

Transforming Indian TVET Programs For Industry-4.0

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Introduction

Virtually every Indian industry is impacted by the disruptive power of digital technology which has been quietly ushering in the fourth industrial revolution across the globe. Industry 4.0 considers the current trend of automation and data exchange in manufacturing technologies.

This demands well trained TVET graduates not only in skill development but also in cognitive computing. Industry 4.0 includes Cyber-Physical Systems, Internet of Things (IoT), Cloud Computing and Cognitive Computing. The advantages of Industry 4.0 are fast, flexible, high quality and efficient production system.

Industry 4.0 is being driven by four disruptions, viz, the rise of data volumes, the emergence of analytics, new forms of human-machine interactions and the improvements in transferring digital instructions.

Indian TVET trainers, administrators and leaders have to focus on the changes as they look for ways to develop new technical, avocational, educational and training programs to take advantage of the opportunities that arise from Industry 4.0.

After globalization of Indian economy multinational companies have established state of art production facilities both for national needs and export. Now, it is very important to modernize the TVET programs and update the abilities of the faculty members.

The Education National Policy 2019 suggests needed changes in TVET system. This research focuses on the current problems and the needed planning to meet the industry demands due to Industry 4.0. The manufacturing industry is poised for dynamic growth.

Objectives of this Paper

1. To conduct SWOT Analyses to plan for transformations of the TVET Programs, develop the faculty, modernize the resources and the institutes on project mode.
2. To identify the Industry-4.0 specific skills and cognitive competencies in various TVET Programs.
3. To consider various solutions suggested in the National Education Policy 2019 for improving the TVET.
4. To accelerate the collaboration between the industry and TVET Institutes, CII, FICCI, SIAM, NASSCOM, MSMEs, etc. to improve the regional competitiveness in Asian Region

Literature Survey

In the last five years the developed countries have opened their eyes towards the fast- changing disruptions due to the digital technology. James George (1990) researched on the curriculum development for robotics introduction in the secondary schools. Keith Watson (2006) reviewed the technical education in developing countries. OECD (2011) brought out a detailed study on the vocational challenges in meeting the labor market needs and work place learning is needed.

It concluded that career guidance. Christina Boateng (2012) focused on the restructuring vocational and technical education of Ghana. Lei Wang and Heidi (2013) identified the current issues in the Chinese vocational education. Asian Development Bank (2014) deliberated on innovation strategies in technical and vocational education and training for accelerated human resource development in South Asia. Hew Gill (2016) studied how learning must evolve with times. Asmaa Abu Mezied (2016) researched on the role of education in the fourth industrial revolution. Brenna Sniderman et al. (2016) described the manufacturing ecosystems in Industry-4.0. Claudia Salchow (2016) advocated learning by doing in vocational schools. Erik Skov Madsen et al. (2016) advocated the introduction of digitization for vocational students to undertake works in Industry 4.0. FICCI (2016) prepared a white paper on the skill development for Industry 4.0. Ali Durmus and Abdulkadir (2017) initiated steps to integrate vocational schools to Industry-4.0 by updating curriculum and programs.

Dieter Weganer (2017) studied the new opportunities and challenges on Industrial Internet. Dorleta Ibarra, et al. (2017) focused on the new opportunities to meet the new jobs under Industry-4.0. Dorleta, et al. (2017) developed business model innovation through Industry 4.0. Alan Talla Ferrow, et al. (2018) focused on the delivering digital talent and preparing the logistics and distribution of workforce for Industry-4.0. Cisco Research (2018) studied the global trends in vocational education and training. Chun-Mei Chou et al. (2018) evaluated the manpower to meet the challenges of Industry-4.0. FESTO (2018) identified the needed qualifications for Industry-4.0. Jihee Choi et al. (2018) explored the needed linkages between vocational education and training providers and industry. McKinsey Global Institute (2018) termed manufacturing the future would be the next era of global growth and innovation.

Manufacturing Institute (2018) has identified needs of manufacturers. According to it, the industry needs skills certification. Siti Zahrah, et al. (2018) reviewed the emerging needs of technical and vocational education and training to meet the demands of Industry-4.0

Most of the advanced and fast developing countries systematically evaluate the needs of Industry 4.0 and bring changes in curriculum and focused work place training. The TVET system is being continuously updated and the faculty members are continuously exposed to the advances of the industry due to digital disruptions.

As the industries adopt to Industry.4.0, the demand for industry ready TVET graduates increases. India has to focus on these so that the economy is increasing.

