Tools and Techniques for Re-Training and Re-Skilling of Industry 4.0 Workforce

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ABSTRACT

The purpose of the paper is to review the tools and techniques used in re-skilling and re-training employees so that they are ready for working in Industry 4.0. Since 2012, the industry in India and across the globe has been moving towards a new phase of technological advancement also termed as Industrial Revolution 4.0. To be able to utilize the opportunities created by Industry 4.0, organizations must take cognizance of the various requirements arising out of the new phase and analyze their standing in terms of skills requirements. In the new era, the workforce must have the skills and capabilities to handle advance technologies and work in new roles. This calls for a comprehensive review of the existing skills of the workforce. The World Economic Forum (2016) report states that "more than a third of the desired core skill sets of most occupations will be comprised of skills that are not yet considered crucial to the job presently". In other words, organizations will face a large talent and skills shortage. This shortage will force the organizations to work simultaneously on two fronts. One is to work on the strategies for re-skilling and re-training existing employees to render them Industry 4.0 ready and the other is to work on providing effective strategies for handling the employees displaced due to increased automation. This calls for judicious application of advanced and innovative training programs that use a combination of technology and communication. The paper reviews the applicability of existing tools and makes several suggestions on how they can be adapted to aid in skilling and re-skilling of employees.

Key words: Industry 4.0, training, skills, competencies

INTRODUCTION

The term, 4th industrial revolution or Industry 4.0 refers to the transformation of traditional manufacturing and industrial practices. Industry 4.0 envisages a system where production is made of modular and efficient manufacturing systems and products are empowered to control their own manufacturing process, all made possible by using modern and smart technology (Lasi et al, 2014). To realize its dream of becoming a global manufacturing hub and to build long-term competitiveness, India needs to gear up and acquire all the necessary skills and capabilities needed for Industry 4.0. As per the Six-dimensional model developed by VDMA (2015) to assess the readiness for Industry 4.0, employees are an integral aspect along with smart factories, smart operations, and smart products. Most companies have already recognized that a workforce with broad skill sets is a key success factor in reaching the goals of Industry 4.0 (VDMA report, 2015). This paper probes into the effective strategies that organizations can adopt to train(re-train) their employees.

The Industry 4.0 wave is built on technological advancement that is a harbinger of significant change. The adoption of Industry 4.0 technologies results in people working in a digitized and networked workplace that calls for employees with unique and specialized skills set (Kergroach, 2017). However, most industry leaders have no clarity on the modalities and processes involved in the training of their employees (Sony & Naik, 2020). In a recent survey conducted on 2000+ top executives across the globe, the leaders expressed a deep commitment to adopting Industry 4.0 technologies but were unsure about the appropriate actions to be taken (HBR, March 2019). The need for a suitable skills development framework suitable to bridge the gap between the existing and required skill set of employees has been felt (Maisiri et al, 2019). Techniques like blended learning have been suggested for delivery of learning to employees (Moica et al, 2019). The new skill sets required for Industry 4.0 are considered as the 'internal environment' of the organization and cooperation and coordination with external agencies has been suggested for the process of timely and accurate acquiring of knowledge (Stachová et al, 2019). It has been stated categorically that the training of employees should not be confined to training in advanced technical skills alone. The need for employees' adaptation to the new technological mode awards the highest priority on social competencies as far as the preparedness for this phase of industrialization is concerned Hence, the training must address both technical and social competencies of the employees(Popkova & Zmiyak, 2019).

Industry 4.0 calls for a specific level of employee skills for handling its specialized technologies (Weerasinghe et al, 2020). The training continuum of organizations aspiring for Industry 4.0 standards should cover three categories of skills:

- Technical skills-for handling advanced technologies involving Big Data, Cloud Computing, Internet of Things (IOT), etc.
- Transformation skills- to accept and adopt changes concerning production systems, supply chains, security, etc.
- Social skills-to effectively participate in teamwork and collaboration for transfer, acquisition and synchronization of knowledge (Schallock et.al,2018).

This paper is written with the aim of achieving the following objectives.

