1. Challenges/trends ahead and justification

1.1. Challenges/ trends ahead

As countries recalibrate their growth models to consolidate their positions in the global economy, availability of a highly skilled and technically qualified human resource base will be a crucial determinant of success. In their quest to gain market shares in higher-order manufacturing and services, governments and other stakeholders are paying close attention to developing the requisite technical and scientific capabilities. Skills development for employability, referred to as technical and vocational education and training, has been identified by all countries as a priority area for educational policy and practice. Improving education for the world of work is one of the key skills challenges to developing countries. Moreover, as industries and industry sectors reengineer their resource and energy inputs, the training of the general labor force has become a priority.

The future of Education and Training is expected to face three formidable challenges. The first, a macro level challenge, is the prediction of ***Future of Learning***. It has four major drivers: Labour Market Trends, New Skills, New Ways of Learning and ICT trends. The second, a micro level challenge, is the individual 'Habits of Mind' in learning. Both these challenges have contextual and content relevance. The third challenge, a medium level challenge that lies in between these two challenges, is the design and development of methodologies that shall lead to convergence of three knowledge types: Pedagogy, Content and Technology, to make Education and Training more effective.

The World Bank, UNESCO, ILO and special entities in respective countries are working towards addressing these three level issues associated with future education and training. These efforts have led to the identification of some of the critical problems that are associated with future education and training across the globe and in India. They are:

1.1.1. Need for newer learning models

Educators across the globe have repeatedly argued that present approaches to teaching and structuring learning environments are inadequate to address and support twenty-first century learning needs. Multiple factors are driving change in the way students are educated. Pressures vary from context to context but the message is the same: institutions are failing to prepare children for the challenges ahead.

The UNESCO, as part of its Education Research and Foresight on the theme of 'Futures of Learning', addresses the motivations for a new model of learning, the specific competencies and skills needed for learners to function effectively in the twenty-first century, and the pedagogy required to stimulate those capabilities. That calls for a new model of learning for the twenty-first century.

1.1.2. The Global Employment and Social Outlook Scenario

The World Bank in its report, World Employment and Social Outlook 2018, identified a few major challenges which are of direct concern to education and training institutions. They are:

1. Rising vulnerable employment

2. Action to limit global warming to 2 degree centigrade that shall lead to creation of more jobs
3. Transition to agricultural sustainability and circular economy will result in more and better jobs
4. Significant variations in employment outcomes continue to exist between regions and countries
5. Inequalities in labour market outcomes persist
6. Projected structural shift towards the service sector that could create complex pressures on job quality.

The above scenario warrants institutions to prepare themselves to offer academic and training programmes to remove variations in productivity and skills for the new job.

1.1.3. The Changing Landscape of Technology Education, Research and Training

The UNESCO has also identified multiple drivers that shall drive the future of education and training (Box 1). New competencies for complex new world, availability of anytime-anywhere learning, skill shortages, availability of new learning tools and changing perceptions about the formal of education are some the challenges that need to be accorded high priority in the development strategy of any higher education system in the globe, in particular developing countries.

Box 1
Drivers of Future Education and Training

1. New competencies for a complex world
2. Changing perceptions about the value of formal education
3. Skills shortages
4. Changing models of learning and teaching
5. Availability of new media and other tools for learning
6. Mandates for assessment and accountability
7. Availability of anytime/ anywhere learning
8. Transition of learners from consumers to producers
9. Exponential growth of information

1.1.4. Engineering Education in 21st Century

What exactly is engineering, and how has it had this profound effect on society? A key insight is provided in this quote from the distinguished fluid mechanician, Theodore von Karman :

"A scientist studies what is, whereas an engineer creates what never was"

Thus, engineers create, and innovate, based upon an in-depth, quantitative understanding of the latest developments in mathematics, science, economics, etc. Engineers also conduct research, to develop methods and tools, that enable practicing engineers to solve problems more effectively, systematically and efficiently.

Recently with the advent of Industry 4.0, social transformations due to connected demography and knowledge societies, emergence of new economies, and rapid advancements across engineering disciplines newer challenges have emerged for 21st century engineers. Due to globalization, faster technological developments, shorter concept-to-product development cycles, established technologies and products are rapidly becoming commodities, and being relocated to lower cost regions of the world.

21st century engineering education is gearing up to face the challenges and are accordingly undergoing a transformation, though it is largely limited to the universities of some of the developed counties. A shift in approach to education may be depicted as under.

