 2.0, imparted various technologies related to electrical and chemical. With the entry of computers, soft engineering sector robotics and biomedical in engineering education known as the era of engineering education 3.0. Currently, revolution 4.0 is going on which includes big data, IoT, DS, cloud computing are ready to change the world. In future AI and ML will helpful to utilized current current technologies and become more humanoid technologies. So, at this movement student require to develop digital skills to compete in this world.

Fig. 8. Engineering education revolution

E. Relationship between various revolutions

As per figure 7, all four revolutions are interdependent and nation's economy grows only when all other sectors grows simultaneously and open for new challenges. Today, we have the era of globalization and having different challenges such as internationalization of education, increasing the demand of interdisciplinary education, addition of emerging technologies at very fast rate, advanced transportation and communication etc. To cope with these globalization and digital economy challenges, the education system should also be adopting changes very fast.

III. Engineering Education

India holds an important place in the global education industry. In existing scenario, India is having world's largest population of 138 Crore and about 500 million of the age brackets of 5-24 years who are eligible and directly concerned with education system which includes primary, secondary and higher education. India is having largest networks of highest education institute (HEI) in the world. However, there is still a lot of potential efforts are required for further development in the existing system of HEI. As per the KPMG report around 11 % or 249,366.776 thousand persons of population are ready for higher education whereas, many students are taking higher education after the age of 25 years such as in post graduates, PhDs, post-doctoral courses. So, the target is to provide best and finest opportunities in India itself to stop the migration of students in foreign for higher education. India has to develop a system to focus on quality,standard and outstanding education system by the integration of emerging technologies.

A. Engineering Education 1.0 (Early 18th century):

Due to the first industrial revolution lots of variations were observed in the field of agriculture, production, transportation, infrastructures and military technologies leads to change in engineering education and considered as a new beginning for engineering education.

B. Engineering Education 2.0 (1880s-1930-40):

To establish the pace between second industrial revolution and engineering education, incorporation of the technologies related to chemical and electrical engineering, as independent disciplines introduced as a new concepts to engineering is known as engineering education 2.0. It was a time to move first step towards the combination of theoretical and practical aspects of engineering. These technologies brought mass-production and mass-personalization in engineering education. The whole society and engineering education reformulated in terms of industrial design, and profoundly focusing on conception of professional training.

C. *Engineering Education 3.0 (1940s- 1980-90):*

This era is of digital revolution in engineering education, in which some contemporary engineering disciplines started such as: biomedical, electronics, computers, robotics. These emergence technologies promote new discipline and reshaped the landscape of engineering known as engineering education 3.0. Now the world became more communicative and increasing

internationalization of programs and engineering students.

D. Engineering Education 4.0 (21st century):

The continues research give birth to the new technologies and incorporation of information technologies to education system. The period of education 4.0 indorses laboratory and research practice, transition from analogue to digital records. Nowadays, cloud computing, cyber physical interfaces, IoT, big data, simulation methods, autonomous robots, additive manufacturing changed the future of engineering education. Due to increasing of internationalization in engineering education compared to the last decades, more technologies can be easily transferable and world become more transparent.

E. Engineering Education 5.0 (21st and future):

The combination of well-established and validated engineering education models, adopted and taking encouragement from the previous education system for building the future, while incorporating radically innovative aspects and relying on advanced technologies, as a necessary complement for more effectively and efficiently transform engineering, in order to successfully
12 e global societal and environmental challenges. The engineering education give more emphasis on educational innovation, professional skill, research and reformulating professional training. More democratization of education through a more equitable access to the content and knowledge such as Wikipedia, google information. More online education system is available for example Khan Academy, White-Hat Junior, Byju and etc. [2-3]

IV. Engineering Education Scenario

The engineering sector is broadly divided into two sectors heavy and light engineering. The heavy engineering further divided into three parts; (i) heavy electrical, mechanical and civil works (ii) Heavy engineering and machine tools and (iii) automobiles. All these heavy engineering essential for the growth of manufacturing, energy and civil sectors. The light engineering is further divided into two parts i.e. low technology product and high technology product. The light engineering includes such as computer, information technology, data science, AI, electronics, robotics, mechatronics.