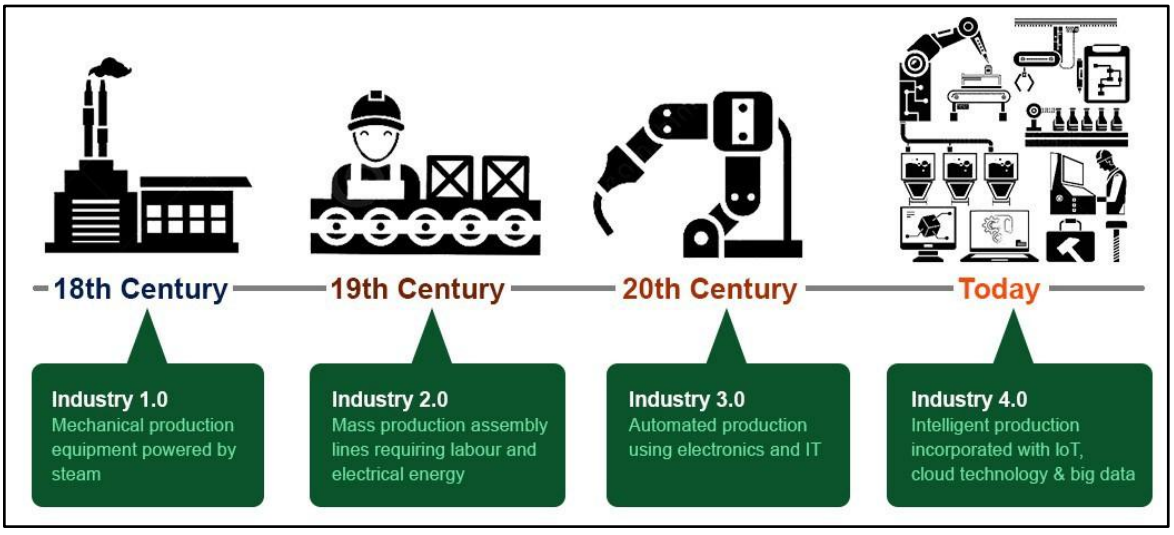
1) To discuss the need for re-skilling and re-training workforce in Industry 4.0 organizations
2) To discuss the learning strategies that can be adopted by organizations to effectively inculcate all the three skills-technical, transformational, and social- into the training and development programs
3) To discuss the pros and cons of some of these advanced learning tools that will be of use in Industry 4.0 organizations.

LITERATURE REVIEW

Technological advances have driven dramatic increases in industrial productivity since the dawn of the Industrial Revolution. Use of water and steam helped to create the 1st industrial revolution leading to mechanized production. Electric power helped create mass production in the 2nd industrial revolution and the 3rd industrial revolution was made possible due to advances in electronics and information technology leading to automation of production (see Fig 1).

Market enlargement, internationalization and intense competitiveness have led to the 4th industrial revolution. This industrialization is the result of technological advances such as the emergence of artificial intelligence, robotics, the internet of things, autonomous vehicles, bio and nanotechnology, 3-D printing, material science, quantum computing and energy storage (Diwan, 2017).

Fig 1: Evolution of Industrial Revolution from IR 1.0 to IR 4.0



This phase of industrialization originated in German manufacturing sector in 2012 and is characterized by the following aspects.

- The rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks
- The emergence of analytics and business-intelligence capabilities
- New forms of human-machine interaction like touch interfaces and augmented-reality systems and

- Improvements like advanced robotics and 3-D printing (McKinsey & Company Global Report, 2015).

The evolution of jobs and skills that can integrate the above aspects is essential for the successful implementation of Industry 4.0. This capability is of significant contemporary interest and importance to researchers, policymakers and practicing managers (Weerasinghe et al, 2020).

Industry 4.0 requires trained knowledge workers, who can be leaders and/or managers and they must possess new (improved) skill sets to adapt, to manage, and/or to take advantage of the new opportunities provided by the digitized and automized manufacturing processes (Ras et al, 2017). The employees must be critical thinkers, problem solvers, innovators, communicators, and provide value driven leadership. They must be able to find innovative solutions using technology that will benefit society and mankind (Grzybowska & Łupicka, 2017).