Conventional	**Emerging**
Department based	Topic based
Campus centric	Global reach
Building block courses	Holistic curriculum
Few links to industry	Robust industry partnership
Research vs education	Integration of research and education
Education vs training	Integration of education and training
Teacher centric	Learner centric
Problem solving based	Problem Based Learning (PBL) centric
Discipline specific	Interdisciplinary & innovative

The 21st century engineer will first of all need to be an agile and independent learner, who can acquire new knowledge as needed to tackle new problems. Such an engineer will need to be strongly grounded in fundamentals, which may now include science and mathematics topics such as biology, statistics, discrete-mathematics. These new fundamentals will also include: principles of design and manufacturing, systems engineering, material science, computer programming, Software Engineering or Machine Learning for Engineers, deriving meaning from large data sets, especially those or being used to impact technological systems, sensors & sensor networks, engineering statistics, data science & analytics, smart and connected systems, and robotics and automated systems, the ability to research new topics, skills in communication and teamwork, as well as strategic, economic, social, artistic, environmental and global perspectives.

The engineering education of the 21st Century must enable the graduate to work on technologies that had not yet been invented while they were in school, and will certainly involve high-quality and efficient lifelong learning. The renaissance engineer for the 21st century must ideally be a holistic designer, an astute maker, a trusted innovator, a harm avoider, a change agent, a master integrator, an enterprise enabler, a knowledge handler and a technology steward.

Engineering workplace is rapidly expanding beyond the scope of any single engineering major. In today's world of interconnected products, a multidisciplinary approach to engineering problem solving, product and systems design is needed, hence the need to change the engineering degree curricula that provides adequate exposure to multiple engineering fields, while maintaining focus on discipline-specific focus in the engineering degree programme. For example, these days a mechanical engineering student may be required to use knowledge of computer engineering, and vice-versa. For this purpose the concepts of majors, concentrators, and minors will be introduced in the design of

engineering curricula. A Concentration, goes hand in hand with a Major, as it has to be in the same field of study as a Major. One can pursue a Concentration within their Major and a Minor in some unrelated (or related) field of study. The purpose of minor in the programme will be to provide an option to study course in unrelated fields of study for the purpose of undertaking secondary project or pursue research or innovation.

1.1.5. National Skill Development Mission of India

India has launched the National Policy for Skill Development and Entrepreneurship in 2015 to provide harmonization of training costs, processes, assessments, certification and outcome. Presently over 20 Ministries are implementing skill development schemes. India has made many strides in the area of skill development. More importantly, 18 out of 20 ministries have aligned skill development programmes with other schemes of respective ministries under Common Norms. More than 2,000 Qualification Packs developed in four years for Enforcement of **N**ational **S**kills **Q**ualification **F**ramework (NSQF). However, the skill development ecosystem of the country is looking for solutions from education and training system in the country for the following issues:

a) Ensure vertical and horizontal pathways by integrating VET in the formal education system.
b) Increase the capacity and quality of training infrastructure as well as trainers to ensure equitable and quality education and training.
c) Establish an information system for aggregating the demand and supply of the workforce which can help match skills development to the needs of the economy.
d) Improve the quality of vocational teachers and trainers.
e) Enhance the employability of trainees.
f) Leverage technology in teaching and training of TVET courses.
g) Develop assessment models of future skill needs.
h) Monitor tracking of progress and the results achieved.
i) Undertake evidence-based research on impact of skill development initiatives.

1.1.6. Research needs on technical education and TVET systems

Some of the issues that warrant further research to support policy initiatives and their impact on skilled development in India are:

a) Policy reviews and TVET reforms
b) Synergy in cooperation between stakeholders
c) Effectiveness of funding for skill development
d) Impact of capacity building on quality of training
e) Policy and strategy on social inclusion and equity
f) Institutional mechanisms for dissemination of knowledge and information
g) Skills for green transition
h) Impact of cross-sector approaches and
i) ICT in closing the digital divide

1.1.7. National Policy on Technical Teachers Training

Recently, in order to improve the quality of technical education system in the country, AICTE has framed the National Policy on Technical Teachers Training. As per the policy, at the entry level, teacher is expected to go through an 8-module certificate training programmes through blended mode. NITTTR is entrusted with the role of mentor institutes to develop training programmes for the benefit of entry level teachers. As per the policy, there shall be another two higher level programmes for in-service teachers. This necessitates structured training programmes leading to certificate, diploma and degrees in pedagogy for technical education.