Challenges to TVET Indian System [1,4,8,11,14,15,16,20, 22,24, 25,30, & 33]

The following questions are considered for identifying the new challenges to face the disruptions due to Industry.4.0

- What is the role of employers in developing vocational programs and ensuring the skill development that are needed in the modern work place under Industry- 4.0?
- How will you ensure the graduates with generic, transferable skills to occupational mobility and lifelong learning, and with occupationally specific skills that meet employers' needs?
- What is the role of the employers in sharing the cost of vocational education under Industry-4.0?
- How will you plan and implement workforce training to meet the needs of employers and as well as that of the students?

There is a need for comparative study to know how some of the well performing countries like China, Korea, Germany and Switzerland. An attempt has been made in this paper and the findings are presented. Further the suggestions from the National Education Policy 2019 could be considered for implementation.

SWOT Analysis of Indian Technical Vocational Education and Training

Since the problem of developing industry relevant TVET graduates is growing day by day due to digital disruptions, it is essential to conduct a SWOT analysis so that comprehensive solutions can be suggested.

Strengths

- Economy is growing due to FDI, FII and WTO since 1992 due to globalization of Indian economy.
 - The need for multiskilled vocational graduates increases due to 'Make in India Scheme' and Industry-4.0.
 - Fast- growing industrial corridors and hubs attract many MNCs to start quality production centers in India.
 - Focus on vocational education in all educational programs by NEP 2019.
 - Industrial Training Institutes (ITI) and Polytechnics supply needed skilled workers to industries.
 - Board of Apprenticeship Training Provides Industrial Training with Stipend.
- #### Weaknesses
- Vocational education in India has yet to create an impact on the human capital.
 - Lacks strong industrial links.

- Work-based skill development has to improve.
- Vocational teachers need industrial exposure and training.
- Vocational curricula need to be evaluated and improved in collaboration with employers.

There are three fragmented segments of TVET Subsector: ITI subsystem, Polytechnic Colleges- and Vocational Schools without any cooperation among them.

Vocational education programs were not accredited like that of polytechnics.
Opportunities

- Under globalized Indian economy, more multiskilled workers with deep cognitive abilities are needed.
- Demand for new innovative products increases in India due to fast growth of middle class and as well for export.
- Government target for 5 trillion-dollar economy would demand more industries and skilled TVET Graduates.
- Establishment of industrial corridors like a Delhi-Mumbai-Bangalore-Chennai-Vizag-Kolkata; Chennai-Coimbatore; North East Corridor would demand millions of TVET Graduates.

Threats

- Fast growing economy in the East Asian Countries like China, Korea, Vietnam, Cambodia would become as serious competitors and would attract MNCs to their countries.
- ROI from obsolete vocational courses and programs will be minimum.
- Improperly prepared vocational courses without active collaboration with user companies will not be creating needed human capital.
- Industry-4.0 demands cognitive skills and contextual knowledge, if they are focused by vocational education, the opportunities will be grabbed by other countries.

There is need to integrate the three subsystems of Indian TVET institutes, viz, Polytechnics, Industrial Training Institutes, and Vocational Schools. All the weaknesses are to be eliminated within a few years, preferably by 2025. Through a project mode these three types of the institutes are to be developed within five years.

TVET Programs for Indian Economic Competitiveness[1,3,6,8,16,20,21, & 25]

Global economic competitiveness increasingly requires India to compete on the quality of goods and services. This requires well developed, motivated and high performing human resource with a range of middle level trade, technical, and professional skills associated with engineering education. Strains in existing vocational systems include lack of workplace learning and training. Hence, it is possible to implement workplace learning and training through Corporate Social Responsibilities and Board of Apprenticeship Training.

Demand for a Broad Range of Skills in TVET Programs[1,2,3,5,6,8,11,16,18,20,21,& 33]

Indian employers are ready to recruit ITI graduates since they are industry ready. Indian TVET programs are to be redesigned to meet the needs of Industry-4.0. A high-skilled labor force shall attract Foreign Direct Investment in India, and increase economic growth. Further well- designed and validated programs can pay off in the labor market and good return on investment (RoI).

Strengthening Links between TVET Institutions and Industry[1,2,10,15, 17,20,21,& 33]

All TVET Institutions are to be linked with industry for periodically evaluating the curricula, training the students, and faculty, conducting campus selection and participating in the institutional planning. The professional associations like CII, FICCI, NASSCOM, Associations of MSME, etc. can play a greater part to get industry ready graduates.