Implementation of the fourth innovation wave in manufacturing sector offers four main challenges as far as the workforce is concerned (Ras et al, 2017). They are:

1) Complexity- The manufacturing scenario has changed from assembly line to automation to the modern digitization, exponentially increasing the complexity involved in processes. The workforce needs to understand the underlying processes, their dependencies, and develop the know-how needed for collecting and utilizing data and leveraging digitization in the intelligent production of smart products with flexible lot sizes (Ras et al, 2017).
2) Fast and dynamic changes-Industry 4.0 implementation calls for rapid standardization, development, and deployment of intelligent assistant systems. Increased and varying degrees of digitization for each component of the system further complicates the process. Organizations compliant with Industry 4.0 norms should ensure that effective training and performance assessment is in tune with the rapid changes of the system (Madonna et al, 2019).
3) Shifting job profiles-Unlike the traditional manufacturing system, the Industry 4.0 involves job profiles that are multi-disciplinary. A worker in the digitized system needs to be acquainted with mechanical aspects of the process along with data analytics, design, and effective communication skills. Hence, new skills must be developed in the workforce that are not only effective but also rapid and future-proof (Kozak et al, 2018).
4) Work-life balance: The interdisciplinary workplace envisaged in the new digitalization era poses huge challenges in terms of maintaining work-life balance. Just as in the traditional workplace, the Industry 4.0 workplace will need to ensure an effective work-life balance for the employees. The socio-technical approaches to work along with the expected lifelong learning places a huge burden on the Industry 4.0 employees and proper work-life balance strategies are needed to ground the employees and ensure steady performance (Ganiyu & Oladejo, 2021).

The skill sets that were present in workers of earlier eras are different from the required skills for the knowledge workers. There is every likelihood that the changes in technology and the process of production will bring about drastic changes in the job profiles of the industry. The new era of industrialization will lead to creation of new skilled jobs, which will require altogether different types of training and knowledge. The table below provides some insights into the creation of new jobs and change of skill sets at the Industry 4.0 workplace.

Table 1: New job roles and changed skill sets in Industry 4.0 scenarios (projected)

Sector	Workforce that will be deployed in new jobs that do not exist today	Workforce that will be deployed in jobs that have radically changed skill set
IT/BPM	10 to 20%	60 to 65 %
Automation	5 to 10 %	50 to 55%
Textiles &Apparels	5 to 10%	35 to 40%
BFSI	15 to 20 %	55 to 60%
Retail	5 to 10%	20 to 25%
Projections for year 2022 *Source: Bhat, (2020), India and Industry 4.0*		

It is evident from the table that most of the workforce (except in retail sector) will see huge changes in the required skills and capabilities. If Industry 4.0 technologies are to be widely adopted, necessary actions need to be taken to acquire these skills.

To ensure that competent and skilled workforce is available, a two-pronged strategy needs to be adapted by organizations. One aspect is to recruit personnel with the required competencies and the other is to re-train and re-skill the existing workers with both communication and technical skills. This paper focuses on the aspect of re-training and re-skilling the existing workers.

With respect to the 4 different eras of industrial revolution, each era is characterized by different conditions of social economy and specialized skilled set of human capital (Table 2).

- In Education 1.0, knowledge transfer was from the teacher to the learner, with the most common technique being that of memorization
- In Education 2.0, learning took place through internet. However, focus was on teaching how to use technology as tools in the work.
- Education 3.0 supported the concept of 'self learning'. Technology in form of teaching materials, digital media and social media was an integral part of this era.
- Education 4.0 refers to catering to the need of the society in 'innovative era'. The era is characterized by high intensity, complex and rapid changes. It calls for rapid adaptation to the changing technology (Puncreobutr, 2016).

Table 2: Era of industry and associated learning processes

Era	***Nature of economy***	***Nature of learning***
Industry 1.0	Agricultural	Memorization
Industry 2.0	Industrial	Learning through internet
Industry 3.0	Knowledge-based	Consumption of knowledge and labor
Industry 4.0	Innovative	Education as enable to create change

Source: Puncreobutr, 2016

The competencies needed for Industry 4.0 are numerous and diverse (Hecklau et al, 2016). They are not the same as needed for previous eras of industrial revolution. These competencies can be categorized as given below (Leinweber, 2013):

- Technical competence which equips the employees with latest knowledge, process understanding, technical skills, etc.
- Methodological competence which inculcates creativity, entrepreneurial thinking, problem solving, conflict resolution, decision making, analytical skills, research skills, and efficiency orientation in employees.
- Social competence which includes intercultural skills, language skills, communication skills, networking skills, adaptation to team culture, ability to be compromising and cooperative, ability to transfer knowledge and leadership skills.
- Personal competence that includes adaptability, uncertainty tolerance, motivation to learn, ability to sustain stress, balanced mindset, and conformity.