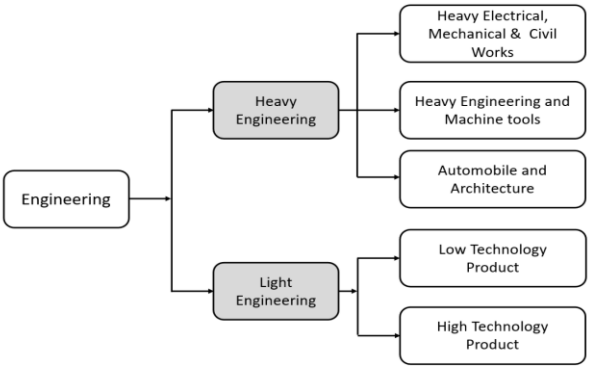

Fig. 9. Engineering Education Fields

The engineering education is still evolved in India. As per the research conducted by the world economic forum (WEF) for countries produces engineers, China produces 1.3 trillion, India produces one-trillion and might have largest number of engineers, Russia has 454,400 graduates, United State produces 2,37,800 and Iran produces 2,33,695 graduates in which 70 % are women so, Iran has highest number of women engineering graduates per year in the world.

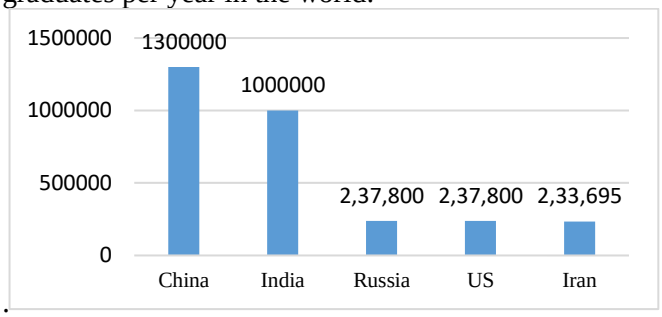

Fig. 10. Engineering graduate rate /year

A report of Aspiring Minds National Employability Report 2015 surveyed 150000 students from 650 engineering college in India and found that 60-70% of the engineering graduates were unemployable. In 2022 as per the stastica survey, the average rate of employability is about 50%–55% and remaining 45% – 50 % are not ready for job due to lack of skills.

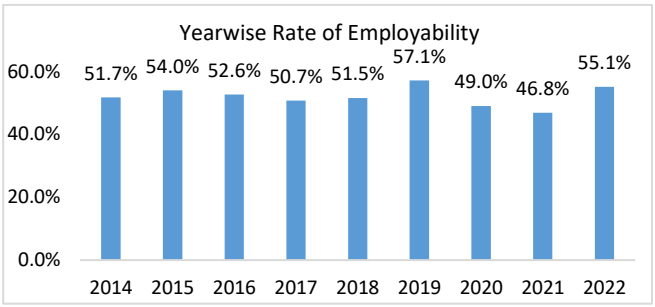

Fig. 11. Year wise rate employability of engineers in India

At present in India has total 23 Indian Institute of Technology (IITs) and 31 National Institute of Technologies (NITS) and other engineering colleges

(state level, private and Autonomous). In recent year, some of the private engineering colleges shut down due to lack of admissions. Also, the graduate students are not adequately trained on the other hand students are not find suitable internship, industry linkage to developed their skills. As a result, many graduates switch to other field such as sales, marketing, banking etc. The entire system requires to develop in such a way that institutions produce employable engineers, and the government and the private sector should work together with institutions for apprenticeship, internship and employment. In current Indian scenario, engineering is one of the largest industrial sectors. It has 27% of the total factories and having 63% of the overall foreign collaborations. The Increasing industrialization— and economic development drives growth in the capacity of all sector goods market. In India the engineering sector is highly dominated by large players employing over 4 million skilled and semi-skilled labor. The improvement in the economy by enhancement various commercial sector such as infrastructure, power, mining, oil and gas, refinery, steel, automotive and consumer durables are driving the heavy demand in the engineering sector. The economic progression can be achieved by reducing manufacturing costs, expanding market knowledge and technology, increase skilled based workforce and creativity leading to higher investment in the nation. The initialization of new startup, business, engineering industries required skilled oriented youth and the market conditions. The basic questions arise related to the education and nations economy [4]:

Q1. How does a nation's education system relate to its economic performance?
Q2. How education and training interact with the economy.

V. Engineering and Economics development

Growth of economy means increasing the prosperity of a country. The economic development depends on production, labour and capital along with the efficiency with which they are utilized. The current scenario of engineering sector data which states the economy of India are as follows:

1. Turnover of the capital goods industry was US$ 92 billion in 2019 and is forecast to reach US$ 115.17 billion by 2025.
2. Growth in the power industry is expected to drive growth in the electrical equipment industry.
3. Electrical equipment market is forecasted to grow at 12% CAGR to reach US$ 72 billion by 2025 from US$ 48-50 billion in 2021.
4. Export market of electrical equipment is forecasted to reach US$ 13 billion by 2025, from US$ 8.62 billion in 2021.
5. According to the National Association of Software and Service Companies (Nasscom), India's share in the global engineering and research and development (ER&D) market is likely to expand at a CAGR of 12-13% to reach US$ 63 billion by 2025.
6. In October 2022, exports of engineering goods from India stood at US$ 7.4 billion.
7. In Financial year 2022, India exported engineering goods worth US$ 111.63 billion, a 45.51% increase year of year
8. Indian telecom equipment market is likely to increase owing to the government's Rs. 12,195 crore (US$ 1.6 billion) production linked incentive scheme approved for telecom gear manufacturing in February 2021.
9. Export of telecom equipment enlarged from US$ 2.58 billion in 2018-19 to US$ 4.68 billion in 2019-20. [5-6]

VI. Recommendation and Discussion

The engineering is also the developing at the beginning of the social revolution from basic living technology to advanced technology as shown in figure 7. All the discoveries in the field of engineering for the social welfare give rise to industrial revolution. Industrial development always improves social life and economy of the nation [9-10]. To maintain the sustained growth, the engineering education should be linked with these goal of growth for improving economy of nation.

A. Goal of Engineering Education

1. **Engineering and sustainable development:** In current scenario, creation of infrastructure such as roads, dam and bridges are not sufficient to support the economy but at the same time, communication infrastructure, digital market development, space communication technology, energy sector development, waste management, water supply management, research and innovations are also required. Today, digital infrastructure is a backbone of every sector such as education, health, commercial and industrial. Investment in research, innovation and technology also supports the entrepreneurship and bring more business to the nation. To sustained the economy of the country has to bring more business to create new goods and services. A robust communication network and infrastructure permits speedy and free flow of information and materials to

ensue businesses grow rapidly and taking timely decisions.

2. **Engineering Skill and Employment:** Today the engineer required technical as well as non-technical skill to make more effective engineers such as communication, project management, leadership, teamwork rather than the acquisition of theoretical and technical knowledge.
3. **Engineering and Society:** The gap should be identified that what society needs and what technologies engineer provide to the society. The technology will be provided to the society and what it actually does for the welfare of the society rather than simply promote globalized competition.
4. **Engineering ethics & Social Theory***:* The engineering education should be more focus towards society and widen its vision and make students more socially responsible engineers.
   i. Engineers should have responsibility for both at individual and professional level.
   ii. Solving engineering problems and serve the society interest and give solution to solve the societal problem.
   iii. Aware of current scenario changes in public policy, including laws, or social practices.
   iv. Engineers should know resources and required local technology to improve the living standard.[7]

B. Key Area for Improvement

The following are the key things in India to promote skill in education and to raise the economy of India:

1. **Diversification:** Several engineering industries and companies, start-ups should be diversified, either geographical or sector-wise.
2. **Entry of international companies:** Encouraging more international players and entered in the Indian engineering sector to create more growth opportunities.
3. **Partnership:** Engineering industries should make tie up with technology providers, institute-industry relation to boost their competences and withstand the market uncertainties.
4. **Skill improvement:** Imparting of skill is very important to increase the employability of engineering graduates in the country. In India, Ministry of Human Resource Development (MHRD) is working along with Sector Skill Councils (SSCs) under National Skill Development Corporation (NSDC) commence and focuses on skills, aptitude and on-job training.
5. **Internship & Training:** Including apprenticeship/ internship implanted degree programs with a fundamental courses on the development of knowledge, All India Council for Technical Education (AICTE) has entered into collaborations with the Ministry of Micro, Small & Medium Enterprises (MSME) ministry, National Highways Authority of India (NHAI) and district magistrate (DM) offices in 150 districts to facilitate engineering internships for students.
6. **Research & Development:** Academic institute should establish center of excellence for technology development and engineering facility centers with prominent research across the country.
7. **Educational support:** The AICTE has launched educational books, digital library, research platform for diploma and under-graduate engineering courses. Some of the courses in local language, so that students can learn better in their native or local language.

The economic growth of any country depends on many factor and one of them are the government policies and
14 nning. The government provides the conditions to do business better by public and private sector. The government should facilitate the following measures be to sustained the good economic growth:

1. Long-term view
2. Ease of doing business condition
3. Incentives for good performance
4. Investment and subsidy
5. Scale and pace of the demand for infrastructure growth required for business
6. Promotion of research, innovation and development in technology
7. Good communication, transport and digital network.

C. Initiative taken by Government of India for engineering Education

1. **Swayam**: An initiative under the "Digital India" drive undertaken by the Government of India in 2015 for imparting quality education to school/undergraduate/post-graduate students.
2. **e-PG Pathshala** started by the Ministry of Education under NME-ICT (National Mission on Education through ICT) and the University Grant Commission (UGC). It is an online portal for PG courses and over 700 e-books in over 68 PG courses are available. e-PG Pathshala module namely:
   i. e-Adhyayan consists of e-books and video contents.
   ii. MOOC (Massive Open Online Courses) UGC

courses offered under the SWAYAM portal.

iii. e-Pathya offers offline and distance-learning courses for postgraduate students.

3. **Swayam Prabha** was intellectualized by the Ministry of Education that comprises 32 DTH channels and telecast educational contents 24x7 for students across India.
4. **National Digital Library** (NDLI) developed under NME-ICT by the Ministry of Education. The online platform is available 24x7 in more than 70 Indian languages with a wide variety of learning resources such as eBooks, videos, thesis, manuscripts, documents, and many more. It can be downloaded from google Play Store for mobile application.
5. **E-Shodh Sindhu** jointly and strategically planned by the Ministry of Education and the Government of India to provide e access to e-resources like journals, eBooks, thesis, factual, bibliographies, citations, etc. for higher education on online portal for PG courses.
6. **National Programme on Technology Enhanced Learning** (NPTEL) is another project funded by the Government of India and Ministry of Education and collective initiatives by Institute of Science, Bangalore, and seven other IIT institutes (Delhi, Bombay, Kanpur, Kharagpur, Guwahati, Roorkee, Madras). It offers various online courses in engineering, science, social sciences, and humanities without any course fees, however, certification exams will nave minimum cost to bear candidate.
7. **Virtual Labs** provides access to the laboratory virtually this is an digital association for under graduate and post graduate students founded by the Government of India with the Ministry of Education under the NME-ICT initiation. This platform is collaboration of 12-13 participating institutes with 700 experiments with lab facilities [8].

In conclusion, the engineering education plays very important role and eengineering always acts as a backbone of a nation and helps the countries by developing various sectors like infrastructure, communication, energy, transport, food and water security, education, health sector etc.

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