Industry-4.0[1, 2, 4, 6, 9, 11, 12,14, 15, 16, 18, 26, 27, & 28]

Virtually every Indian industry is being impacted by the disruptive power of digital technology which has been quietly ushering in the fourth industrial revolution across the globe. Educational administrators and leaders have to focus on the massive changes as they look for ways to develop new TVET Programs to take advantage of the opportunities that arise from the emergence of Industry-4.0.

Industry 4.0 is fast, flexible, and provides high quality products through efficient production system. It includes Cyber-Physical Systems, Internet of Things (IoT), Cloud Computing and Cognitive Computing.

Industry 4.0 is being Driven by Disruptions[1, 2, 4, 6, 9, 11, 12, 13, 14, 15, 16, 26, & 28]

- The rise of data volumes, computational power and connectivity;
- The emergence of analytics and business intelligence capabilities;
- New forms of human-machine interactions, such as touch interfaces and augmented reality systems;
- Improvements in transferring instructions to the physical world such as Advanced Robotics and 3DPrinting;
- Forces shaping digital future are acceleration, convergence and individualization.

Trends in Industry 4.0. [1, 4, 6, 9, 12, 15, 16, & 28]

- Connects digital technologies with industrial processes, products and logistics
- Industrial Automation: Device connectivity, robotics, and data exchange in the manufacturing environments.
- Perfect maintenance / condition monitoring.
- Augmented Reality (AR) and Virtual Reality (VR).
- Human machine interface (HMI).
- Artificial Intelligence (AI).

Learning Systems for Industry 4.0[2, 4, 9, 14, 15, 16, 26, & 28]

- Plug and produce;
- Monitoring of System States and Energy Consumption;
- Mobile Robotics.

The Features of the Production under Industry-4.0[6, 11, 14, 16, 26, & 28]

- Entire production plants will be digitally networked;
- The plant has a virtual emulation which will enable automatic start-up and reconfiguration;
- Rapid balancing of capacity utilization in a production network;
- Automatic adoption of production lines to ordering capacities through simple, rapid extension or reduction of the manufacturing facilities;
- Simple compensation for defective units;
- Control of production is being more intelligent and adoptable;
- Automatic start-up and reconfiguration of facilities;
- Consumer specific production;
- Humans and technologies are cooperating to an increasing extent.

Preparations for the Smart Factory

- The use of mobile terminal devices such as tablets and smart phones in production;
- Planning and organization for networking of intelligent system components and modules;

- Integration of facilities into ERP systems;
- Vertical networking of production sites throughout the value-added chain via the virtual world of the Internet.

Providing Right Mix of Skills for the Indian Market

In the 21st century, those entering the labor market need immediate job skills, but they also need.

Role of Employees

Employees play an important role as problem solvers, experts and decisionmakers within the manufacturing networks that consist of virtual and mechatronic production sequences. They will remain irreplaceable in the future as idea generators, and developers of new products and work processors, enabling their capacities and skills to continuously evolve into essential resource.

Leadership 4.0.

Management capacities needed to support the pace of Industry-4.0 are:

- Competition: Spot and react quickly to new competition on the horizon
- Hierarchy: Needs to free up the decision-making processes to maximize opportunities, while keeping clear communication flowing throughout the organization
- Technology: harness the talents of individuals who can fully explore, utilize and maximize new technological advancements.

Challenges to TVET Institutes in India[16, 20, &33]

- Have you integrated three subsystems of TVET Institutes in planning emerging programs due to Industry.4.0?
- Have you stated planning new TVET Programs in collaboration with the employers?
- Have you planned industrial work-based learning and skill development as a cooperative education?
- Have you designed the blended learning?
- Have you linked all TVET Institutions with various industries in the industrial corridors and hubs?
- Have you assessed the need for new and innovative TVET programs to meet the demands of Industry 4.0?

Establishing State-of-Art-of TVET Institutes in the Proposed Industrial Corridors and Hubs

- Adopt Public-Private-Partnership Model in establishing new TVET Institutes.
- Collaborate with professional associations like CII, FICCY, SIAM, NASSCOM, Associations of MSMEs.
- Conduct summative evaluation and tracer studies involving the alumni and employers
- Develop new programs in emerging technology
- Ensure continuous transformation in teaching, learning, skill development, and internship.