As Industry 4.0 implementation has severe implications on the organizational structure and operations and delivery model of any enterprise, the need for better knowledge and training will be applicable to even the most sophisticated and advanced companies of Industry 3.0 era (Fitsilis et al, 2018).

The new vision of learning in Industry 4.0 encourages learners not only to absorb the required skills and knowledge but also to identify the source to learn these skills and knowledge. Nine different trends of learning are identified as part of education imparted to Industry 4.0 workforce (Fisk, 2017).

Table 3: Types of learning for Industry 4.0 and characteristics

S.No	Type of learning	Characteristics
1.	Remote, self-paced learning	• Learning can take place anytime anywhere • E-learning, interactive learning
2.	Personalized learning	• Progressive mastery; easy to moderate to hard tasks • Positive reinforcements to promote positive learning experience
3.	Blended learning, BYOD approach	• Choice in determining how students want to learn • Freedom in choosing learning tools & techniques
4.	More project-based learning	• Focus on short term projects • Improving of organizational, collaborative and time management skills
5.	More hands-on learning	• Taking up of internships, mentoring projects and collaborative projects • Face-to-face interaction facilitating quick knowledge transfer
6.	Focus on data interpretation rather than calculation	• Predicting trends and inferences • Manual mathematical skills replaced by macros and programs
7.	Testing application of facts not theory	• Unconventional assessment • Application of learnt theory practically tested on-the-job
8.	Curriculum updating based on student requirements	• Designing and updating curriculum based on students' requirements • Contemporary and useful curricula
9.	Teachers-instructors to facilitators	• Independence in learning • Dependence on teachers reduced

(Source: Fisk, 2017)

These learning processes help in developing the learner's ability to apply the new technology. Experts have argued that the 'innovative era' associated with Industry 4.0 needs changes in behavior that are associated with special characteristics of parallelism, connectivism and visualization (Puncreobutr, 2016).

Training of employees involves imparting knowledge in both soft and hard skills. Soft skills for employees include the life skills or the innovative skills required to live in the era of Education 4.0. The other soft skills are leadership, creativity and innovation, digital literacy, effective communication, emotional intelligence, entrepreneurship, problem- solving critical thinking and teamwork. Employees also need to be trained in cross-cultural understanding, information and media literacy, career and learning skills.

Employees also need to be assessed for presence of transversal skills. These are "Skills that are typically considered as not specifically related to a particular job, task, academic discipline or area of knowledge and that can be used in a wide variety of situations and work settings" (Demchenko et al, 2019). Hard skills refer to training in technologies and other related competencies. Table 4 describes the key Industry 4.0 elements and the crucial skills required to function in this environment.

Table 4: Top Transversal Skills for Industry 4.0

Key Industry 4.0 Elements	Top 10 Skills for Industry 4.0
Cyber-physical systems Internet of things Internet of services Smart factory Mobile technologies Cloud computing Big data	1. Complex problem solving 2. Critical thinking 3. Creativity 4. People management 5. Coordinating with others 6. Emotional Intelligence 7. Judgement and decision making 8. Services orientation 9. Negotiation 10. Cognitive flexibility