In summary, the changing global technological and economic needs demand that every individual be a life-long learner, to be part of the development process. As the learning has to happen lifelong, personalized learning paradigms working at the intersection of pedagogy, technology and content knowledge spaces may be the future need. The future technological needs, industrial activities and skill needs demand engineering curriculum to be multidisciplinary. In the Indian context, there is a greater need for a bridge to connect industry and academia, translate their needs and create synergetic relations. NITTTR Bhopal, since 1960s, has been in the forefront to address training needs of both industry and academic personnel. However, in order to address the future challenges there is a need for it to assume bigger role to address the needs for newer learning models, innovative teaching and learning methods and the need for multidisciplinary curricular models. The means of achieving these ends by the proposed Deemed-to-be-University are advanced below:

Justification

NITTTR BHOPAL ROLE IN ADDRESSING FUTURE NEEDS OF EDUCATION AND TRAINING

As NITTTR Bhopal envisions itself to be the world leader in education and training, all the above given seven factors: the need for newer learning models, World Employment and Social Outlook, changing landscape of education, training and research, engineering education in 21st century, issues related to skill development mission of India, research needs on TVET system and National Policy on Technical Teachers Training become the major motivating factors for NITTTR to:

1. adopt newer strategies to design and develop methodologies that shall lead to convergence of three knowledge types: Pedagogy, Content and Technology, to make Education and Training more effective.
2. reorient its' mission to keep up with the new developments in learning and work towards effective technology integration, recognizing technology, pedagogy, content and context as interdependent aspects of teachers' knowledge necessary to teach content-based curricula effectively with educational technologies.
3. design and offer newer academic, research and training programmes that shall address the skill shortage and training needs of the work force; and to
4. promote research-based pedagogies that foster academic engagement, translate research knowledge into usable teaching strategies and to develop expertise in: learning and assessment theories, student-center teaching and inclusive teaching and signature pedagogies.

The Deemed-to-be-University status for NITTTR will be the first enabling factor in this regard.

At present, NITTTR, ***under an affiliating system***, is facing number of challenges in effectively undertaking and implementing the following:

1. Design and experiment innovative pedagogical practices to address the future learning needs-individualized and collaborative learning practices.
2. Design and offer academic courses that shall lead to vocationalization of academic offerings at all levels to address the skill needs of the country lead to skill-oriented.
3. Design and offer structured modular programmes leading to enhancement of qualifications of the workforce and promote life-long learning.
4. Experiment new curricular models, assessment systems and technology integrated delivery models.
5. Conduct research for design of evidence-based corrections in pedagogical innovations, policy corrections and design of newer methods.
6. Establish national and international collaborations leading to transfer of best practices in pedagogy, integration of technology and pedagogical practices in teacher training, teaching and learning and skill development through teacher training.
7. Offer collaborative academic programmes and transfer best practices through teacher training.
8. Facilitate student and staff exchange to gain international experience.
9. Conduct research on systemic issues.
10. Surrogate experience on curriculum implementation, students' assessment learning outcomes.
11. Support TVET system in establishing quality assessment framework and
12. Provide formal recognition of training offered in a structured and modular framework.

While, other institutions/universities work for transfer of knowledge or skill in specific knowledge domains, NITTTR is mandated to work at the intersection of the three knowledge areas of technology, content and pedagogy. It is mandated to make innovation and transformation in the whole of the technical education system. Hence, academic autonomy is very critical for fulfilling its mandate as well as for addressing the future skill needs of all vocations related to technical education and technology based industries. For this purpose, it desires Deemed-to-be-University status with full freedom to make experimentation with new curriculum models, innovative pedagogical to transfer all its innovations through academic programmes and teacher training.

Given the DU status, NITTTR shall (1) experiment with newer curriculum models, implement and test them for their effectiveness in increasing the employability of future workforce, (2) Design and offer new modular academic programmes at Certificate, Diploma and Degree levels, with multi-entry and multi-exit options, (3) Design and offer vocationalized tertiary education programmes, balancing both horizontal and vertical integration knowledge and skills, that shall address the skill and knowledge needs of the future and present workforce, (4) Conduct research on learning and skill development and create evidence for policy corrections, (5) Establish international collaborations to promote education, training and research in the TVET system and (6) Contribute towards national missions of Government of India by providing research based support.

Newer Academic Programmes:

To begin with, in first five years of becoming Deemed to be university, the Institute will offer 12 or more Integrated M.Tech programmes in engineering with large number of electives in Technical Education, Integrated MBA, M.Tech. programmes in Engineering Education & Education Technology apart from large number of certificate programmes, MOOC programmes and need

based diploma programmes. All our programmes will have distinct features some of them have been outlined below:

1.2.1 Engineering Degree curricula to spread over multiple-discipline yet maintaining focus on discipline major. Integrating Multidisciplinary Elements in Core Discipline: Some examples:

Civil Engineering:
IoT applications in home environment, Sensor Networks in building services-
Emergence of Smart Cities concept leads to integrate computer science with urban planning by way of applications of big data, sensor networks, spatial data, and environmental technology, neuro-fuzzy control systems, etc.

Mechanical Engineering:
Use of AI, AR-VR, autonomous machines and robots require integrated approach of mechanical, electronics, and computer science base for development of human-computer, and human-robot interfaces, etc.