Engage Stakeholders [33, &34]

- Engage employers in TVET Policy and Provisions through State Industrial Development Corporations;
- Engage all stakeholders to develop and implement Qualifications Framework Coupled with quality assurance for flawless implementation;
- Develop standardized National Skill Assessment Framework to underpin the quality and consistency in training provision;
- Collect data on labor market outcomes of TVET in collaboration on Institute of Applied Manpower Research (IAMR);
- Analyze the data and plan for the establishment of TVET institutes, programs, work-place learning.

Providing Workplace Learning and Training[1, 2, 5, 14, 15, 19, 20, 24, 26, & 31]

Workplace learning and training is very essential for skill development, attitude development, interpersonal relationships, achievement, motivation and productivity. Plan needed workplace learning in cooperation with the employers. Encourage critical thinking and problem solving.

Career Guidance[2, 3, 4, 6, 10,16, & 25]

Develop a coherent career guidance focused on the emerging jobs, choosing careers, or planning higher education. Arrange campus interviews or job fairs. Provide online support for submitting the Cvs.

Training the Instructors, Faculty Members and Part-time Skill Trainers[20]

- Recruit sufficient instructors and trainers for TVET Institutions and ensure that this team is provided needed preservice training to meet the demands of Industry-4.0;
- Plan periodical upgraded training to prevent faculty 'burn- out';

- Ensure flexible pathways of recruitment, and plan MOOCs to improve cognitive skills;
- Provide needed andragogical training to supervisors and administrators.

Needed Preparations of Indian TVET Trainers[20]

Pandit Suderlal Sharma Central Institute of Vocational Education (PSSCIVE) should link with National Institutes of Technology, National Institutes of Technical Teacher Education and Research, Board of Apprenticeship Training/ Skill Training, State Technical Universities, Polytechnic Colleges, Vocational Schools, Industrial Training Institutes, and Corporate Executive Development Centers and Human Resource Development Centers of Universities. This will help in evaluating the outcome and the impact of vocational programs and train and develop the faculty members of vocational schools.

Crucial Skills that are Needed to Face the Industry-4.0 Revolution[1, 2, 4, 6, 9, 10, 14, 16, 18, 19, 20, 24, 25, 28, 30, 31, & 33]

The following skills are synthesized from various researchers and included here.

- **Virtual Collaboration:** The ability to effectively collaborate between virtual team members via digital technology;
- **Cognitive Information Management:** The ability to effectively filter information and maximize cognitive functions;
- **Design Mind Set:** The ability to represent and develop tasks and to focus on the work processes to achieve the desired outcomes;
- **Social Intelligence:** The ability to convey concepts to others deeply and directly and be able to sense and stimulate reactions;
- **Adoptive Thinking:** Demonstrating the proficiency of thinking and coming up with solutions, and the ability to determine the deeper meaning of what's being expressed.

Strengths of TVET Programs of China, Germany, Korea and Switzerland

China[8, 9, 22, 30, 32, 33 & 34]

- Upper secondary vocational educational provides specialisms, a good percentage of general academic skills underpinning all the programs, and a commitment to workplace training and close relationships with employers.
- Teachers in vocational schools are required to spend one month in industry every year.
- Many schools employ a significant number of part-time teachers from industry.

Germany [10,25, & 26]

- German system offers qualifications in a broad spectrum of professionals and flexibility adapts to the changing needs of labor market.
- The dual system integrates work-based and school-based learning to prepare apprentices for a successful transition to fulltime employment.
- The TVET system as a whole well-resourced.
- Federal institutes for TVET and a National Network of Research Clusters conduct research studies and support continuous innovation and improvement in the TVET System.

Korea [19, 23,& 29]

- Strong employer involvement in TVET policy development and implementation.
- The tertiary TVET sector is well developed.
- Around 33% of tertiary students are enrolled in junior colleges and polytechnic colleges.

Switzerland [25]

- The TVET System is strongly employer and market oriented.
- The partnership between Confederations, Cantons and Professional Organizations works well.
- School and work-based learning are well integrated.
- TVET System is well resourced and able to modernize with up to date equipment
- Flexible pathways have been introduced to allow for mobility and avoid the risk of dead-ends.
- Quality control is ensured and national assessment procedures are in place.

Synthesis of the Best Practices

- **China:** Work-place training, close relationship with employers, and one-month internship, and employment of part-time teachers.
- **Germany:** Flexibility to adapt to industry, work-based and school-based learning, well-resourced TVET System, and National Network of Research Clusters.
- **Korea:** Strong employer involvement, well developed TVET system, and further education of TVET graduates.
- **Switzerland:** Strong employer oriented, partnership with professional associations, integrated work-based learning, modernized system, flexible pathways, and quality control.