Source: Demchenko, 2019

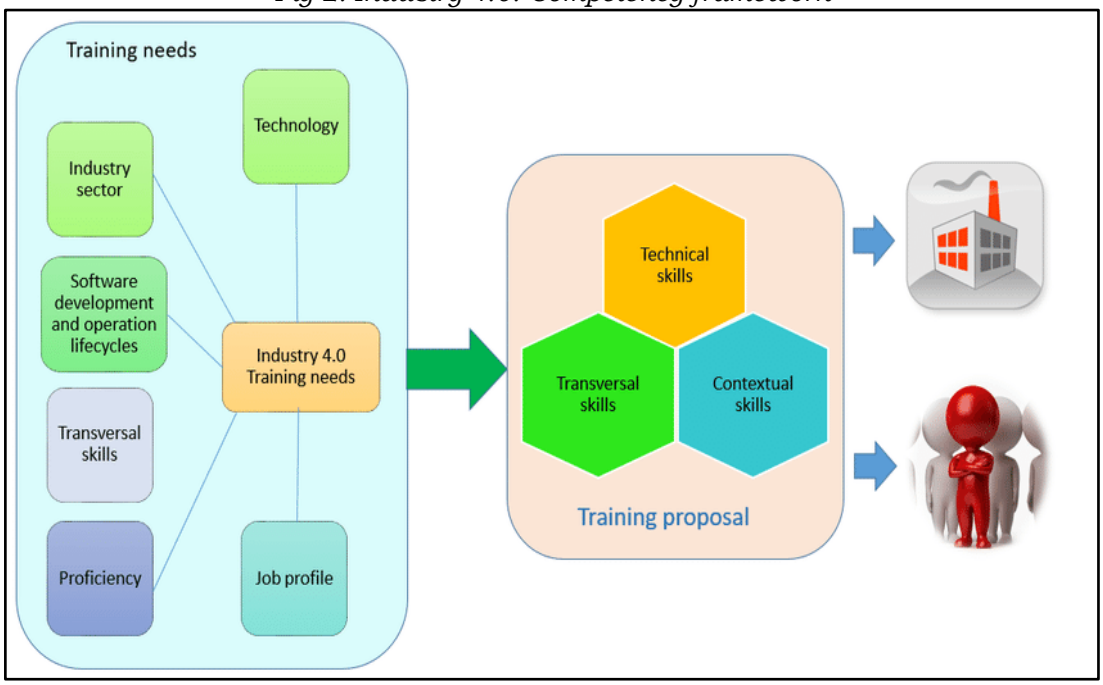
For effective training of employees, assessment of training needs of employees prior to imparting training is mandatory. While assessing the training needs of the employees, it needs to be understood that all employees do not have the same needs or capabilities for training. Additionally, the following aspects must be kept in mind while evaluating the training needs of employees (Fitsilis et al, 2018).

The following points should be considered while deciding on the level and type of training:

- There is no 'technological determinism', i.e., choice of technology should depend on the needs of the operating process and not on popularity of the technology
- Skill needs must be assessed according to the specific industry needs
- Assessment must take into cognizance the existence of different workforce segments
- Presence of different sectors and existence of different subsets of the technologies must be considered
- Different product lifecycles require different kinds of learning.

The assessment of employee needs is displayed in Fig 2 below:

Fig 2: Industry 4.0: Competency framework



(Source: Fitsilis, P., Tsoutsa, P., & Gerogiannis, V. (2018), Industry 4.0: required personnel competences. Industry 4.0, 3(3), 130-133)

Rendering the employees prepared for handling advanced technology involves recruiting and selecting candidates with the right qualifications, skills, and competencies. It also involves re-training and re-skilling of existing employees after assessing the present level of the employees and the level to which they need to be trained. This paper focuses on the second activity, namely re-training and re-skilling of existing employees.

It is evident that Industry 4.0 requires new, diverse skill sets and different competencies as compared to the earlier industrialization eras. Toprepare, train, and develop industry 4.0-ready workforce, organizations should reduce dependence on in-house training cells/departments. The focus, instead, should be on establishment of interdisciplinary research communities. The goal should be to assemble and connect a community of highly placed education and training providers, content developers, systems developers, and scholars in the relevant technical and administration fields (Ras et al, 2017). To achieve this, a high degree of human resource management maturity along with establishment of relationships with external knowledge networks is needed (Stachová et al, 2019).

Leaders of manufacturing firms and the human resource managers need to look for training modules and programs that can deliver the technical, personal, and social skills required for a knowledge worker in the highly digitized and automized industry (Weerasinghe et al, 2020). This paper rejects the extension of traditional training and development programs that depend on one-size-fits-all modules. Instead, organizations should utilize advanced, learner-friendly learning tools that can provide the required skills in an innovative and asynchronous manner. These modules help impart knowledge continuously without interrupting the job flow. This paper reviews some of the non-traditional learning tools that are ideally suited for training of the employees.