Electronics Engineering:
New materials and technologies for future industrial production systems, and power additive manufacturing technologies (3D printing, etc.), flexible electronics etc.

Electrical Engineering:
Combating climate change with renewable energy technologies (green energy production, conversion, storage and transmission systems designs, and mechanisms), etc.

Computer Engineering:
Sensors, Green Engineering, Embeded Systems, Engineering Statistics, etc.

All programmes will have large number of electives to provide this muti-disciplinarity.

1.2.2 Major/ Minor Projects and focus on translational research

The Senior Design Projects based on real life problems of industry to become part of academic experience. This will be a chance to do a focused, research- and design-based project led by faculty or industry mentors. Students to work in teams and to bring the knowledge gained in the experience – to bear on a real challenge, often one posed by a real company, field agency, government organization, or R & D lab. **Students will be provided opportunity to do translational research as part of their projects.**

1.2.3 Digital learning – Flipped Mode

There is a growing realization that there are ways to make advanced educational technologies like online learning, AR & VR technologies, and MOOCs etc. They have potential to transform the quality of pedagogy and engineering education in general. However, such a use can have even better justification if we put these technologies to help students in self-learning, and promote student centric learning. The way forward to use

these technologies to achieve this objective is to practice flipped learning pedagogy in teaching the courses. Use of these technologies will not only facilitate engineering faculty in teaching the courses but will also make interaction with industry personnel and other experts possible in real time. **The students will be exposed to variety of learning apart from face-to-face, such as MOOCs, courses delivered by experts from industry/ research/ profession through online mode, working in industry/ world of work/ research laboratories/ other institutions to earn credit.**

1.2.4 Industry as partner in Innovation

The standing expectation in partnering with industry is that universities do basic-to-applied research solely for purpose of creating new knowledge, and that industry can take that knowledge and use it to create products that can benefit society. Alternative models such as the one to create partnerships, that give companies an avenue to explore and test the feasibility of their ideas for profitable new products, while allowing universities and faculty to reap fair compensation when that process is successful, and the like will be explored. Certain ways in which the interaction may be desiged may be based on the following.

- Research, problem solving, design, development and testing of innovative products and solutions for industry
- Partner in pedagogy and training of industry personnel
- Development of Product and Innovation Centres through full or partial funding from industry, instituting Faculty Chair in specialised area of interest / study.
- Industry professionals and experts to work with institution as adjunct/ visiting faculty, and project/ research guides/ mentors.

The students will work hand-in-hand with industry for problem solving/ innovation/ research etc.

1.2.5 Connect with the Society

Technical education is aimed to ensure that the graduates can be creators of the scientific and quantitative spheres. They need to understand how technology works so that they can be effective as innovators. They also need "soft" skills, such as the ability to communicate their technical ideas and concepts, and galvanize a wide array of people, including those without technological backgrounds and people from other cultures. Combine these skills with the ability to be life-long learners, and our graduates have the potential to make real impacts that can better our quality of life for generations to come.

Another need to develop a societal insight in the students is to provide an international exposure of a quality UG/ PG/ Research in engineering programme is to put them through a regular and related set of course(s) or a project in some overseas university of high repute. In conventional universities and colleges, this does not happen so easily. Our engineering programme will have these provisions.

The students will have liberal component of liberal arts to make them sensitive to concerns of society.

1.2.6 Making problem solving and innovations a central theme of engineering studies

Problem solving and creativity form the basic fabric of engineering, and they cut across tight compartmentalization of engineering studies, as problems are not pure electrical, or mechanical or civil or computer engineering rather they involve more than one engineering discipline wrapped around a major discipline. Problem Based Learning (PBL, therefore, has received wider attention recently. PBL and Project Based Learning have led to newer approach to design of engineering curricula. PBL combined with creativity and intelligence of high achievers lays down foundation of innovations. Leading universities world over have undertaken to nurture creativity and innovations through promotion of concept-to product process approach. And for this to happen, separate Innovation Centres for development of Engineering Products have been set up.

The students will be exposed to project based leaning and problem based learning so as to make them handle complex engineering problems and complex engineering activities.

1.2.7 Our Students/ graduates

The student(s) of Deemed-to-be-University programme(s) would be individual(s) with a sense of purpose and appreciation for how engineering education and experiences are superior foundations for improving society. Besides being a 'T' shaped engineer, he/she will be a notch up in development of new technologies, of course, but will also be empowered to create economic value and jobs, improve health care, use wealth to advance society, formulate public policy, and myriad other possibilities in this country and around the world. Their education will prepare them to work in multi-disciplinary teams, often, but not exclusively, matching technology with the needs of the marketplace to bring innovation into practical use.

To sum up, Institute will provide unique courses involving blended mode of delivery and implemented by involvement of academia, industry and society.