All these good practices are to be incorporated in the Indian TVET System.

Directions from the National Educational Policy 2019 (NPE 2019)[20]

The directions from the NPE 2019 are briefly presented in this section.

- Integrate vocational education into all programs of educational institutes.
- Provide access to vocational education to at least 50% of all learners by 2025.
- Broad definition of vocational education would include professional education as well.
- Vocational education should integrate not just hands on skilling component but also the theoretical knowledge, attitudes and mindsets, and soft skills that are required for particular occupations, through broad-based education.

Fresh Approach to Vocational Education

- Implementation of vocational education should be improved.
- Recruit teachers, develop infrastructure and industry specific curriculum.
- Vocational education must be fully integrated within main stream of education.
- A national committee for the integration of vocational education (NCIVE) will be set up.
- Academia has to work closely with standards bodies and with potential employers, so that graduates have adequate employment opportunities.
- Collaborate with ITI s, Polytechnics, local industries and businesses, etc.
- Induct external experts in different vocations.
- Train the teachers to offer vocational education.
- Conduct assessment of all vocational education courses, jointly with partners that are providing the practical skills training.

It is essential to work with the professional leaders like National Institutes of Technical Teachers Training and Research (NITTTRs) in Bhopal, Chandigarh, Chennai, Kolkata and their extension centers[20].

- Create curriculum and supplementary educational materials for vocational education that are adopted to local needs.
- National Committee for the Integration of Vocational Education (NCIVE) will need to create a plan for this in collaboration with all stakeholders.
- NCVET has host a Labor Market Information System of track certified candidates, courses, training providers, trainers, and assessors.

- Gather data for determining the types and nature of courses that will be required in particular geographies.
- MIS for data on successful courses conducted by all the institutions in various sectors of the economy.
- Technology platforms for training of the teachers and end to end delivery of vocational education.
- NCIVE will develop a plan for collection and analysis.

National Skills Qualifications Framework (NSQF)[20]

- The generic competencies defined at each of the 10 levels by the umbrella framework of the NSQF will be translated into specifics for each of the disciplines/ vocational / professions in different sectors.
- Course content and assessment criteria, and appropriate curricular and assessment frameworks will be standardized by academic institutions with other stakeholders aligned to these levels.

National Occupational Standards and International Compatibility of Standards[20]

- Indian standards must be aligned with the International Standard Classification of Occupations (ISCO) which is maintained by the International Labour Organization (ILO).
- The Qualification Packs- National Occupational Standards (QPs-NOS) must be aligned with International Standards.
- Employers have to specify the most appropriate standards for each job roles within their organization and educators can train to the same standards.

National Qualification Register (NQR)[20]

- NQR has to be designed to be the official national public record of all qualification aligned to the NSQF.
- Educational institutions offering an NSQF-aligned qualification can enter details of their training programs on the NQR portal that can be used by other institutions.

Strengthening of the Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE) through an International Development Agency like Asian Development Bank or World Bank[20]

- This national institute requires massive Capacity Development, Quality Improvement, and Efficiency Improvement.
- Further it has to be linked with other National Institutes of Technical Teacher Training and Research in Bhopal, Chandigarh, Chennai, and Kolkata and their extension centers.

- The existing vocational programs in all vocations are to be evaluated against the current needs on the industry.
- Each vocational program has to be improved in collaboration with the user industry.
- Addition technology based vocational programs have to be started in various industrial corridors and hubs as Private-Public-Partnership Mode.
- The existing faculty members of the PSSCIVE have to be trained to meet the needs of modern industry need.
- Additional faculty members have to be recruited to train the vocational teachers to handle new courses in Industry-4.0
- All the initiatives require funding through soft loan from an International Development Agency (IDA) like Asian Development Bank (ADB) or World Bank.

Conclusions

There vocational courses are to be updated and improved to serve the new industries who are switching to Industry.4.0 mode. There is a need for well- trained faculty to train the vocational teachers. PSSCIVE has to be further expanded in a large scale through an IDA assisted model. Further, PSSCIVE can create an active link with all the leaders in faculty training like NITTTRs. The vocational programs are to be linked to the user companies for active collaboration for jointly developing the programs, train the students and the teachers. An action plan can be prepared and implemented to supply industry ready vocational graduates.

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