Methodology (Quantitative analysis)

Tools and techniques for re-training and re-skilling Industry 4.0 workforce

Tools and techniques used in training existing employees work effectively when the major learning responsibilities shift from the instructors to the learners. One of the tools that work effectively in training existing employees is massive open online courses (MOOCs).The use of MOOCs is apt to impart learning if learning is associated with social media, in large groups and in virtual environment (Schulz & Jeske, 2014). MOOCs have been already used to educate workforce in Industry 3.0 era extensively. Hence, MOOCs are ideal for imparting Education 4.0 content to individuals effectively.

MOOCs

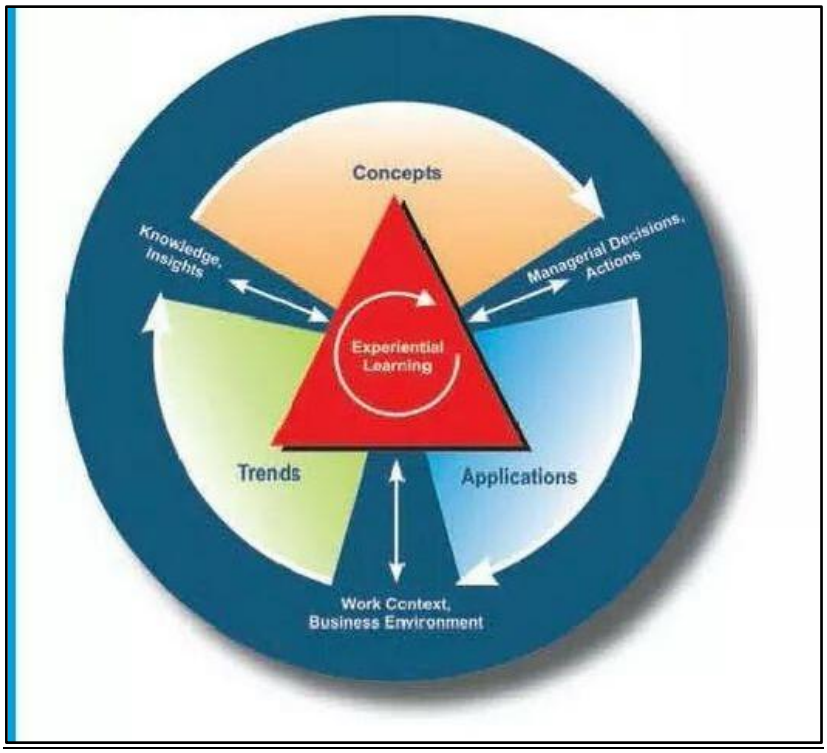
MOOCs can be of great help in creating a more realistic and practical approach to learning and can bring about great student learning outcomes. Use of MOOCs to impart Education 4.0 is already successful in countries like Malaysia (Hussin, 2018; Maria et al, 2018). Similar use of MOOCs to impart Education 4.0 is highly recommended in developing economies like India. Learning ecosystems through a MOOCs knowledge repository system can be used effectively to impart technical knowledge and training to employees in organizations (Thanachawengsakul & Wannapiroon, 2021).

This ecosystem using MOOCs is comprised of four components where the first component includes instructors and learners. A digital knowledge engineering learning process that describes the roles of instructors and learners, learning activities, and instructional tools forms the second component. The third component in this ecosystem is the MOOCs knowledge repository system which is made of software intended to enhance the learners' competencies digitally. The fourth and final components of this ecosystem refers to the learners' digital competencies.

The learning outcomes arising out of the use of this system are of vital significance to the learning process of the employees. This system has been used successfully to enhance the competencies of entrepreneurs in Malaysia (Thanachawengsakul & Wannapiroon, 2021). This system has potential to be used to create and enhance learning competencies of employees in mainly technical aspects. This ecosystem's chief advantage is that it can be personalized to suit the organizational requirements by suitable modification of the knowledge repository system. This system offers the additional advantage

as multiple knowledge experts can participate in the learning process and make significant contributions to enhancing the learning competencies of the employees (Putra et al, 2020).

CAT-XL



(*Source: ICFAI University, Tripura*)

CAT-XL or 'Concepts, Applications, Trends – Experiential Learning' is an experiential learning framework adopted by few universities in India. It is a learner-centered approach that considers the fact that the learning needs of self-motivated, mature individuals are different from that of fresh graduates. This approach has been used to impart management education and has great potential to be used for imparting education for Industry 4.0 requirements.

This learning tool incorporates basic and advanced concepts and trends into practical scenarios to enhance the learning process of the learner. This method has been successfully used to strengthen managerial and administrative aspects in learning. This tool has great potential to strengthen the personal skills like leadership, communication, emotional intelligence, conflict resolution and decision-making in managers and employees.

Both these concepts can be adopted to deliver the learning approaches required for Industry 4.0. As traditional learning approaches do not yield required outcomes in Industry 4.0, one or many of the following approaches need to be used. The use of these approaches is still in infancy stage in India and needs to be developed and adapted for its extensive use. The learning ecosystem can comprise of:

Personalized learning: It recognizes that learners have distinct needs due to differences in needs, aspirations, cultural backgrounds and interests. The learning is based on what the learner knows and how he/she learns the content.

New learning infrastructures: This refers to the set of physical and digital buildings, applications, services, and people that provide and support the environments for learning.

Shift from presence learning to distance learning: Learner is not required to be physically present in the class or follow a set structure or timetable for learning. Learning takes place at learner's pace.

Individualism as a global phenomenon: In individualism, persons (learners) give priority to their goals and how to achieve them and not to collective goals. This phenomenon was originally thought to be a western phenomenon but is now found to be present globally.

Personalization (Heutagogy) and individualization: Heutagogy, also known as self-determined learning, is a student-centered instructional strategy that emphasizes the development of autonomy, capacity, and capability.

DIY education: Do-It-Yourself education is the preferred mode of learning by the young employees and a shift away from the traditional mode of learning.

Shift from physical to virtual world: Educational content delivery is converted to a virtual world and enables learners to not only see and understand but also to interact with it, enriching the learning experience.

Self-paced learning: Self-paced learning is defined as a specific learning method in which the learners can control the amount of material they consume as well as the duration of time they need to learn the new information properly.

Individual modular degrees: A module is a part of the curriculum. As the student progresses through learning module-wise, he/she would be able to monitor and evaluate his/her progress and performance at the end of the module.

These approaches need a non-traditional delivery system as a class-room scenario is not suitable for achieving the required outcome. Some probable delivery modes that can provide higher-order learning are indicated below and they are of significant value in industries that have taken up digitization.

Higher-order learning

Gamification: Gamification uses video games design and games elements to deliver the learning content. It is an effective approach to make positive change in students' behavior and attitude towards learning, to improve their motivation and engagement (Almeida & Simoes, 2019).

On demand learning: On-Demand Learning is a training strategy for how a learner gains access to knowledge-based content in real time, anywhere and at any time (Tvenge & Martinsen, 2018).

Inverted classroom/ Flipped classroom: In this instructional strategy, learners are delivered the instructional content (usually through video lectures) which they view and understand at their own pace. Activities like projects, assignments and homework are performed in the classroom with more interaction with the teachers (Yusuf & Nur, 2019).

Blended learning: This is a style of education in which learning is enabled through both traditional and modern media (Moica et al, 2019).

CONCLUSION

Industry 4.0 is the new phase of industrial revolution which is significant for the way products are manufactured and services are provided. There is a strong and compelling need to create trained, qualified professionals who can contribute significantly to highly globalized and digital-driven world of work. It is evident that the skills and competencies required in worker belonging to Industry 4.0 are different from those required in workers of earlier eras. Workers in Industry 4.0 are knowledge workers and with the proliferation of advanced technologies, there is not only a need for enhancing technical skills of the employees but there is also the need for human skills like creativity, empathy, problem-solving, and communication.

The training of employees should involve non-traditional learning processes that involve personalization, e-learning, peer interaction and reduced interaction with teachers or mentors. Organizations should understand that different workers have different training needs, and the actual process of training should commence only after a comprehensive assessment of training needs of workers has taken place.

Online learning platforms like MOOCs and learner-centered approaches like CAT-XL are effective tools for delivering the content to employees of Industry 4.0.

The tools and techniques for imparting skills for Industry 4.0 are still in the infancy stage. More number of universities and course providers must initiate specialized courses. Many companies are looking to adopt technologies such as data analytics and industrial Internet-of-Things to improve their manufacturing competitiveness. The requirements for a successful transition to Industry 4.0 go far beyond technology change and require full knowledge and expertise that can be provided by full-fledged training courses.

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